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The Pollen Flora of Faiyum, Egypt
I- Archichlamydeae

Eman M. Shamso[1] and Fujiki Toshiyuki[2]

[1] *The Herbarium, Botany Department, Faculty of Science, Cairo University, Giza 12613 Egypt; e-mail: e.Shamso@yahoo.com*
[2]*International Research Center for Japanese Studies, Japan; e-mail: fujikky@pop06.odn.ne.jp*

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The aim of this investigation is dealing with determination of pollen micro- and macro-morphological characters of Egyptian taxa of subclass Archichlamydeae to provide palynological information and an identification key adapted for use with archeobotanical materials. The pollen of 41 Egyptian taxa belongs to 18 families representing the current vegetation of Faiyum area described and illustrated with both LM and SEM micrographs. On the basis of pollen units, number and type of aperture**s,** exine patterns were great diagnostic significance among the examined taxa. Seven major pollen types and 18 subtypes included in two groups (complex and single pollen groups) were recognized. Pollen types: Polyads, triporate, tetra- hexaporate and pantobrevicolpate are characterized to Mimosoideae, Urticaceae, Fumariaceae and Portulacaceae respectively; while pantoporate, tricolpate and tricolporate pollen types show highly diversity in pollen characters, comprising 16 pollen subtypes distributed among 14 families. A description, illustriation in the form of scanning electron micrographs and a key for identification of the different taxa is provided.

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Introduction

Western Desert of Egypt is one of the main geomorphologic units, which extends from the Mediterranean Coast in the north to the Egyptian-Sudanese border in the south (ca. 1073km) and from the Nile Valley in the east to the Egyptian-Libyan border in the west (width ranges between 600-850 km), i.e. it covers about > of Egypt (El Hadidi 2000).

Faiyum province is one of the depressions of the Western Desert of Egypt. Being the nearest to the Nile Valley and after being connected with the River Nile by a large irrigation canal (Bahr Yusuf), The Faiyum Depression is considered as apart of the Nile Region (Nile Faiyum). The depression has a total area of about 1700 km² (Zahran & Willis 2009).

The plants of the Nile system of Egypt (about 553 species) represent 29.9% of the total flora of Egypt. About 126 species are not recorded elsewhere in Egypt; of these species 64 characterize the Nile Faiyum (Zahran & Willis 1992).

Täckholm (1974) recorded about 129 taxa representing subclass Archichlamydeae restricted to the Nile Valley area. The current vegetation of the Faiyum area was the subject of several recent accounts, Abd El Ghani (1985) recorded 158 species in the northern district of Faiyum area, which constitute the major bulk of the weed assemblages associated with the crops of the farm land.

El Fayoumi (1996) studied the main features of the current vegetation in El Gharag El Sultani area which constitute the southern districts of the farm land in the Faiyum depression, he recorded 121 species, among which 115 species are weeds of the farm land.

Saad & Sami 1967, El shenbary 1985, Ritchie 1985 and Ayyad *et al.* 1992b studied the fossil pollen content in different areas of Egypt. Mehringer *et al.* 1979 carried out a pollen analytical study in the lake Qarun area and elucidated the history of Birket Qarun and Fayium over the last 325 years, while El Hadidi & El Fayoumi 1997 recognized 86 pollen types grouped under 21 pollen classes in El Gharag El Sultani area using light microscopy (LM), he provided artificial key and brief descriptions for the pollen types.

The present investigation is dealing with determination of pollen micro- and macro-morphological characters of 41 taxa of subclass Archichlamy-

deae (sensu Engler 1964) representing the current vegetation of Faiyum area, using light and scanning electron microscopy. This investigation aims to provide palynological information of all examined taxa, to cluster the taxa involved according to resemblance in pollen characters and to present an identification key based on pollen morphology adapted for use with archeobotanical material.

Materials and Methods

Pollen samples of 41 species representing 37 genera and 18 families had been collected from herbarium specimens kept in the Cairo University Herbarium (CAI) and fresh materials collected from the field (Table 1). All materials were taken from mature anthers of flowering buds. List of specimens investigated is in accordance with the system of Engler 1964; nomenclature of the taxa was updated according to Boulos (2009). Voucher specimens and pollen slides were kept in Cairo University Herbarium (CAI).

Pollen grains for light microscope (LM) and scanning electron microscope (SEM) were prepared by 10% KOH treatment and Erdtman's acetolysis method (Erdtman 1960). For light microscope, samples were dehydrated with ethanol series (60, 80 & 99.5%) after acetolysis method, then substituted with xylene; and were mounted in eukitt on the slide. Light microscopic observations were made by using Nikon Eclipse E 600, the pollen sizes were measured at 600 x magnification, and photographs of the samples taken at 400 x. As for scanning electron microscopic observations, samples were fixed and conductive coated with 2% Osmium tetroxide solution after acetolysis, then dehydrated with ethanol series (60, 80, and 99.5%) and substituted with xylene. The acetolyzed pollens were spattered with gold – palladium for about five minutes on the sample stand. Scanning electron microscope observations were made using JEOL JSM-6300F (the laboratory of International Research Center, Japan). The SEM images were taken at acceleration voltage of 3-4kv. Comparative analysis of pollen morphology and masurements of qualitative parameters of pollen grains as well as pollen preparations were done at the laboratory of International Research Center for Japanese Studies (Japan) and the Herbarium of Cairo University (Egypt).

All measurements are based on at least 15-20 pollen grains for each specimen, various pollen characters viz: shape, size, aperture type and exine

sculpture were determined. The terminology used follows Erdtman (1952), Praglowski & Punt (1973), Praglowski & Raj (1979) and Punt *et al.* (2007).

Results

The palynological data of the investigated taxa are summarized in Table (2). The examination of the available pollen materials revealed the presence of two groups based on pollen units:

A. Complex grains group: Pollen grains released in polyads, composed of 16 or 32 grains in regular arrangement. This group represented by a unique major pollen type known as Polyads type, which subdivided into two subtypes.
B. Single grains group: pollen grains released in monads, usually spheroidal or varied from prolate-spheroidal to prolate or suboblat. Six major pollen types can be distinguished based on the shape and number of apertures viz. triporate, tetra-hexa porate, pantoporate, panto-brevicolpate, tricolpate and tricolporate types. Among these major types, 16 pollen subtypes were recognized based on the exine sculpture, pollen shape and size and other pollen characters.

TABLE (1). Collection data of the investigated taxa arranged in accordance with the system of Engler 1964 (arranged alphabetical).

Family	Examined taxa	Locality
Aizoaceae	*Mesembryanthemum crystallinum* L.	Burg el Arab, Mariut; 22/3/1956; *I. El Sayed* s.n. (CAI).
Amaranthaceae	*Alternanthera sessilis* (L.) DC.	Wadi El Rayan; 15/4/2000; *Boulos* s.n.(CAI).
	Amaranthus graecizans L.	Tamiya District, Kafr Mahfous; 12/11/1982; *Abd El Ghani* 4423(CAI).
Capparaceae	*Capparies decidus* (Forssk.) Edgew.	Wadi El Allagi (upstream part); 25/1/1963; *Täckholm et al*. s.n.(CAI).
Caryophyllaceae	*Silene rubella* L.	Near Qarun lake; 29/2/1988; *E. Shamso* s.n.(CAI).
	Spergularia marina (L.) Bessler	Faiyum; 29/4/1979; *A. Hosny* s.n.(CAI)
	Vaccaria hispanica (Mill.) Rauschert	Faiyum; 12/1/1952; *El Hadidi* s.n.(CAI).
Chenopodiaceae	*Arthrocnemum macrostachym* (Moric.) K. Koch.	In the salt marshes near Lake Quroun, Faiyum; 6/12/1965; *Botany Depart. Excursion* s.n.(CAI).
	Beta vulgaris L.	Kom Aushim, Faiyum; 18/3/1977; *Täckholm et al.* s.n.(CAI).
	Chenopodium album L.	Faiyum; 12/1/1959; *A. Amin* s.n.(CAI).
	Suaeda aegyptiaca (Hasselq.) Zohary	8 km from Faiyum on the Lahun-Faiyum road; 6/10/1967; *Täckholm et al*. s.n.(CAI).
Cruciferae	*Brassica nigra* (L.) Koch	Faiyum; Kom Aushim; 4/3/1962; *Täckholm et al.* s.n.(CAI).
	Sinapis arvensis L.	Faiyum; Kom Aushim; *Täckholm et al.* s.n.(CAI).
Fumariaceae	*Fumaria bracteosa* Pomel	Ikingi Marut; 3/4/1977; *Kosinova et al.* s.n.(CAI).

Leguminoseae	*Acacia nilotica* (L.) Delil.	Nag El –Ismailia, Ballana; 22/12/1963; *Boulos* s.n. (CAI).
	Alhagi graecorum Boiss.	Beheira province, Abu Hummus; 24/11/1987; *Amer* s.n.(CAI).
	Faidherbia albida (Delil.) A. Chev.	River bank, Khartum, Sudan; 9/12/1954; Unknown (CAI).
	Lathyrus hirsutus L.	Sennuris, Faiyum; 5/5/1967; *El Hadidi* s.n.(CAI).
	Lotus halophilus Boiss. & Spruner	Beheira province, Idku; 29/4/1987; *Amer* s.n.(CAI).
	Lotus pusillus Viv.	25 km W of Syrte; 8/3/1968; Boulos s.n.(CAI).
	Medicago intertexta (L.) Mill.	Faiyum; 11/1/1972; *I El Sayed* s.n.(CAI).
	Melilotus indicus	Behiera Province, Kom Hamada; 17/1/1987; *Amer* s.n.(CAI).
	Sesbania sesban (L.) Merr.	Khour Rl Mlagi; 21/3/1962; *Abdalla et al*. s.n.(CAI).
	Trifolium resupinatum L.	Baharia Oasis, El Heig Aui Heg; 13/9/1971; *M. Iwan* s.n.(CAI).
	Vicia monantha Retz.	Kharga & Dakhla Oasis, Dakhla: Mut; 13/2/1952; *Täckholm & Kassas* s.n.(CAI).
Malvaceae	*Malva parviflora* L.	Faiyum; 4-1-1991; *Araffa* s.n.(CAI).
Oxalidaceae	*Oxalis corniculata* L.	Bawiti, Ain Miftilla, in a date palm grove; 17/7/1978; *Abd El Ghani* s.n.(CAI).
Polygonaceae	*Emex spinosa* (L.) Campd	El Faiyum; 31/1/1975; *Hossny et.al* s.n.(CAI).
	Persicaria salicifolia (Brouss. Ex Willd.) Assenov	Samouh cultivations behind Nuzha Gardens, Alexandria; 23/3/1956; *Täckholm & El Hadidi* s.n.(CAI).
	Polygonum equsetiforme Sm.	Qouran lake, El Faiyum; 24/4/1972; *Zahran* s.n.(CAI).
	Rumex dentatus L.	Ali Bey SW of Madinet El Faiyum; 21/11/1926; G. *Täckholm* s.n.(CAI).
	Rumex pectus Forssk.	Cairo-Alexandria desert road; 8/3/1978; *A. Soliman* s.n.(CAI).
Portulacaceae	*Portulaca oleracea* L.	Near Qarun lake; 29/2/1988; *E. Shamso* s.n.(CAI).
Salicaceae	*Salixmucronata* Thunb.	Zohria Garden; 15/1/1959; Hefnawy s.n.(CAI).
Salvadoraceae	*Salvadora persica* L.	Wadi El Balie, Hurghda district; 5/9/1960; *Täckholm et al*.s.n.(CAI).
Tamaricaceae	*Tamarix nilotica* (Ehrenb.) Bunge	Kom Aushim, Faiyum; 21/9/1959; *Täckholm* s.n.(CAI).
	Tamarix tetragyna Ehrenb.	Kom Aushim, Faiyum; 11/3/1987; *E. Shamso* s.n.(CAI).
Thymelaeaceae	*Thymelaea hirsute* (L.) Endl.	Mariut, N of Amria station; 25/3/1927; *G. Täckholm* s.n.(CAI).
Urticaceae	*Urtica urens* L.	Beheira Province, Damanhour; 6/3/1988; *Amer* s.n.(CAI).
Zygophyllaceae	*Fagonia Arabica* L.	Faiyum; 11/3/1987; *E. Shamso* s.n.(CAI).
	Zygophyllum coccineum L.	El Faiyum; 11/5/1973; *Sisi* et al. (CAI).

Description of Pollen types

A. Complex grains group

1. *Polyads type:*

Polyads biconvex and circular to slightly elliptic in outline, medium to large, mean polar axis ranges from 24.8-47.3Pm and mean equatorial diameter ranges from 39.4-101.9 Pm; composed of 16 or 32 grains in a regular arrangement. The pollen grains are heteropolar, pyramidal or polygonal, colporate or indistinct aperture, exine sculpture foveolate or subrugulate. This type can be divided into two subtypes as follow:

TABLE (2). The pollen morphological characters of the examined taxa of subclass Archichlamydeae (values in parentheses represent average lengths).

Family	Taxa	Polar axis P (-m)	Equatorial axis E (-m)	P/E ratio	Shape in Equatorial view	Shape in Polar view	Aperture type	Colpus shape	Ora shape	Exine sculpture Pattern
Aizoaceae	*Mesembryanthemum crystallinum*	19.2 – 21.7 (21.1±0.8)	18.4 – 21.7 (19.5±0.9)	0.96-1.18 (1.08±0.06)	Spheroidal or subprolate	Circular	Tricolporate	Narrowly oblong	Sunken & Lolongate	Micro-perforate-granulate
Amaranthaceae	*Alternanthera sessilis*	13.4-16.7 (14.6±1.0)	13.4-16.7 (14.6±1.0)	1.00	Spheroidal	Octagonl	Pantoporate	---	Flat & Circular	Metareticulate (Fenestrate)
	Amaranthus graecizans	18.4-23.4 (20.0±1.0)	18.4-23.4 (20.0±1.0)	1.00	Spheroidal	Circular	Pantoporate	---	Sunken, Circular & operculate	Granulate to granulate with faint perforate
Capparaceae	*Capparies decidus*	15.0-20.9 (18.8±1.4)	13.4-17.5 (15.8±1.1)	0.90-1.39 (1.19±0.90)	Spheroidal subprolate or prolate	Circular	Tricolporate	Fusiform	Flat & Lolongate	Perforate
Caryophyllaceae	*Silene rubella*	31.7-34.5 (34.5±0.2)	31.7-34.5 (34.5±0.2)	1.00	Spheroidal	Circular	Pantoporate	---	±Sunken, Circular & operculate	Microechinate-anulopunctate
	Spergularia marina	15.9-21.7 (18.7±1.4)	17.5-23.4 (19.9±1.6)	0.85-1.09 (0.94±0.06)	Suboblate or Spheroidal	Circular	Tricolpate	Oblong	---	Microechinate-perforate
	Vaccaria hispanica	35.1-40.9 (38.3±1.3)	35.1-40.9 (38.3±1.3)	1.00	Spheroidal	Circular	Pantoporate	---	±Sunken, Circular & operculate	Microechinate-anulopunctate
Chenopodiaceae	*Arthrocnemum macrostachym*	20.0-23.4 (21.0±0.9)	20.0-23.4 (21.0±0.9)	1.00	Spheroidal	Circular	Pantoporate	---	Sunken, Circular & operculate	Granulate – psilate
	Beta vulgaris	16.7-20.9 (18.6±1.1)	16.7-20.9 (18.6±1.1)	1.00	Spheroidal	Circular	Pantoporate	---	Sunken, Circular & operculate	Granulate – psilate
	Chenopodium album	21.7-30.1 (23.8±2.0)	21.7-30.1 (23.8±2.0)	1.00	Spheroidal	Circular	Pantoporate	---	Sunken, Circular & operculate	Granulate – psilate
	Suaeda aegyptiaca	21.7-26.7 (24.5±1.3)	21.7-26.7 (24.5±1.3)	1.00	Spheroidal	Circular	Pantoporate	---	Sunken, Circular & operculate	Granulate – psilate
Cruciferae	*Brassica nigra*	21.7-25.1 (23.6±1.4)	21.7-26.1 (23.7±1.2)	0.93-1.2 (1.00±0.06)	Spheroidal	Obtusely triangular	tricolpate	Fusiform	---	Reticulate with free standing columellae in lumina

	Sinapis arvensis	21.7-26.7 (23.9±1.1)	23.4-28.4 (26.5±1.2)	0.82-1.00 (0.9±0.04)	Oblate-sheroidal or suboblate	Obtusely triangular	Tricolpate	Fusiform	---	Reticulate with free standing columellae in lumina
Fumariaceae	*Fumaria bracteosa*	21.7 - 26.7 (24.9±1.3)	21.7 - 26.7 (24.9±1.3)	1.00	Sheroidal	Circular	Tetra- to hexa-porate	---	Raised, circular & aspidate	Verrucate - perforate
Leguminosae	*Acacia nilotica*	23.4-26.7 (24.8±0.7)	36.7-43 (39.4±1.7)	0.58-0.68 (0.63±0.03)	Oblate	Circular	Colporate	Y-shaped	indistinct	foveolate
	Alhagi graecorum	15.0-20.0 (16.5±1.3)	13.4-15.9 (14.1±0.8)	1.00-1.50 (1.18±0.10)	Prolate-spheroidal, subprolate or prolate	Sub-circular	Tricolporate	Slightly fusiform	Raised & lolongate	Microreticulate
	Faidherbia albida	4.18-51.8 (47.3±4.1)	91.9-115.2 (101.9±6.4)	0.42-0.53 (0.47±0.04)	Prolate or oblate	Circular or ellipsoidal	indistincate	---	---	Subrugulate
	Lathyrus hirsutus	31.7-41.8 (37.6±2.1)	22.5-30.1 (26.3±1.4)	1.22-1.64 (1.51±0.11)	Subprolate or Prolate	Obtusely triangular	Tricolporate	Narrowly oblong	Flat & lolongate	Faint rugulate
	Lotus halophilus	15.0-18.4 (16.8±0.8)	10.0-12.5 (11.6±0.6)	1.33-1.57 (1.44±0.06)	Prolate	Circular	Tricolporate	Slit-like	Flat & lolongate	Rugulate-fossulate
	Lotus pusillus	14.2-18.4 (16.1±1.0)	10.0-12.5 (11.1±0.7)	1.29-1.58 (1.44±0.07)	Prolate	Circular	Tricolporate	Slit-like	Flat & lolongate	Rugulate-fossulate
	Medicago intertexta	26.7-32.6 (28.8±1.4)	25.1-31.7 (27.9±1.6)	0.94-1.13 (1.03±0.05)	Spheroidal	Sub-circular	Tricolporate	Narrowly oblong	Flat & lolongate	Rugulate-fossulate
	Melilotus indicus	20.9-26.7 (24.2±1.3)	16.7-21.7 (18.4±1.4)	1.17-1.50 (1.32±0.08)	Subprolate or Prolate	Sub-circular	Tricolporate	Slightly fusiform	Raised &lolongate	Microreticulate
	Sesbania sesban	23.4-26.7 (24.2±1.0)	21.7-26.7 (24.7±1.4)	0.91-1.14 (0.98±0.06)	Spheroidal	Sub-circular	Tricolporate	fusiform	Raised &lolongate	Perforate
	Trifolium resupinatum	25.1-28.4 (26.3±0.9)	19.2-23.4 (20.6±1.0)	1.15-1.39 (1.28±0.06)	Subprolate or Prolate	Sub-circular	Tricolporate	Narrowly oblong	±Raised & lolongate	Reticulate-fossulate
	Vicia monantha	31.7-36.7 (34.1±1.4)	20.0-23.4 (22.1±0.9)	1.36-1.79 (1.54±0.11)	Prolate or perprolate	Sub-circular	Tricolporate	Narrowly oblong	±Raised & lolongate	Reticulate-rugulate
Malvaceae	*Malva parviflora*	75.2-85.2 (80.3±3.0)	75.2-85.2 (80.3±3.0)	1.00	Spheroidal	Circular	Pantoporate	---	Flat & circular	Sharp echinate & perforate
Oxalidaceae	*Oxalis corniculata*	23.4-36.7 (31.1±2.5)	26.7-36.7 (32.7±2.1)	0.88-1.05 (0.95±0.05)	Spheroidal	Circular	Tricolpate	fusiform	---	Microreticulate to perforate
Polygonaceae	*Emex spinosa*	21.7-26.7 (24.6±1.2)	25.1-28.4 (26.4±1.2)	0.87-1.10 (0.94±0.04)	Suboblate or spheroidal	Circular	Tricolporate	Very short & fusiform	Sunken & lolongate	Fossulate-perforate with granules

	Persicaria salicifolia	36.7-51.8 (45.8±3.8)	36.7-51.8 (45.8±3.8)	1.00	Spheroidal	Circular	Pantoporate	---	Sunken & circular	Lopho-reticulate
	Polygonum equsetiforme	28.4-33.4 (30.0±1.2)	21.7-25.9 (23.2±0.9)	1.20-1.43 (1.31±0.05)	Subprolate or Prolate	Sub-circular	Tricolporate	oblong	Sunken & lolongate	Microperforate with granules
	Rumex dentatus	21.7-26.7 (24.1±1.3)	25.1-28.4 (26.2±1.3)	0.87-1.07 (0.93±0.05)	Suboblate or oblate-spheroidal	Circular	Tricolporate	Slit-like	Sunken & lolongate	Fossulate-perforate with granules
	Rumex pectus	18.4-21.7 (20.4±0.8)	20.0-23.4 (21.3±0.9)	0.86-1.00 (0.96±0.04)	Suboblate or oblate-spheroidal	Sub-circular	Tricolporate	Slit-like	Sunken & lolongate	Fossulate-perforate with granules
Portulacaceae	*Portulaca oleracea*	48.2-58.5 (53.6±3.2)	48.2-58.5 (53.6±3.2)	1.00	Spheroidal	Circular	Pantocolpate	Slightly fusiform	---	Microechinate - anulopunctate
Salicaceae	*Salix mucronata*	16.7-23.4 (20.8±1.6)	15.0-20.0 (17.1±1.4)	1.09-1.47 (1.22±0.12)	Spheroidal, or prolate	Obtusely triangular	Tricolporate	Fusiform	Sunken & circular	Uneven reticulate with columellae in lumina
Salvadoraceae	*Salvadora persica*	10.9-15.6 (12.9±1.3)	10.9-10.0 (12.6±1.2)	0.88-1.21 (1.02±0.08)	Spheroidal or subprolate	Obtusely triangular	Tricolporate	Widely oblong	Sunken & lalongate	perforate
Tamaricaceae	*Tamarix nilotica*	13.4-16.4 (14.2±0.9)	13.4-16.7 (14.6±0.9)	0.89-1.15 (0.97±0.08)	Spheroidal or subprolate	Obtusely triangular	Tricolpate	fusiform	---	microreticulate
	Tamarix tetragyna	15.0-18.4 (16.9±0.9)	15.0-19.2 (16.8±1.1)	0.91-1.22 (1.00±0.08)	Spheroidal or subprolate	Obtusely triangular	Tricolpate	fusiform	---	microreticulate
Thymelaeaceae	*Thymelaea hirsute*	21.7-25.1 (22.7±1.1)	21.7-25.1 (22.7±1.1)	1.00	Spheroidal	Circular	Pantoporate	---	Sunken & circular	Croton pattern
Urticaceae	*Urtica urine*	11.7-14.2 (13.4±1.1)	11.7-16.7 (14.7±1.3)	0.84-1.00 (0.91±0.05)	Suboblate or oblate-spheroidal	Circular	Triporate	---	Sunken, annulate & operculate	Densely spaced microechinate
Zygophyllaceae	*Fagonia arabica*	15.0-20.9 (17.8±1.6)	13.4-18.4 (16.3±1.3)	0.95-1.33 (1.10±0.08)	Spheroidal or subprolate	Circular	Tricolporate	Fusiform	Flat & lalongate	Microreticulate
	Zygophyllum coccineum	9.2-10.0 (9.9±0.3)	9.0-10.2 (9.9±0.9)	0.92-1.20 (1.02±0.6)	Spheroidal or subprolate	Circular	Tricolporate	Fusiform	Flat & lalongate	Microreticulate

1a. Acacia subtype

Polyads circular, medium sized (23.4-26.7 Pm x 36.7-43.4 Pm), composed of 16 grains. Eight grains in the centre, placed in two planes, each plane four grains surrounded by eight peripheral grains. Pollen grains colporate, colpi Y-shaped. Exine sculpture foveolate. (Plate 1)

Examined taxa: *Acacia nilotica* (L.) Delile

1b. Faidherbia subtype

Polyads slightly elliptic, large in size (41.8-51.8 Pm x 91.9-115.2 Pm), composed of 32 grains. 16 grains in the centre, placed in two planes, each plane eight grains surrounded by 16 peripheral grains. Pollen grains with indistinct aperture. Exine sculpture subrugulate. (Plate 2).

Examined taxa: *Faidherbia albida* (Delile) A. Chev.

B. Single grains group

2. *Triporate pollen type*

Pollen grains small in size with mean polar axis 13.4 ±1.1 Pm and mean equatorial diameter 14.7 ±1.3 Pm, suboblate or oblate spheroidal in equatorial view, circular in polar view. Grains triporate, pores circular, sunken, annulate with microechinate operculum. Exine sculpture tectate, tectum densely spaced microechinate. This type characterized to Urticaceae (*Urtica urnes* L.), (Plate 3).

3. *Tetra- Hexaporate pollen type*

Pollen grains small in size with mean dimension 24.9 ±1.3Pm, spheroidal and circular in all views. Grains tetra to hexaporate, pores circular, raised, aspidate, with psilate and membranous-like operculum. Exine sculpture tectate, tectum verrucate with faint perforate. This type characterized to Fumariaceae (*Fumaria bracteosa* Pomel), (Plate 4)

4. *Pantoporate pollen type*

Pollen grains ranged in its size from small (13.4-25.1Pm in diameter) to medium (31.7-51.8Pm in diameter) or relatively large in size (75.2-85.2Pm in diameter), spheroidal and circular in all views, sometimes octagonal (in genus *Alternanthera*). Grains Pantoporate, pores ranged from 12 to many porate, circular in outline, flat or sunken, operculate or not operculate. Exine sculpture tectate to semitectate or intectate, tectum different patterns. This type represented by six pollen subtypes as follow:

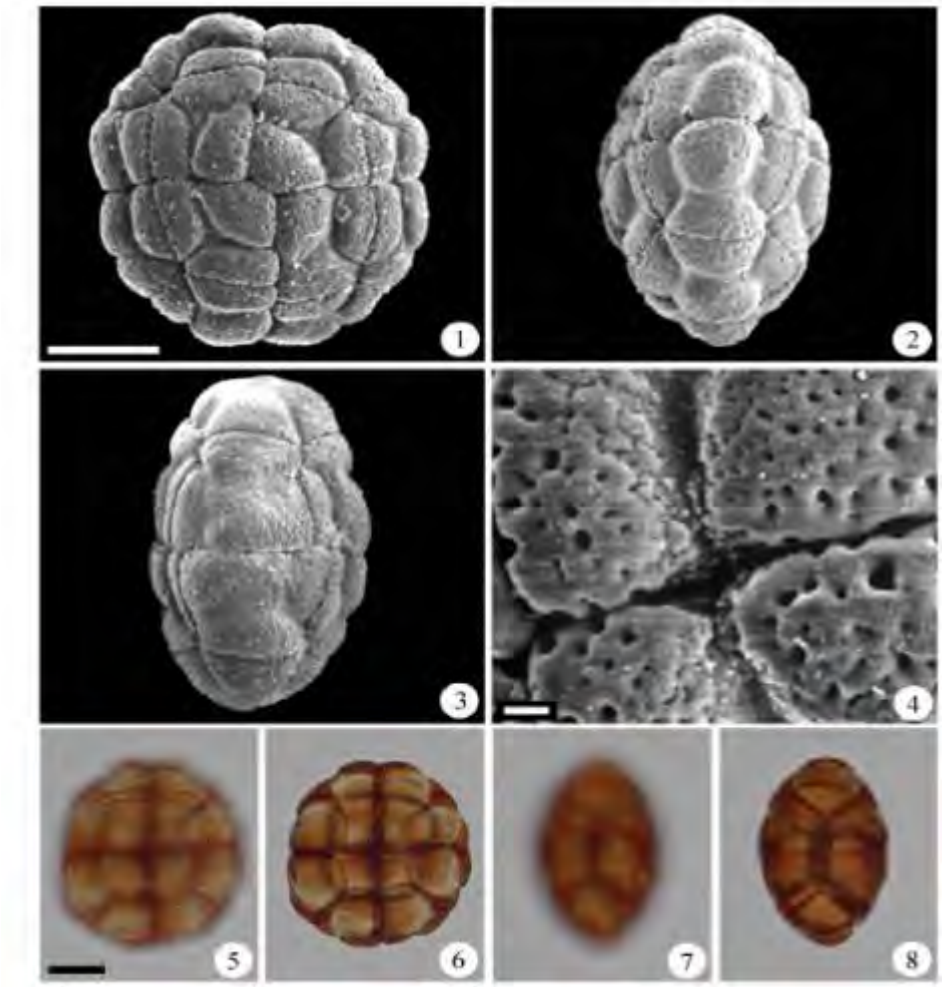


Plate (1). Polyads pollen type (*Acacia* pollen subtype)
***Acacia nilotica* (L.) Delile (Leguminosae)**

1. SEM micrographs showing polyad in polar view, circular with 16 grains and Y-shaped colpi (scale bar = 10Pm)
2-3. SEM micrographs showing polyad in equatorial view, oblate (scale bar = 10Pm).
4. SEM micrographs showing foveolate sculpture (scale bar = 1Pm).
5-6. LM micrographs showing polyad in polar view (scale bar = 10Pm).
7-8. LM micrographs showing polyad in equatorial view (scale bar = 10Pm).

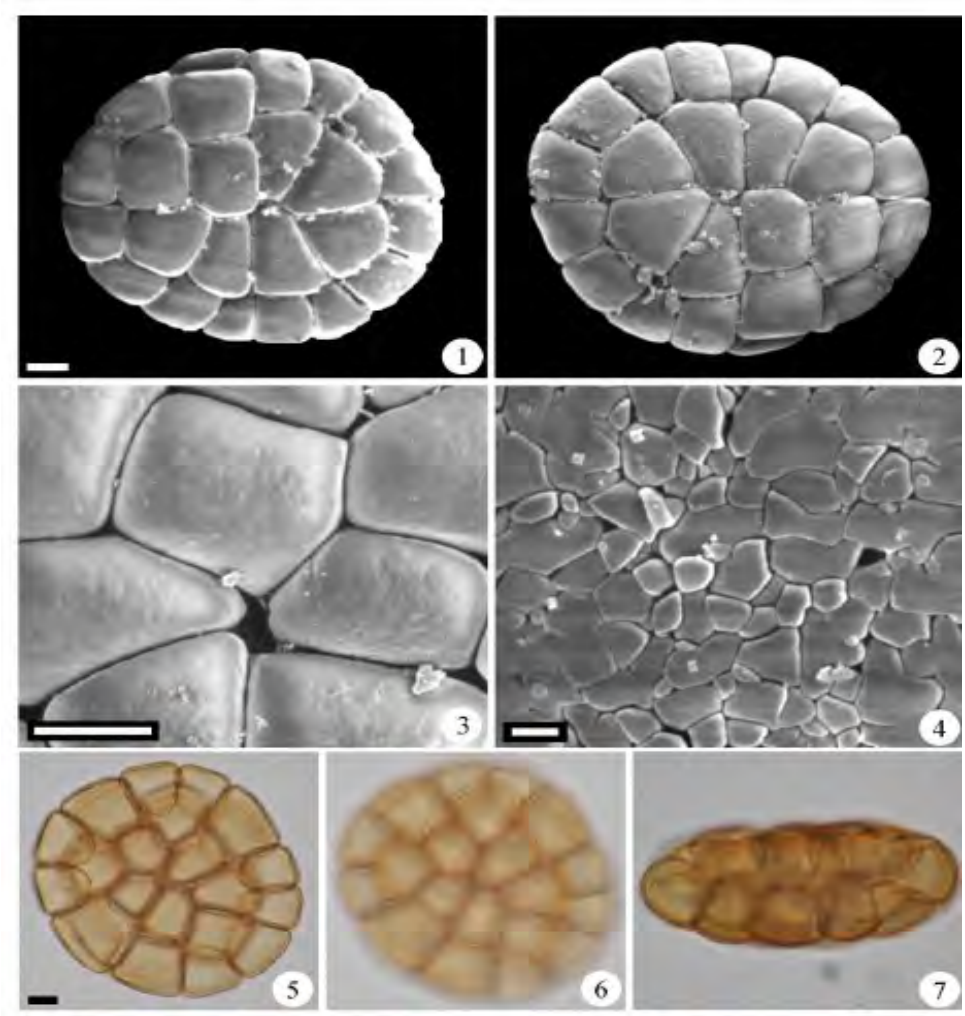


Plate (2). Polyads pollen type (*Faidherbia* pollen subtype)
***Faidherbia albida* (Delile) A.Chev. (Leguminosae)**

1-2. SEM micrographs showing polyad in polar view, ellipsoidal with 32 grains (scale bar = 10Pm)
3. SEM micrographs showing exine sculpture (scale bar = 10Pm).
4. SEM micrographs showing subrugulate sculpture (scale bar = 1Pm).
5-6. LM micrographs showing polyad in polar view (scale bar = 10Pm).
7. LM micrographs showing polyad in equatorial view (scale bar = 10Pm).

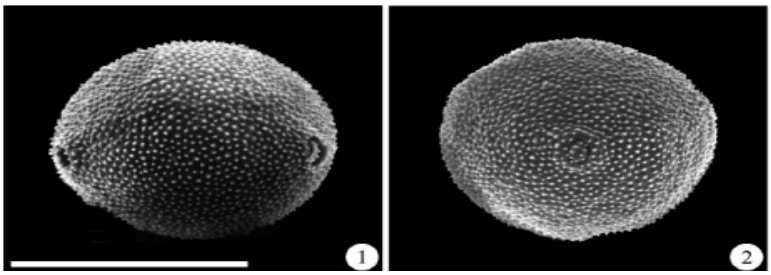


Plate (3). Triporate pollen type
***Urtica urens* L. (Urticaceae)**

1-2. SEM micrographs showing pollen in equatorial view oblate-spheroidal or suboblate, pore sunken, annulate with microechinate operculum, densely spaced microechinate sculpture (scale bar = 10Pm).

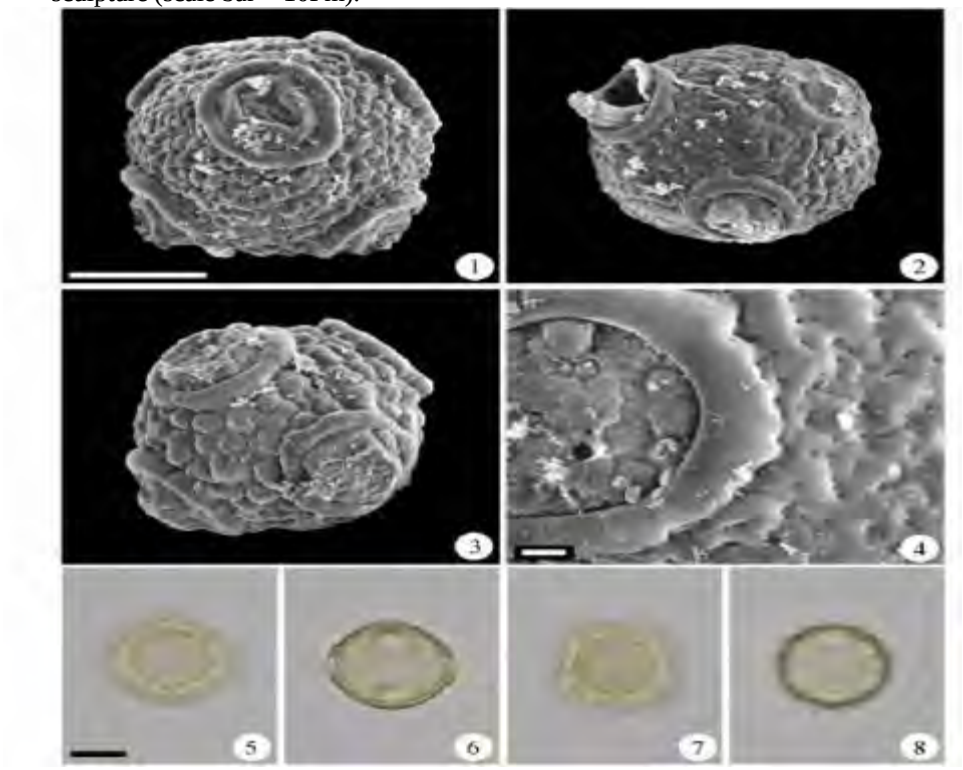


Plate (4): Tetra- Hexaporate pollen type
***Fumaria bracteosa* Pomel (Fumariaceae)**

1-3. SEM micrographs showing pollen overall view spheroidal (scale bar = 10Pm)

4. SEM micrographs showing verrucate with faint perforate sculpture, pores raised, aspidate and operculate (scale bar = 1Pm).

5-8. LM micrographs showing pollen overall view (scale bar = 10Pm).

4a. Persicaria pollen subtype:

Pollen grains medium sized, mean dimension 45.8 ±3.8Pm, pores many porate, sunken, filled the lumen of reticulum, not operculate. Exine sculpture semitectate, tectum lophoreticulate pattern, lophae with ±regular mural pattern, lumina polygonal with free standing columellae. This pollen subtype characterized to genus *Persicaria* (*P. salicifolia* (Brouss.ex Willd.) Assenov.), (Plate 5).

4b. Malvaceae pollen subtype

Pollen grains large in size, mean dimension 80.3 ±3.0Pm, pores many, flat, not operculate. Exine sculpture intectate, sharp echinate and interspinal area perforate, perforation densely spaced and uneven. This pollen subtype characterized to Malvaceae (*Malva parviflora* L.), (Plate 6).

4c. Silene-Vaccaria pollen subtype

Pollen grains medium sized, mean dimension 34.5 ±0.2 – 38.3 ±1.3Pm. Pores 12-many porate, ±sunken, operculate, operculum with 5-6 spinules. Exine sculpture tectate, tectum microechinate with sparsely spaced and even anulopunctate. This type characterized to genus *Silene* and genus *Vaccaria* (*Silene rubella* L. & *Vaccaria hispanica* (Mill.) Rauschert), (Plate 7).

4d. Thymelaeaceae pollen subtype

Pollen grains small sized, mean dimension 22.7 ±1.1Pm. Pores many porate, sunken and not operculate. Exine sculpture intectate, croton pattern. This pollen subtype characterized to Thymelaeaceae (*Thymelaea hirsute* (L.) Endl.), (Plate 8).

4e. Alternanthera pollen subtype

Pollen grains small sized, mean dimension 14.6 ±1.0Pm, octagonal in all views. Pores 12, each filled the lumen of reticulum, ± flat with striate membrane. Exine sculpture semitectate, metareticulate (fenestrate) pattern, reticulum with regular mural pattern, muri microechinate and faintly perforate. This pollen subtype characterized to genus *Alternanthera* (*A. sessilis* (L.)DC.), (Plate 9).

4f. Amaranthus-Chenopodiaceae pollen subtype

Pollen grains small sized, mean dimension 18.6 ±1.1 – 24.5 ±1.3Pm. Pores many, sunken, operculate, operculum with many coarsely granules. Exine sculpture granulate – psilate to granulate – faint perforate. This pollen subtype characterized to genus *Amaranthus* and Family Chenopodiaceae (*Amaranthus graecizans* L., *Arthrocnemum macrostachyum* (Moric.)K. Koch, *Beta vulgaris* L., *Chenopodium album* L. & *Suaeda aegyptiaca* (Hasselq.) Zohary, (Plate 10)

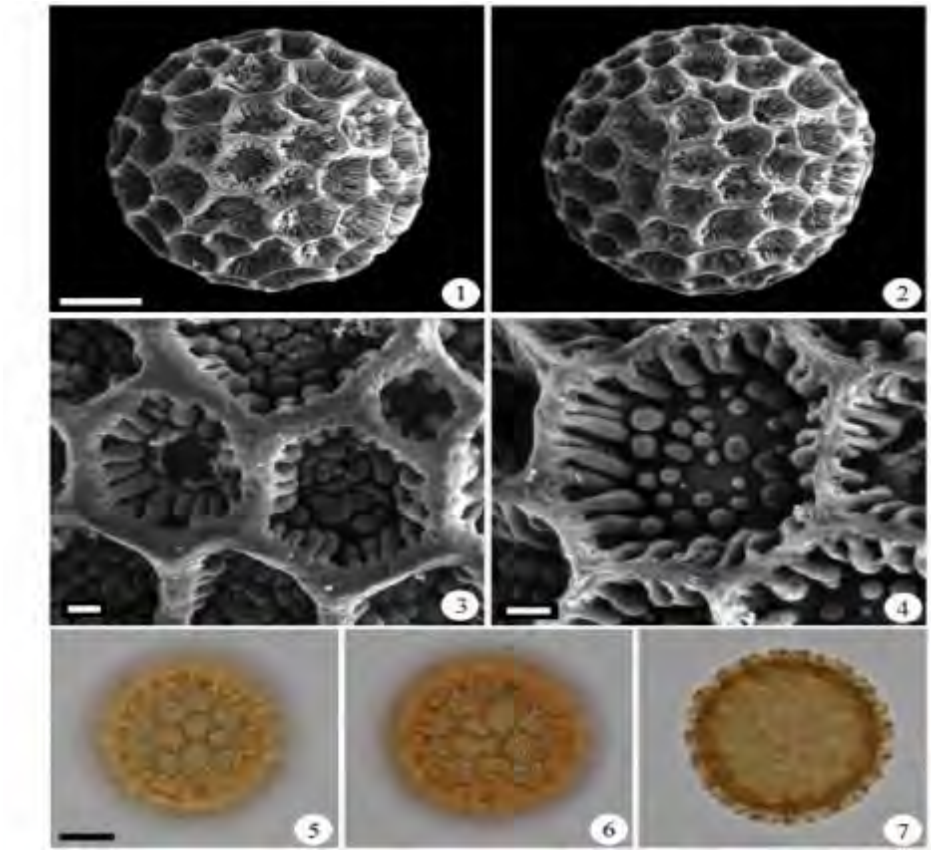


Plate (5). Pantoporate pollen type (*Persicaria* pollen subtype)
***Persicaria salicifolia* (Brouss. ex Willd.) Assenov (Polygonaceae)**

1-2. SEM micrographs showing pollen overall view spheroidal, many porate (scale bar = 10Pm)
3. SEM micrographs showing lophoreticulate pattern sculpture, pores sunken and filled the lumen of reticulum (scale bar = 1Pm).
4. SEM micrographs showing lumina polygonal with free standing collumellae (scale bar = 1Pm).
5-7. LM micrographs showing pollen overall view (scale bar = 10Pm).

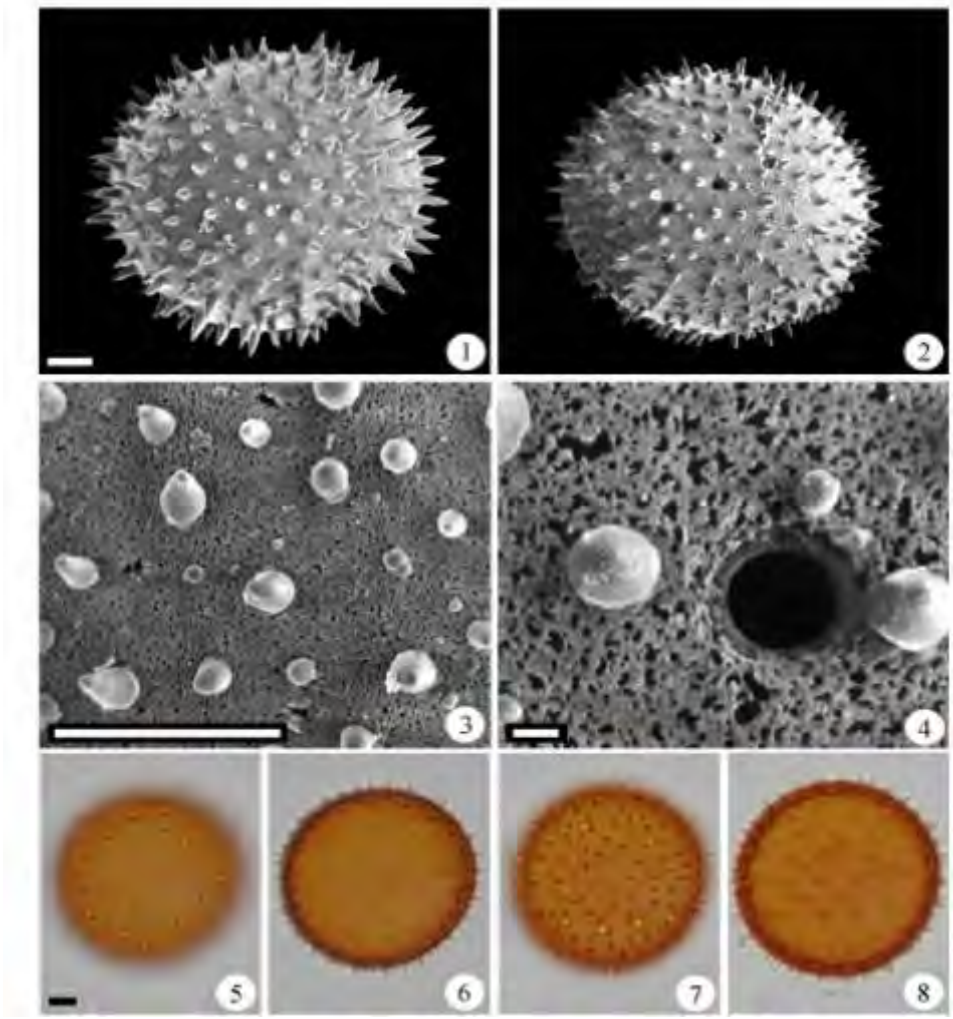


Plate (6). Pantoporate pollen type (Malvaceae pollen subtype)
***Malva parviflora* L. (Malvaceae)**

1-2. SEM micrographs showing pollen overall view spheroidal, many porate (scale bar = 10Pm)
3. SEM micrographs showing sharp echinate-perforate sculpture (scale bar = 10Pm).
4. SEM micrographs showing perforation densely spaced and uneven, pores flat and not operculate (scale bar = 1Pm).
5-8. LM micrographs showing pollen overall view (scale bar = 10Pm).

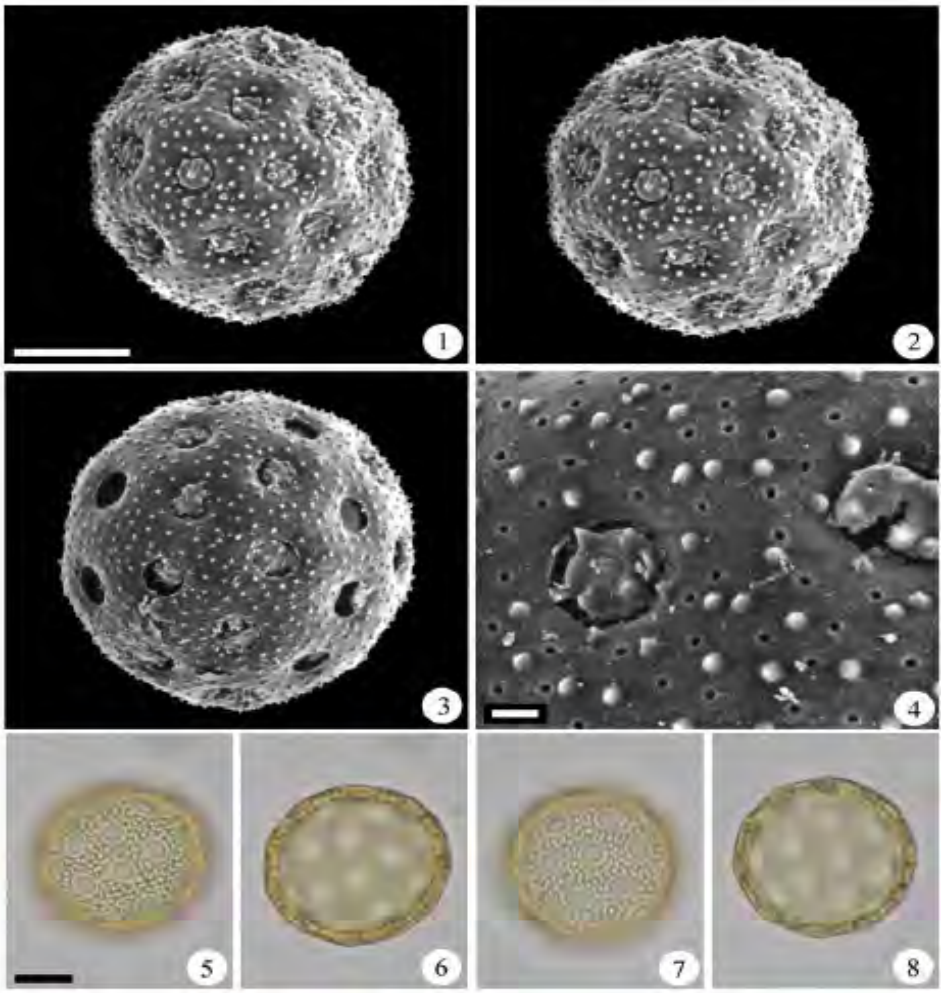


Plate (7). Pantoporate pollen type (*Silene-Vaccaria* pollen subtype)
***Silene rubella* L. (Caryophyllaceae)**

1-3. SEM micrographs showing pollen circular in all views with many porate, pores sunken and operculate, operculum with 5-6 spinules (scale bar = 10Pm).
4. SEM micrographs showing microechinate with anulopunctate sculpture (scale bar = 1Pm)
5-8. LM micrographs, (overall view), scale bar = 10Pm

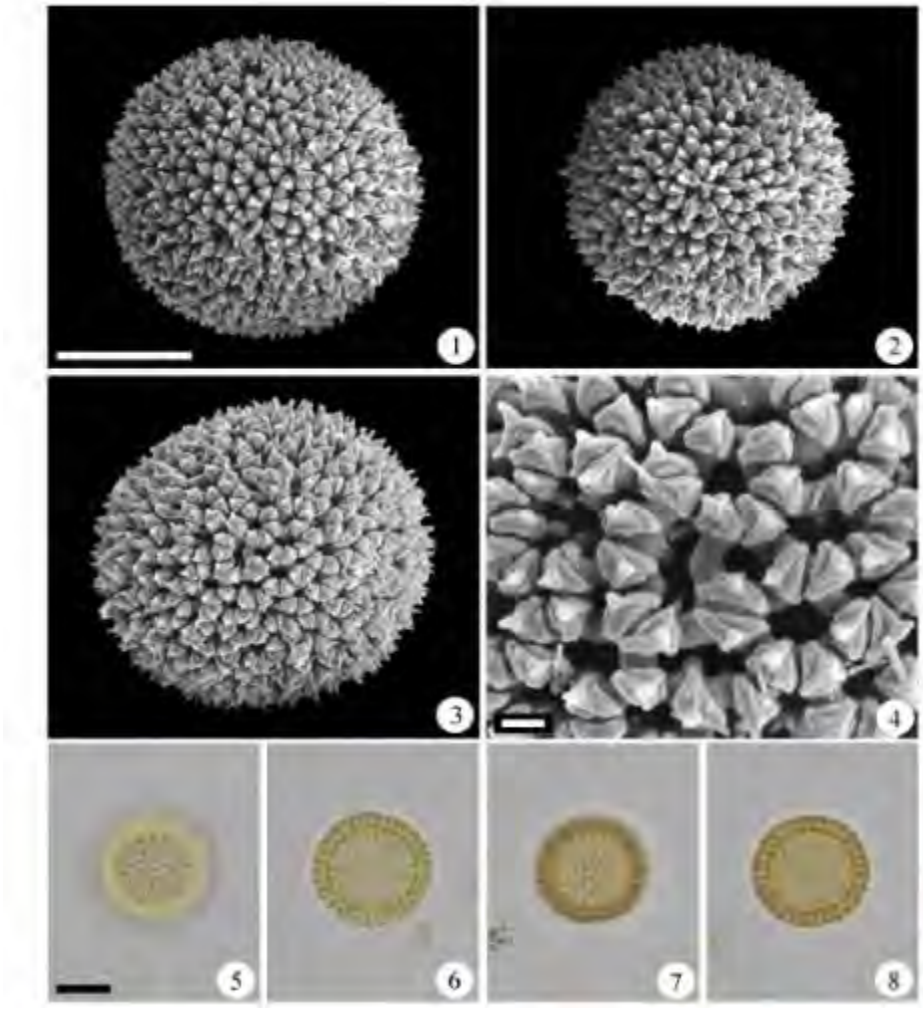


Plate (8). Pantoporate pollen type (Thymelaeaceae pollen subtype)
***Thymelaea hirsute* (L.) Endl. (Thymelaeaceae)**

1-3. SEM micrographs showing pollen overall view spheroidal, (scale bar = 10Pm)
4. SEM micrographs showing microechinate croton pattern sculpture (scale bar = 1Pm).
5-8. LM micrographs showing pollen overall view (scale bar = 10Pm).

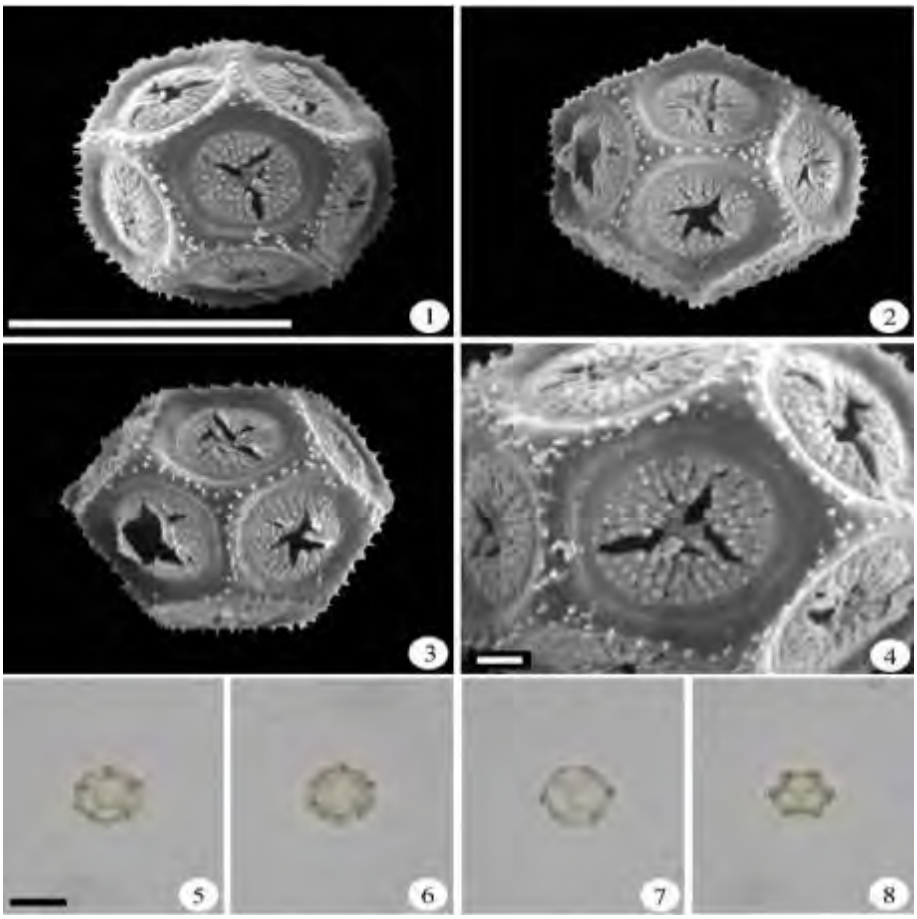


Plate (9). Pantoporate pollen type (*Alternanthera* pollen subtype)
***Alternanthera sessilis* (L.) DC. (Amaranthaceae)**

1-3. SEM micrographs showing pollen octagonal in all views with 12 porate, pores flat and striate membrane (scale bar = 10Pm).
4. SEM micrographs showing Metareticulate sculpture (scale bar = 1Pm).
5-8. LM micrographs, (overall view), scale bar = 10Pm

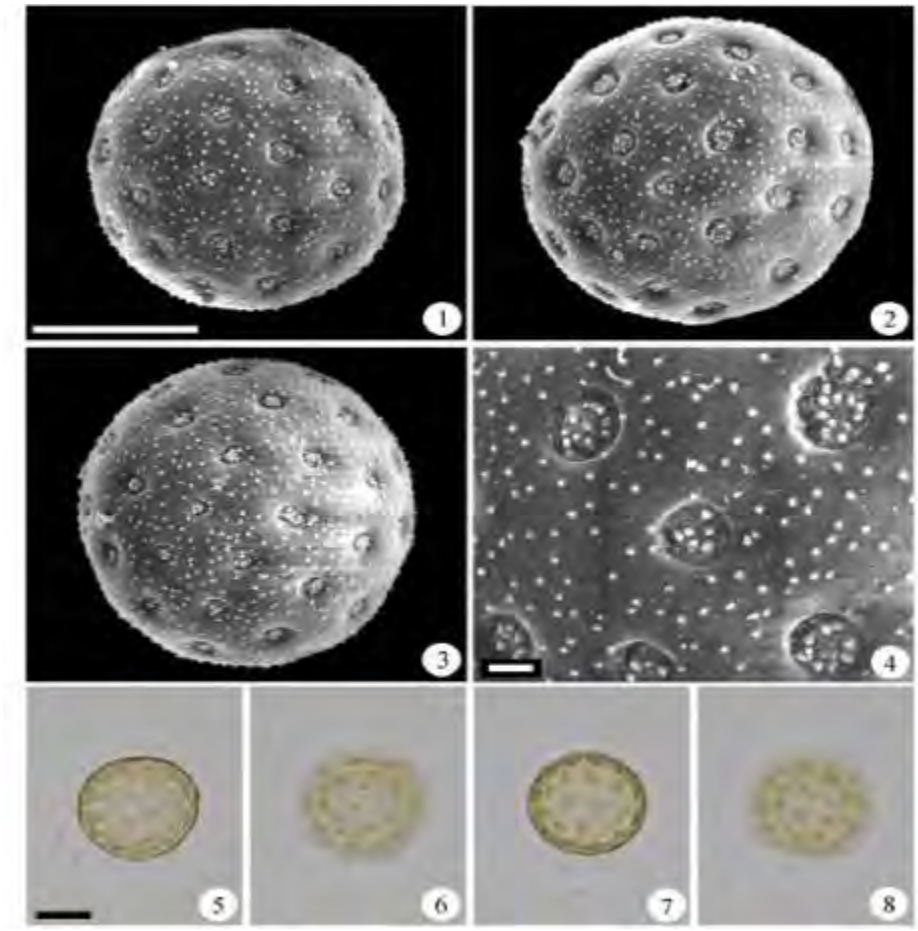


Plate (10). Pantoporate pollen type (*Amaranthus-chenopodiaceae* pollen subtype)
***Chenopodium album* L. (Chenopodiaceae)**

1-3. SEM micrographs showing circular in all views with many porate, pores sunken and operculate, operculum with many granules (scale bar = 10Pm).
4. SEM micrographs showing granulate - psilate sculpture (scale bar = 1Pm)
5-8. LM micrographs, (overall view), scale bar = 10Pm

5. Pantobrevicolpate pollen type

Pollen grains relatively large in size, mean dimension 53.6 ±3.2Pm, spheroidal and circular in all views. Grains pantobrevicolpate, colpi short, fusiform. Exine sculpture tectate, tectum microechinate with sharp anulopunctate (perforation densely spaced and even). This type characterized to Portulacaceae (*Portulaca oleracea* L.), (Plate 11).

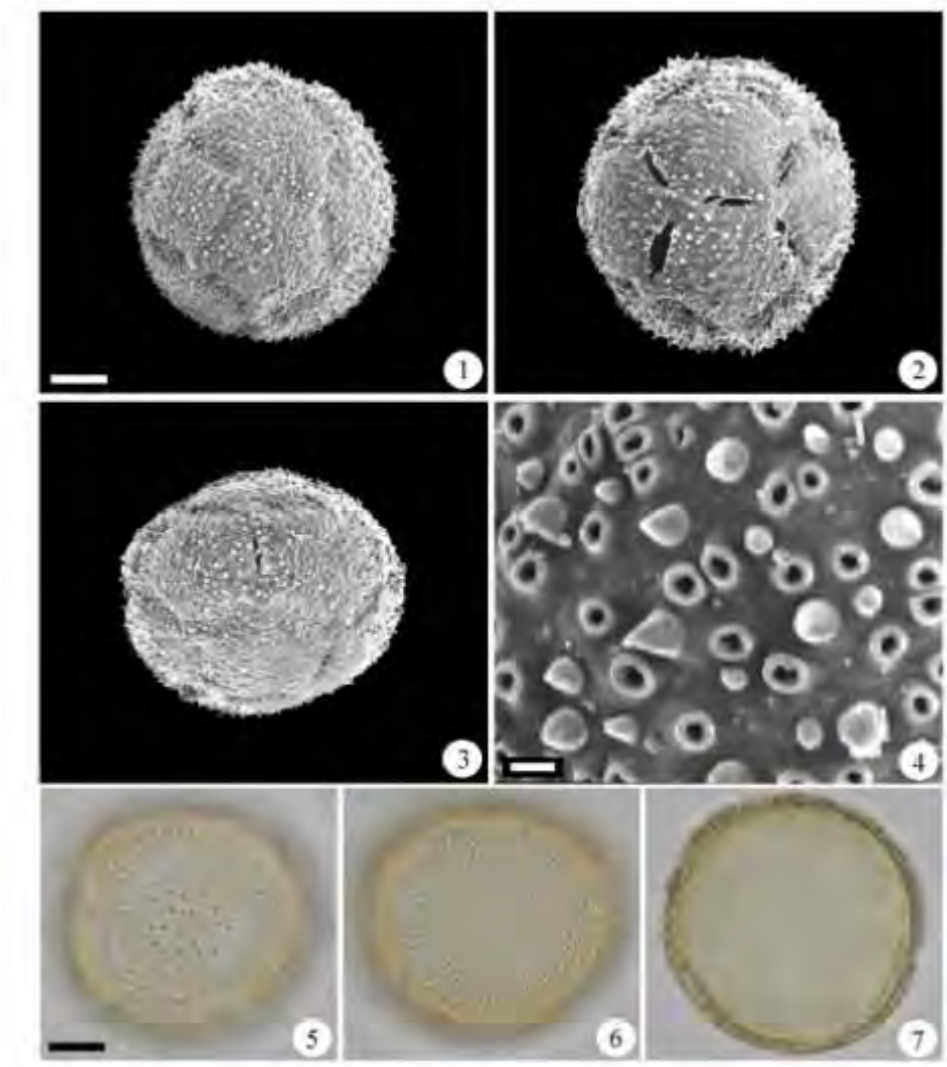


Plate (11). Pantobrevicolpate pollen type
***Portulaca oleracea* (portulacaceae)**

1-3. SEM micrographs showing pollen overall view spheroidal, colpi short and fusiform, (scale bar = 10Pm)
4. SEM micrographs showing microechinate with sharp anulopunctate sculpture (scale bar = 1Pm).
5-7. LM micrographs showing pollen overall view (scale bar = 10Pm).

6. Tricolpate pollen type

Pollen grains small to medium sized with mean polar axis ranges from 14.2 ±0.9- 31.1 ±2.5Pm, mean equatorial diameter ranges from 14.6 ±0.9-32.7 ±2.1Pm, spheroidal to oblate – spheroidal or suboblate in equatorial view and circular or obtusely triangular in polar view. Grains tricolpate, colpi apocolpate, fusiform to oblong, with acute to obtuse apex, colpi membrane scabrate to densely granules. Exine sculpture tectate to semitectate, tectum varies from reticulate to microreticulate-perforate or granulate-perforate. This type included four subtypes which can be distinguished as follows:

6a. Spergularia pollen subtype

Pollen grains small sized, mean polar axis 18.7 ±1.4Pm, mean equatorial diameter 19.9 ±1.6Pm, spheroidal or suboblate in equatorial view and circular in polar view. Colpi oblong with obtusely apex, colpi membrane densely granules. Exine sculpture tectate, tectum granulate -perforate. This pollen subtype characterized to genus *Spergularia* (*S. marina* (L.) Bessler), (Plate 12).

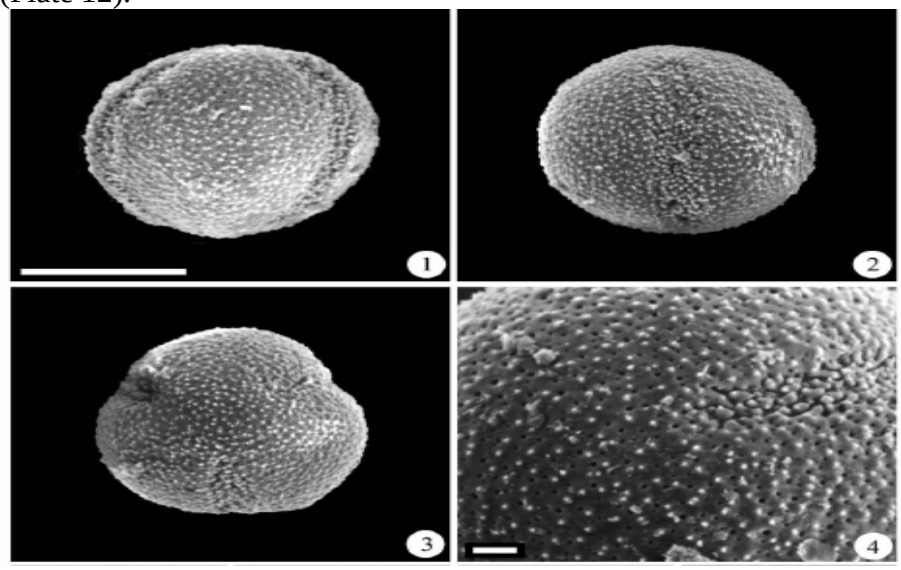


Plate (12). Tricolpate pollen type (*Spergularia* pollen subtype)
***Spergularia marina* (L.) Bessler (Caryophyllaceae)**

1-2. SEM micrographs showing pollen in equatorial view, spheroidal or suboblate, colpi oblong with obtusely apex, (scale bar = 10Pm)
3. SEM micrographs showing pollen in polar view circular, (scale bar = 10Pm).
4. SEM micrographs showing granulate-perforate sculpture, (scale bar = 1Pm).

6b. Cruciferae pollen subtype

Pollen grains small sized, mean polar axis ranges from 23.6 ±1.4- 23.9 ±1.1Pm, mean equatorial diameter ranges from 23.7 ±1.2- 26.5 ±1.2Pm, spheroidal, oblate-spheroidal or suboblate in equatorial view and obtusely triangular in polar view. Colpi fusiform with acute apex, colpi membrane densely granules. Exine sculpture semitectate, tectum reticulate, reticulum with free standing columellae in the lumina. This pollen subtype characterized to Cruciferae (*Brassica nigra* (L.) Koch, *Sinapis arvensis* L.), (Plate 13).

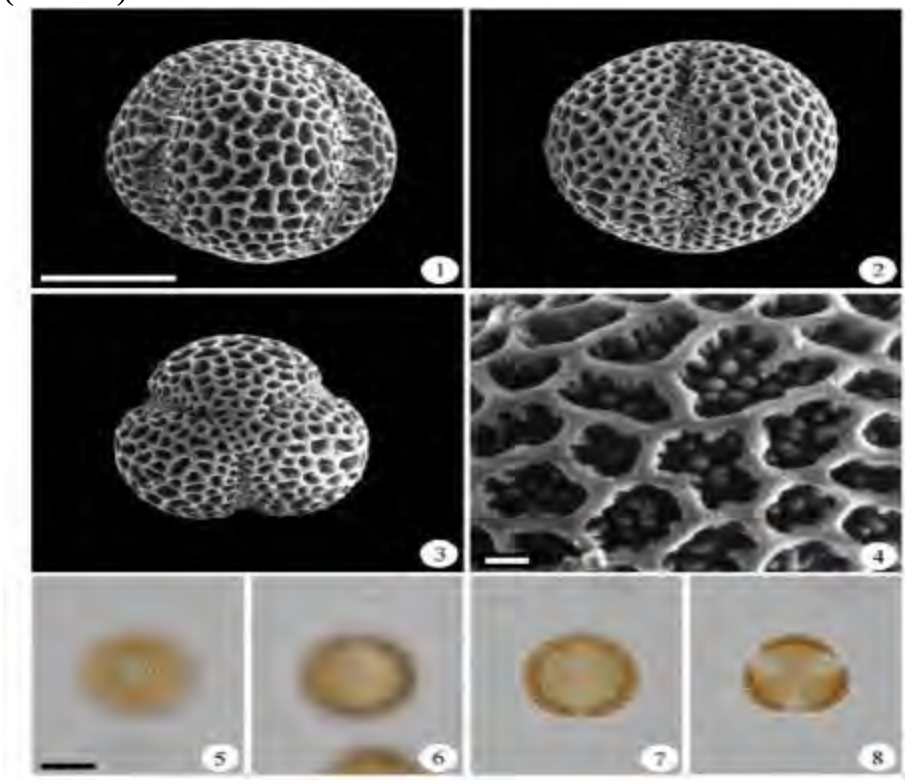


Plate (13). Tricolpate pollen type (*Cruciferae* pollen subtype)
***Brassica nigra* (L.) Koch (Cruciferae)**

1-2. SEM micrographs showing pollen in equatorial view, spheroidal or oblate spheroidal, colpi fusiform with acute apex, (scale bar = 10Pm)
3. SEM micrographs showing pollen in polar view obtusely triangular, (scale bar = 10Pm).
4. SEM micrographs showing reticulate sculpture with free standing columellae in the lumina, (scale bar = 1Pm).
5-7. LM micrographs showing pollen in equatorial view (scale bar = 10Pm).
8. LM micrographs showing pollen in polar view (scale bar = 10Pm).

6c. Tamaricaceae pollen subtype

Pollen grains small sized, mean polar axis ranges from 14.2 ±0.9-16.9 ±0.9Pm, mean equatorial diameter ranges from 14.6 ±0.9- 16.8 ±1.1Pm, spheroidal or subprolate in equatorial view and obtusely triangular in polar view. Colpi fusiform with acute apex, colpi membrane psilate-scabrate. Exine sculpture tectate, tectum microreticulate to perforate. This pollen subtype characterized to Tamaricaceae (*Tamarix nilotica* (Ehrenb.)Bunge & *T. tetragyna* Ehrenb.), (Plate 14)

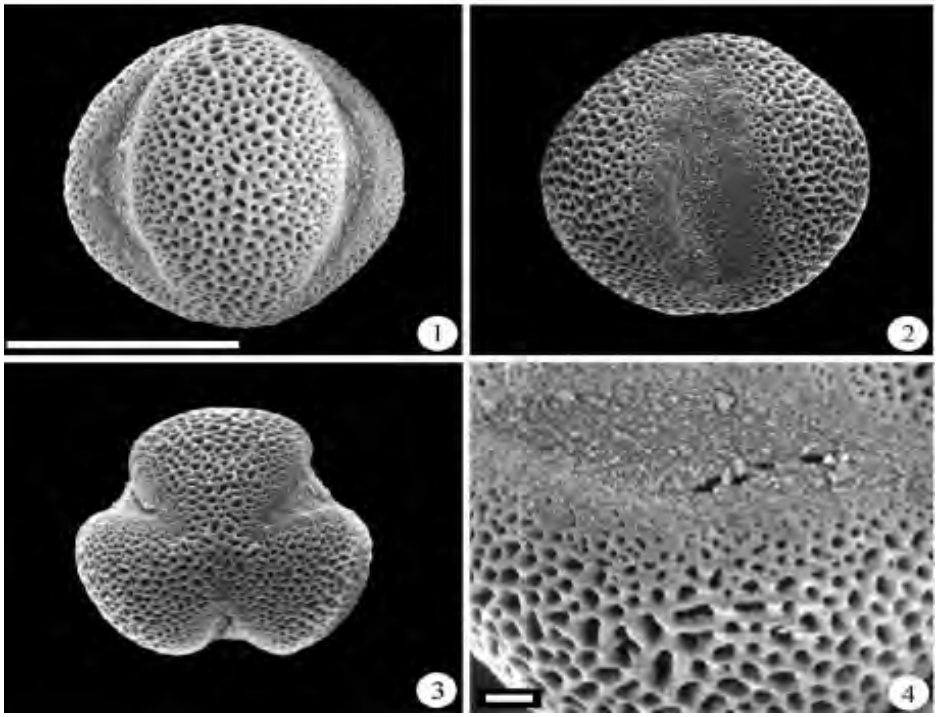


Plate (14). Tricolpate pollen type (Tamaricaceae pollen subtype)
***Tamarix tetragyna* Ehrenb. (Tamaricaceae)**

1-2. SEM micrographs showing pollen in equatorial view spheroidal or subprolate, colpi fusiform with acute apex (scale bar = 10Pm)
3. SEM micrographs showing pollen in polar view obtusely triangular (scale bar = 10Pm).
4. SEM micrographs showing microreticulate to perforate sculpture (scale bar = 1Pm).

6d. Oxalidaceae pollen subtype

Pollen grains medium sized mean polar axis 31.1 ±2.5 Pm, mean equatorial diameter 32.7 ±2.1Pm, spheroidal in equatorial view and circular in polar view. Colpi fusiform with acute apex, colpi membrane densely granules to rugulate. Exine sculpture tectate, tectum microreticulate to perforate. This pollen subtype characterized to Oxalidaceae (*Oxalis corniculata* L.), (Plate 15).

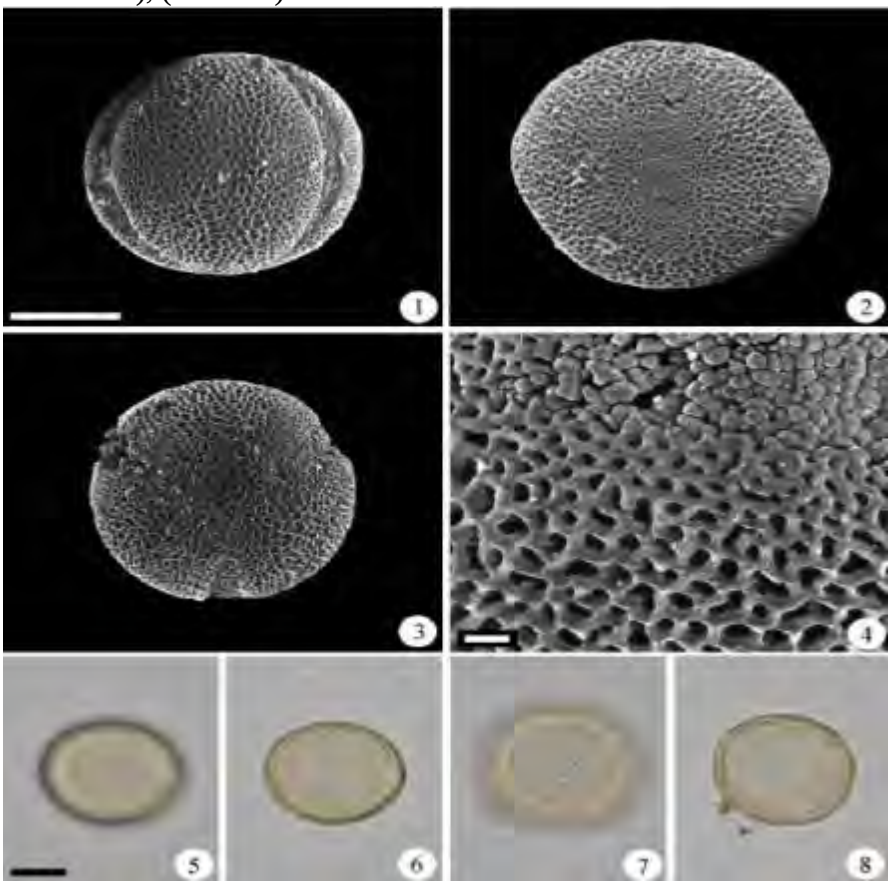


Plate (15). Tricolpate pollen type (Oxalidaceae pollen subtype)
***Oxalis corniculata* L. (Oxalidaceae)**

1-2. SEM micrographs showing pollen in equatorial view spheroidal, colpi fusiform with acute apex (scale bar = 10Pm)
3. SEM micrographs showing pollen in polar view circular (scale bar = 10Pm).
4. SEM micrographs showing microreticulate sculpture, colpi membrane rugulate (scale bar = 1Pm).
5-7. LM micrographs showing pollen in equatorial view (scale bar = 10Pm).
8. LM micrographs showing pollen in polar view (scale bar = 10Pm).

7. Tricolporate pollen type

Pollen grains small to medium sized with mean polar axis ranges from 9.9 ±0.9- 37.6 ±2.5Pm, mean equatorial diameter ranges from 9.9 ±0.9- 27.9 ±2.1Pm, spheroidal to prolate – spheroidal or subprolate to prolate in equatorial view and circular or obtusely triangular in polar view. Grains tricolporate, colpori apocolpate sometimes syncolpate, very short or long, fusiform to oblong to slit-like, with acute to obtuse apex, colpi membrane psilate or granulate to coarsely rugulate, margo distinct or indistinct. Exine sculpture tectate or semitectate, tectum varies from perforate to reticulate or rugulate. This type included six subtypes which can be distinguished as follows:

7a. Melilotus-group pollen subtypes

Pollen grains small sized with mean polar axis ranges from 16.5 ±1.3- 24.2 ±1.0Pm, mean equatorial diameter ranges from 14.1 ±0.8- 24.7 ±1.4Pm, spheroidal to prolate – spheroidal or subprolate to prolate in equatorial view and subcircular in polar view. Colpori apocolpate, fusiform with acute apex, colpi membrane coarsely rugulate, margo distinct, psilate to perforate. Ora raised and lolongate. Exine sculpture tectate, tectum perforate to microreticulate. This subtype characterized to *Melilotus* (*M. indicus* (L.) All.), *Alhagi* (*A. graecorum* Boiss.) and *Sesbania* (*S. sesban* (L.) Merr.), (Plate 16)

7b. Vicia-group pollen subtype

Pollen grains medium sized with mean polar axis ranges from 26.3 ±0.9- 34.1 ±1.4Pm, mean equatorial diameter ranges from 20.6 ±1.0- 22.1 ±0.9Pm, prolate or subprolate in equatorial view and subcircular in polar view. Colpori apocolpate, oblong to slit-like with acute apex, colpi membrane indistinct, margo distinct, psilate to perforate. Ora slightly raised and lolongate. Exine sculpture tectate, tectum uneven reticulate-rugulate to reticulate-fossulate. This subtype characterized to *Vicia* (*V. monantha* Retz.) and *Trifolium* (*T. resupinatum* L.), (Plate 17).

7c. Lotus-group pollen subtype

Pollen grains small to medium sized with mean polar axis ranges from 16.1 ±1.0- 37.6 ±2.1Pm, mean equatorial diameter ranges from 11.1 ±0.7- 24.9 ±1.4Pm, spheroidal, prolate or subprolate in equatorial view and circular to obtusely triangular in polar view. Colpori apocolpate, oblong to slit-like with acute apex, colpi membrane psilate to granulate, margo indistinct. Ora not raised and lolongate. Exine sculpture tectate, tectum rugulate to rugulate-fossulate. This subtype characterized to *Lotus* (*L.*

pusillus Viv. & *L. halophilus* Boiss. & Spruner), *Lathyrus* (*L. hirsutus* L.) and *Medicago* (*M. intertexta* (L.) Mill var. *ciliaris* (L.) Heyn), (Plate 18).

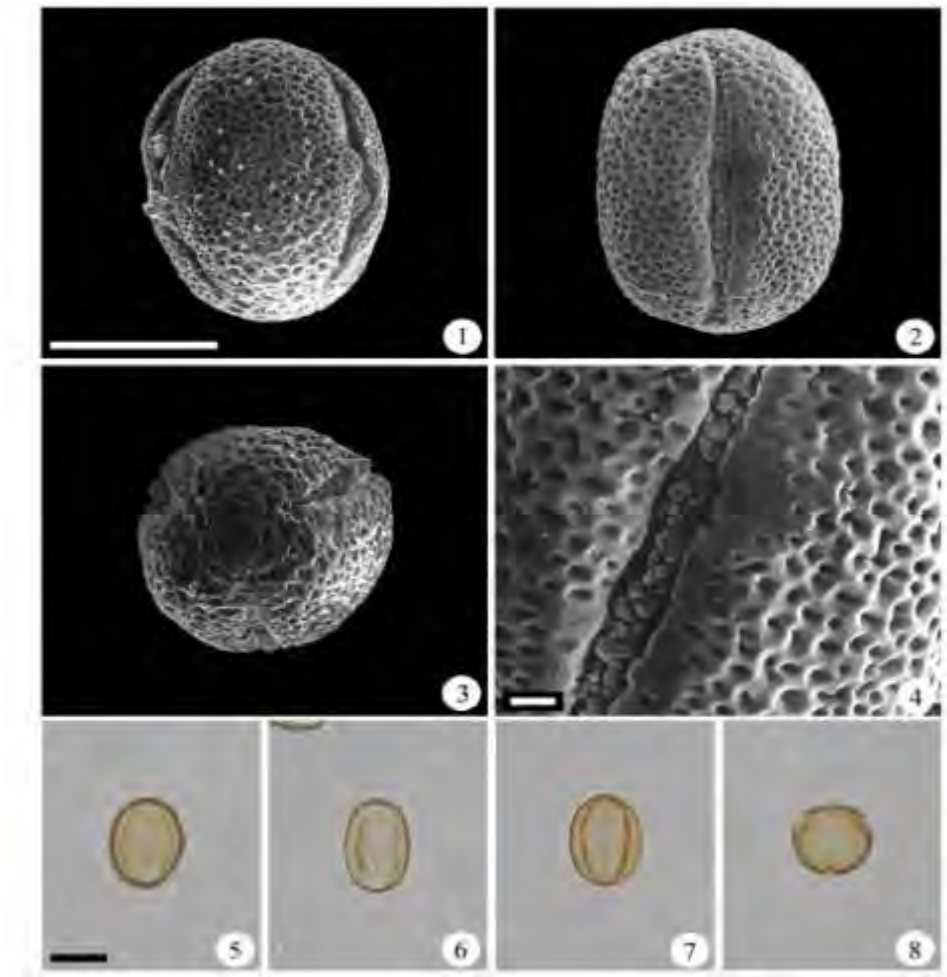


Plate (16). Tricolporate pollen type (*Melilotus*-group pollen subtype)
***Melilotus indicus* (L.) All. (Leguminosae)**

1-2. SEM micrographs showing pollen in equatorial view subprolate or prolate, colpi narrowly fusiform with acute apex, margo distinct (scale bar = 10Pm)
3. SEM micrographs showing pollen in polar view subcircular, (scale bar = 10Pm).
4. SEM micrographs showing microreticulate sculpture and colpi membrane rugulate, (scale bar = 1Pm).
5-7. LM micrographs showing pollen in equatorial view (scale bar = 10Pm).
8. LM micrographs showing pollen in polar view (scale bar = 10Pm).

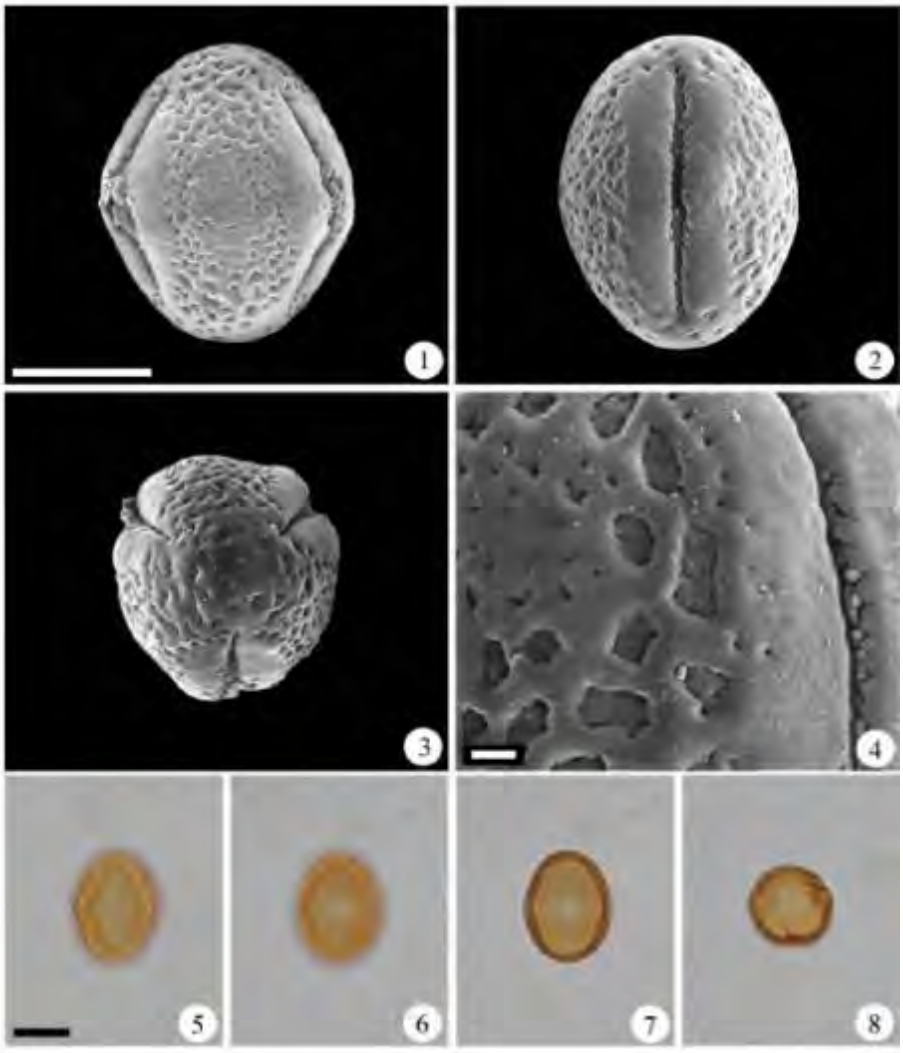


Plate (17). Tricolporate pollen type (*Vicia*-group pollen subtype)
***Trifolium resupinatum* L. (Leguminosae)**

1-2. SEM micrographs showing pollen in equatorial view subprolate or prolate, colpi narrowly oblong with acute apex, margo distinct (scale bar = 10Pm)
3. SEM micrographs showing pollen in polar view subcircular, (scale bar = 10Pm).
4. SEM micrographs showing reticulate-fossulate sculpture, (scale bar = 1Pm).
5-7. LM micrographs showing pollen in equatorial view (scale bar = 10Pm).
8. LM micrographs showing pollen in polar view (scale bar = 10Pm).

7d. Salicaceae pollen subtype

Pollen grains small sized with mean polar axis 20.8 ±1.6Pm, mean equatorial diameter ranges from 17.1 ±1.4Pm, spheroidal, subprolate or prolate in equatorial view and obtusely triangular in polar view. Colpori syncolpate, fusiform with acute apex, colpi membrane granulate, margo distinct, psilate to perforate. Ora sunken and circular. Exine sculpture semitectate, tectum uneven reticulate with granules at lumina. This subtype characterized to Salicaceae (*Salix mucronata* Thunb.), (Plate 19).

7e. Polygonaceae-group pollen subtype

Pollen grains small to medium sized with mean polar axis ranges from 20.4 ±0.8- 30.0±1.2Pm, mean equatorial diameter ranges from 19.5 ±0.9- 26.4 ±1.2Pm, spheroidal to oblate – spheroidal or prolate in equatorial view and circular to subcircular in polar view. Colpori apocolpate, oblong to slit-like (very short and fusiform in genus *Emex*) with acute apex, colpi membrane scabrate sometimes indistinct, margo indistinct. Ora sunken and lolongate. Exine sculpture tectate, tectum fossulate-perforate to microperforate with densely or sparsely spaced granules. This subtype characterized to Aizoaceae (*Mesembryanthemum crystallium* L.) and Polygonaceae except *Persicaria* (*Emex spinosa* (L.) Campd, *Polygonum equsetiforume* Sm., *Rumex dentatus* L. & *R. pictus* Forssk.), (Plate 20 & 21).

7f. Zygophyllaceae-group pollen subtype

Pollen grains small sized with mean polar axis ranges from 9.9 ±0.3- 18.8 ±1.4Pm, mean equatorial diameter ranges from 9.9 ±0.9- 16.3 ±1.3Pm, spheroidal, subprolate or prolate in equatorial view and obtusely triangular or circular in polar view. Colpori apocolpate, widely oblong with obtuse apex or fusiform with acute apex, colpi membrane psilate, margo distinct, psilate to perforate. Ora not raised and lolongate or lalongate. Exine sculpture tectate, tectum perforate to microreticulate. This subtype characterized to Capparaceae (*Capparis decidus* (Forssk.) Fdgew.), Salvadoraceae (*Salvadora persica* L.) and Zygophyllaceae (*Fagonia arabica* L. & *Zygophyllum coccineum* L.), (Plate 22).

Plate (18). Tricolporate pollen type (*Lotus*-group pollen subtype)
***Lotus halophilus* Boiss. & Spruner (Leguminosae)**

1-2. SEM micrographs showing pollen in equatorial view, prolate, colpi slit-like with acute apex, (scale bar = 10Pm)
3. SEM micrographs showing pollen in polar view circular, (scale bar = 10Pm).
4. SEM micrographs showing rugulate-fossulate sculpture, (scale bar = 1Pm).
5-7. LM micrographs showing pollen in equatorial view (scale bar = 10Pm).
8. LM micrographs showing pollen in polar view (scale bar = 10Pm).

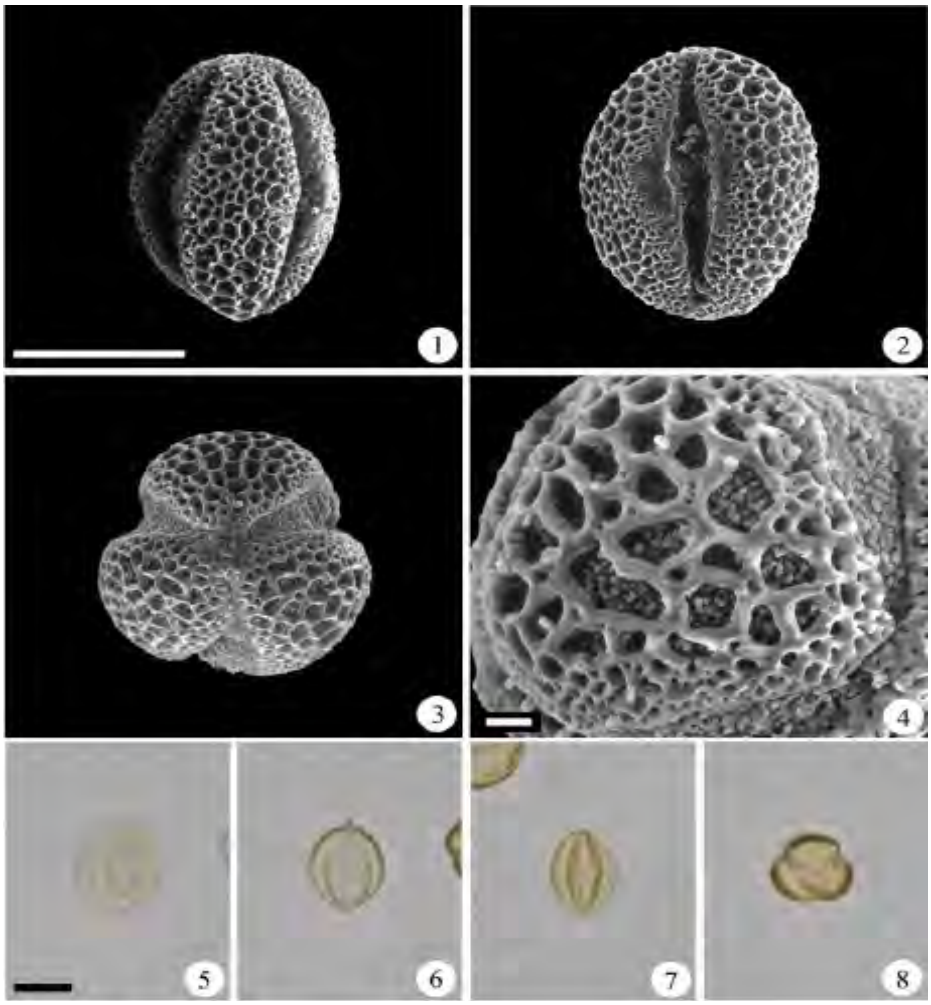


Plate (19). Tricolporate pollen type (Salicaceae pollen subtype)
***Salix mucronata* Thunb. (Salicaceae)**

1-2. SEM micrographs showing pollen in equatorial view subprolate or prolate, colpi fusiform with acute apex, margo distinct (scale bar = 10Pm)
3. SEM micrographs showing pollen in polar view obtusely triangular, syncolpate (scale bar = 10Pm).
4. SEM micrographs showing uneven reticulate with granules at lumina sculpture (scale bar = 1Pm).
5-7. LM micrographs showing pollen in equatorial view (scale bar = 10Pm).
8. LM micrographs showing pollen in polar view (scale bar = 10Pm).

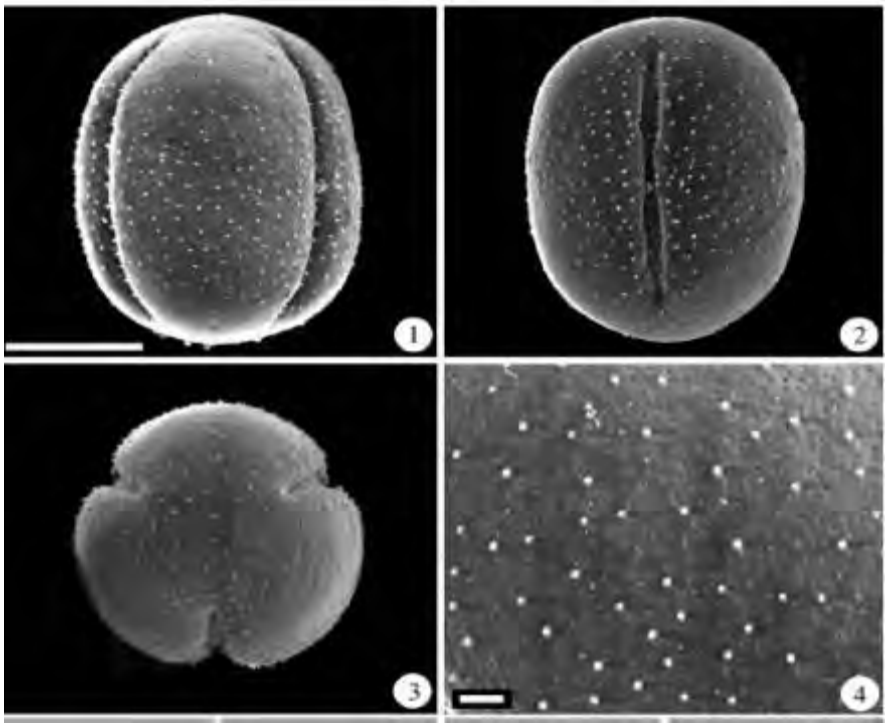
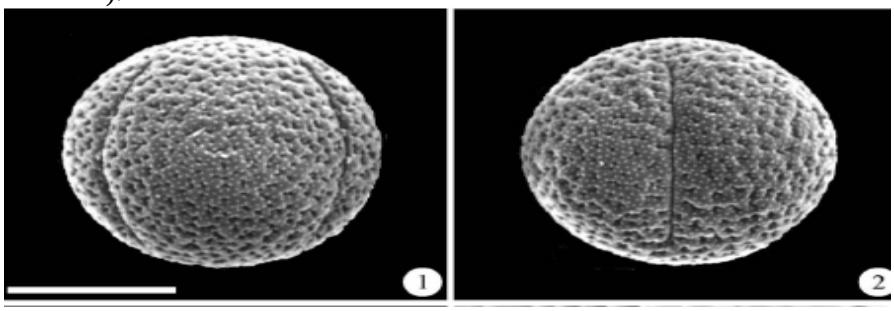


Plate (20). Tricolporate pollen type (Polygonaceae-group pollen subtype)
***Polygonum equsetiforme* Sm. (Polygonaceae)**

1-2. SEM micrographs showing pollen in equatorial view subprolate or prolate, colpi oblong with acute apex, margo indistinct (scale bar = 10Pm)
3. SEM micrographs showing pollen in polar view subcircular, (scale bar = 10Pm).
4. SEM micrographs showing microperforate-granulate sculpture (scale bar = 1Pm).



***Rumex pictus* Forssk. (Polygonaceae)**

1-2. SEM micrographs showing pollen in equatorial view suboblate or oblate spheroidal, slit-like colpus and fossulate-perforate with granules sculpture (scale bar = 10Pm)

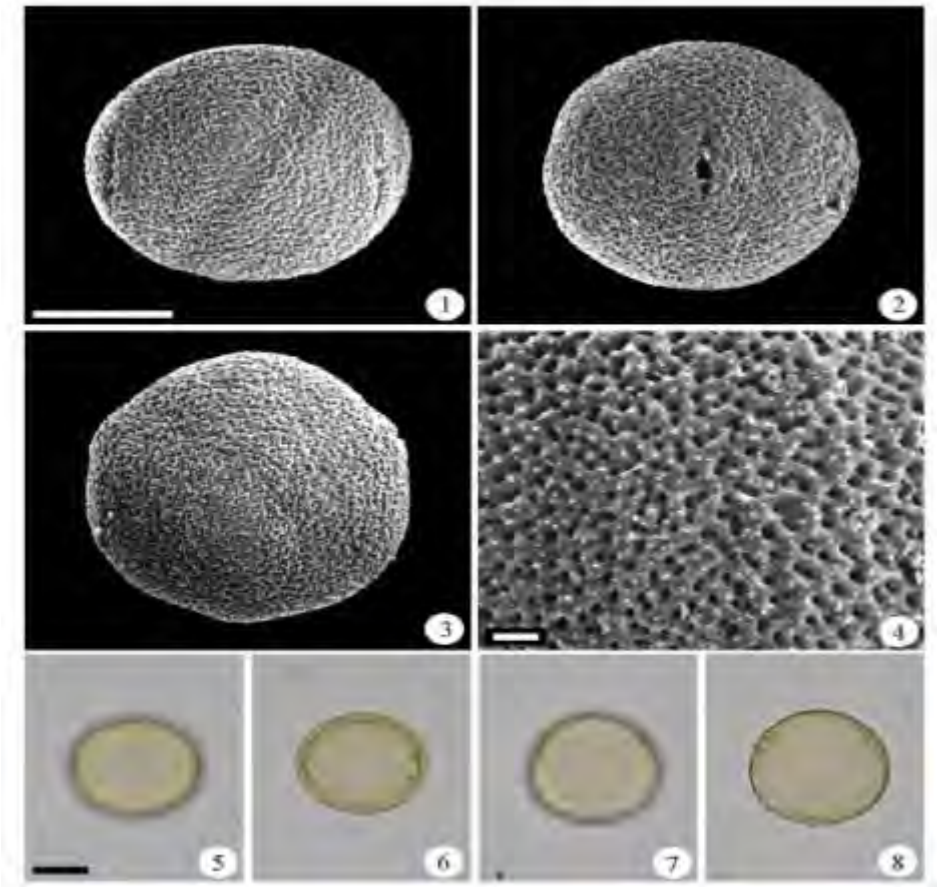


Plate (21). Tricolporate pollen type (Polygonaceae-group pollen subtype)
***Emex spinosa* (L.) Campd (Polygonaceae)**

1-2. SEM micrographs showing pollen in equatorial view suboblate or spheroidal, colpi short and fusiform with acute apex, margo indistinct (scale bar = 10Pm)
3. SEM micrographs showing pollen in polar view circular, (scale bar = 10Pm).
4. SEM micrographs showing fossulate-perforate with densely granules sculpture (scale bar = 1Pm).

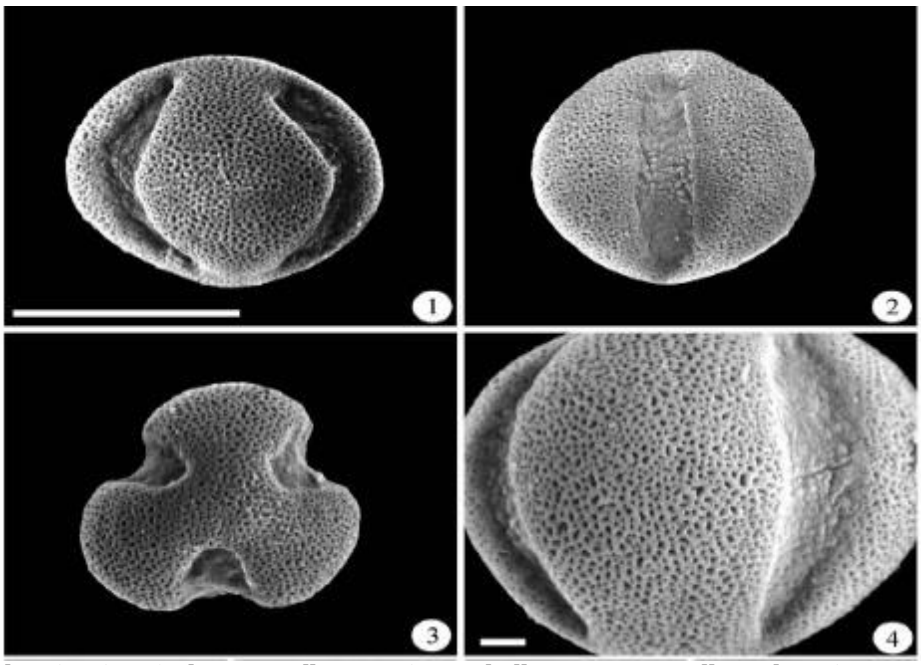
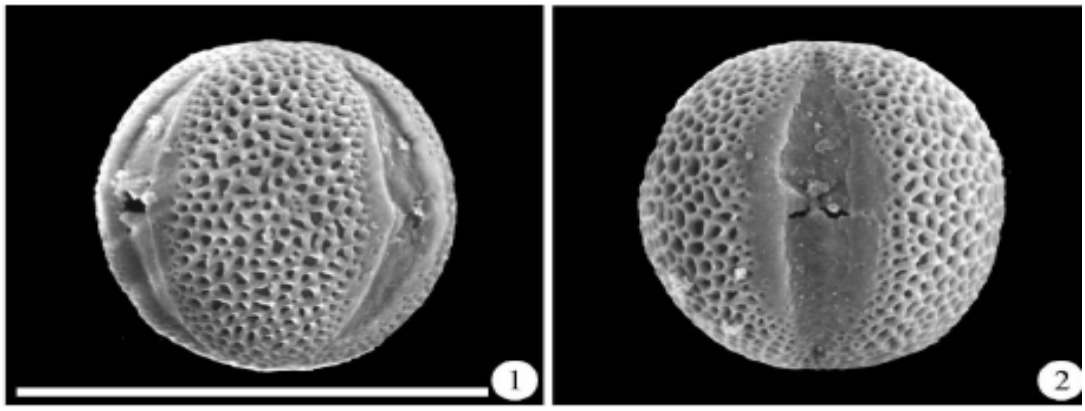


Plate (22). Tricolporate pollen type (Zygophyllaceae-group pollen subtype)
***Salvadora pesica* Wall. (Salvadoraceae)**

1-2. SEM micrographs showing pollen in equatorial view spheroidal or subprolate, colpi widely oblong with obtuse apex, margo distinct and perforate (scale bar = 10Pm)
3. SEM micrographs showing pollen in polar view obtusely triangular (scale bar = 10Pm).
4. SEM micrographs showing perforate sculpture (scale bar = 1Pm).



***Zygophyllum coccineum* L. (Zygophyllaceae)**

1-2. SEM micrographs showing pollen in equatorial view spheroidal or subprolate, colpi fusiform with acute apex, margo distinct and psilate. Sculpture microreticulate (scale bar = 10Pm)

Discussion

Scanning electron micrographs greatly enhanced the characterization and interpretation of pollen morphological features (Sowunmi, 1995). The SEM of the 41 taxa from different families of subclass Archiclamydeae in Faiyum province provided further information on the pollen morphology and complemented the light microscopic observations. Number and shape of apertures, size and shape of pollen grains and exine patterns were of great diagnostic significance among the examined taxa.

On the basis of pollen units, two main groups are recognized viz. complex group and single group. The complex group is represented by a unique major pollen type known as polyads type in which the pollen grains released in groups 16-32 grains, this type restricted to subfamily Mimosoideae and is further subdivided according to the number of grains into two subtypes viz. *Acacia* pollen subtype (16 grains in each polyad) and *Faidherbia* pollen subtype (32 grains in each polyad).

According to the number and shape of apertures, the single group (monads) comprises six pollen types of which triporate, tetra-hexaporate and pantobrevicolpate types are characterized to families Urticaceae, Fumariaceae and Portulacaceae respectively.

The pollen grains of pantoporate type are characterized by having spheroidal shape with different size and exine sculpture patterns. Six families are included in this type distributed in six subtypes viz. Malvaceae, Thymelaeaceae, Chenopodiaceae, Amaranthaceae, Caryophyllaceae and Polygonaceae (*Persicaria*).

Among the under investigation, Pollen of Malvaceae is the largest one, its dimension ranges from 75.2-85.2Pm, with sharp echinate tectum (Malvaceae pollen subtype) whereas the pollen of Thymelaeaceae is characterized by croton pattern tectum (Thymelaeaceae pollen subtype).

Amaranthaceae represented here by two genera viz. *Amaranthus* (subfamily Amaranthoideae) and *Alternanthera* (subfamily Gomphrenoideae). Both genera produce two different subtypes of pollen grains, the *Alternanthera* pollen subtype characterized by octagonal pollen grains in all views, pores 12 and exine sculpture metareticulate pattern; while the *Amaranthus* pollen subtype has circular pollen grains in all views, pores more than 12 and exine sculpture granulate. These results agree with that of Erdtman 1952, Nowick & Skvarla 1979 and Perveen & Qaiser 2002.

Within the order Caryophyllales, Chenopodiaceae regarded by Bittrich 1993 as a sister group with Amaranthaceae, both form a monophyletic

lineage (Downie & Palmer 1994, Manharht & Rettig 1994, Rodman 1994). Hence, the ultrastructure of pollen grains of the studied genera of Chenopodiaceae, shows uniform type characteristics and resembles Amaranthaceae (*Amaranthus* pollen subtype) in several aspects such as the aperature structure, exine sculpture and pollen shape and size. This was also noted by (Tsukada 1967, Youngjae & Lee 1995 and Toderich *et al.* 2010).

Pollen grains of *Persicaria* (family Polygonaceae) characterized by the lophoreticulate sculpture whereas the remaining examined genera of family Polygonaceae characterized by tricolporate apertures and perforate-scabrate sculpture (tricolporate pollen type) sharing family Aizoaceae in the same pollen subtype. As well as Caryophyllaceae is a europalynous family, both *Silene* and *Vaccaria* belonging to pantoporate pollen type with microechinate-anulopunctate sculpture (*Silene-Vaccaria* pollen subtype). While *Spergularia* belong to tricolpate pollen type with granulate-perforate sculpture (*Spergularia* pollen subtype). Nowicke & Skvarla 1977 reported that Polygonaeae is a large and palynological diverse family but the palynological study revealed no pollen types similar to these in the Caryophyllaceae.

Tricolpate pollen type represented here by four pollen subtypes of which pollen of Cruciferae is characterized by reticulate sculpture, whereas both Tamaricaceae and Oxalidaceae have the same exine sculpture (microreticulate to perforate) but differ in pollen size, shape and sculpture of colpi membrane.

The pollen of tricolporate type is quite heterogeneous, most of the examined taxa of this type belong to the subfamily Papilinoideae, and these taxa show a wide range of variation in pollen characteristics. On the basis of pollen shape and size, aperture characters and exine sculpture, six pollen subtypes are recognized, of which three subtypes included eight genera of papilionoideae viz. *Melilotus* group pollen subtype, *Vicia* group pollen subtype and *Lotus* group pollen subtype. Pollen of *Melilotus* group is easily distinguished by its fusiform colpori, coarsely regulate colpi membrane and tectum perforate to microreticulate. This subtype comprises three genera (*Sesbania*, *Alhagi* and *Melilotus*) belonging to three tribes: Robinieae, Galegeae and Trifolieae respectively. *Vicia* group pollen subtype is characterized by distinct margo, psilate to perforate and uneven reticulate-rugulate to reticulate-fossulate tectum. This pollen subtype comprises two genera (*Vicia* and *Trifolium*) belonging to two tribes: Vicieae and Trifolieae respectively. While the pollen of *Lotus* group is characterized by indistinct

margo and regulate-fossulate tectum. This pollen subtype is found in three genera (*Lotus*, *Lathyrus* and *Medicago*) distributed in three tribes: Loteae, Vicieae and Trifolieae respectively. Striking variations were found in pollen characters within this subfamily indicated that it is a eurypalynous; and hence palynology is significant within this subfamily at the tribal and subtribal levels, but less marked at the genera levels. These results also cited by Erdtman 1952, Ferguson & Skvarla 1981 and Perveen & Qaiser 1998.

The remaining three subtypes represented the pollen of six families viz. Salicaceae pollen subtype, Polygonaceae group pollen subtype and Zygophyllaceae group pollen subtype. The former subtype distinguished by reticulate tectum, with free standing columellae in lumina, pollen small sized and colpus syncolpate.

Although the other two pollen subtypes are fairly uniform in their pollen characteristics. On the basis of exine sculpture and colpori characters, the pollen of Polygonaceae group can be distinguished by tectum fossulate-perforate to microperforate with densely or sparsely spaced granules and colpi slit-like with indistinct margo. While, pollen of Zygophyllaceae group is characterized by perforate to microreticulate tectum and colpi widely oblong or fusiform with distinct margo.

In conclusion, SEM based pollen characters are found to be useful in identification and discrimination of taxonomically related taxa. The taxa investigated here illustrate a highly pollen morphological variations especially among the taxa related to families: Leguminosae, Caryophyllaceae, Amaranthaceae and Polygonaceae. The key to identify pollen types and examined taxa given in the present investigation can be additional tool for taxonomic identification. In the future, an investigation of the taxa belong to the other subclass (Sympetalae) will be taken into consideration by the authors.

Key based on the morphological characters of pollen grains of investigated taxa:

1- Pollen in polyads……..……. 2
-Pollen in Monads……...……...…… 3
2- Polyads medium sized (23.4-26.7Pm x 36.7-43.4Pm), composed of 16 grains, pollen grains colporate, colpi Y-shaped, exine sculpture foveolate ……..…. ***Acacia***
- Polyads large in size (41.8-51.8 Pm x 91.9-115.2Pm), compoded of 32 grains, pollen grains indistinct aperture, exine sculpture subrugulate ……..…….. ***Faidherbia***

3- Pollen aperture is porate ……..…… 4
- Pollen aperture is colpate or colporate ……11
4- Pollen aperture tri- or tetra-hexaporate ……. 5
- Pollen aperture pantoporate ……... 6
5- Pollen aperture triporate, pores circular with microechinate annulus, exine sculpture densely spaced microechinate ……...….. **Urticaceae**
- Pollen aperture tetra to hexaporate, pores circular with psilate aspides, exine sculpture verrucate with faint perforate ……..…..... **Papaveraceae**
6- Pollen dimension ranges from 31.7-85.2Pm ……. 7
- Pollen dimension ranges from 13.4-30.1Pm …….. 9
7- Exine sculpture lophoreticulate with free standing columellae in lumina ……..…… ***Persicaria***
- Exine sculpture microechinate or sharp echinate with perforate or anulopunctate ……. 8
8- Pollen dimension ranges from 75.2-85.2Pm, exine sculpture sharp echinate, perforation densely spaced and uneven ……..... **Malvaceae**
- Pollen dimension ranges from 31.7-40.9Pm, exine sculpture micro-echinate, perforation sparsely spaced and circular (anulopunctate) ……..…….…… ***Silene-Vaccaria* group**
9- Exine sculpture is croton pattern ……..…… **Thymelaeaceae**
- Exine sculpture is metareticulate (fenestrate) pattern or granulate 10
10- Exine sculpture metareticulate (fenestrate) pattern, with microechinate and perforate muri. Pores 12, striate membrane. Pollen octagonal in all views ……...…….. ***Alternanthera***
- Exine sculpture granulate pattern. Pores more than 12 with coarsely granules operculum. Pollen circular in all views ……..…… ***Amaranthus* & Chenopodiaceae**
11- Pollen aperture tri- or panto-colpate …….....12
- Pollen aperture tri-colporate ……. 16
12- Pollen aperture panto- brevicolpate …….. **Portulacaceaea**
- Pollen aperture tri- colpate ……. 13
13- Exine sculpture granulates and perforate ..... ***Spergularia***
- Exine sculpture reticulate or microreticulate ……. 14
14- Exine sculpture reticulate, reticulum with free standing columellae in lumina ……..…… **Cruciferae**
- Exine sculpture microreticulate to perforate……. 15

15- Pollen grains small sized (13.4-18.4Pm x 15-19.2Pm), spheroidal or subprolate. Colpi membrane psilate to scabrate ……... **Tamaricaceae**
- Pollen grains medium sized (its dimension 23.4-36.7Pm), spheroidal. Colpi membrane densely granulate .....…… **Oxalidaceae**
16- Exine sculpture rugulate to rugulate-fossulate ..……..... ***Lotus* group**
- Exine sculpture otherwise …… 17
17- Exine sculpture microreticulate to fossulate-perforate or microperforate. Supratectum psilate or best with granules …… 18
- Exine sculpture reticulate ……21
18- Supratectum best with granules …….. **Aizoaceae & Polygonaceae**
- Supratectum psilate ……. 19
19- Colpi membrane coarsely regulate ……..…….…… ***Melilotus* group**
- Colpi membrane psilate ……..... 20
20- Colpus fusiform with acute apex ….. **Capparaceae & Zygophyllaceae**
- Colpus widely oblong with obtuse apex …… **Salvadoraceae**
21- Exine sculpture reticulate with free standing columellae in lumina. Grains small sized (16.7-23.4Pm x 15.0-20.0Pm). Colpus fusiform, syncolpate with perforated margin …….…… **Salicaceae**
- Exine sculpture uneven reticulate-rugulate to reticulate-fossulate. Grains medium sized (25.1-36.7Pm x 19.2-23.4Pm). Colpus oblong, apocolpate with thick & psilate to perforate margin …… ***Trifolium* & *Vicia***

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