

# Pollen Atlas of the flora of Egypt

## 5. Species of Scrophulariaceae\*

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El-Husseini, N. & Shamso, E. 2002. The pollen atlas of the flora of Egypt. 5. Species of Scrophulariaceae. *Taekholmia* 22(1): 65-76.

Light and scanning electron microscope study of the pollen grains of 47 species representing 16 genera of Scrophulariaceae in Egypt was carried out. Pollen grains vary from subspheroidal to prolate; trizonocolpate to trizonocolporate. Exine's sculpture is striate, colliculate, granulate, coarse reticulate or microreticulate. Seven pollen types are recognized and briefly described, a key distinguishing the different pollen types and the discussion of its systematic value are provided.

**Key words:** Flora of Egypt, pollen atlas, Scrophulariaceae.

### **Introduction**

The Scrophulariaceae is a family of about 292 genera and nearly 3000 species of cosmopolitan distribution. It is represented in the flora of Egypt by 50 species belonging to 16 genera, 8 tribes and 3 sub-families (El-Hadidi *et al.*, 1999).

Within the family, a wide range of pollen morphology exists and provides not only an additional parameter for generic delimitation but also reinforces the validity of many of the larger taxa.

Erdtman (1952), gave a concise account of the pollen morphology of some members of the family. Several authors studied and described the pollen of species of the family among whom to mention: Risch (1939), Ikuse (1956), Natarajan (1957), Verghese (1968), Olsson (1974), Elisens (1985c & 1986), Bolliger & Wick (1990) and Argu (1980, 1990 & 1993).

### **Material and Methods**

Pollen grains of 47 species representing 16 genera of Scrophulariaceae were the subject of the present investigation. Polleniferous materials were removed from herbarium specimens kept at Cairo University Herbarium as well as fresh materials collected by the writers. Samples of each species were collected from their natural habitats as shown in Table (1).

For size measurements, the pollen material was boiled for a few minutes in water, macerated in a few drops of an aqueous 10% solution of KOH on a clean slide; then stained with safranin (1% safranin solution in 50% ethanol), and mounted in glycerin jelly. The pollen samples were examined by Leitz light microscope and measured with the aid of a callibrated ocular micrometer. The measurements are the means of the dimensions of at least 50 well-developed pollen grains of five different specimens.

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\* Continued from *Bull. Fac. Sci. Assiut University* 31(2B): 43-53 (2002)  
Received 16 March, 2002. Revision accepted 1 June, 2002

**Table (1):** Collection data of the investigated taxa of Scrophulariaceae.

Species	Locality
<i>Verbascum sinaiticum</i> Benth.	Deir El-Arbain, 12.5.1956; <i>Täckholm</i> s.n. (CAI) - Near the Monastery of St. Catherine, 10.5.1965; <i>El-Hadidi</i> s.n. (CAI).
<i>V. sinuatum</i> L.	Abu Zaabal, 9.4.1954; <i>Boulos</i> s.n. (CAI).
<i>V. eremobium</i> Murb. var. <i>subsinguliflorum</i> Murb.	North of Ousaim from Oaga, Sinai, 26.5.1998; <i>E. shamsou</i> s.n. (CAI).
<i>V. fruticosum</i> Post	17 Km East of El-Arish on the road to Rafah, 18.4.1985; <i>Gibali</i> s.n. (CAI) – North of Qusaim from Ooga, 26.5.1998; <i>E. Shamsou</i> s.n. (CAI).
<i>V. letourneuxii</i> Asch.	Sallum, 5 Km from boundary of the town, 24.5.1963; <i>Täckholm et al.</i> s.n. (CAI) - El-Garawla, 25 Km East Mersa Matruh, 1.4.1972; <i>Täckholm et al.</i> s.n. (CAI).
<i>V. schimperianum</i> Boiss.	Wadi Isla, April 1940; <i>Hassib</i> s.n. (CAI).
<i>Celsia parviflora</i> Decne.	Stepway to Gebel Musa, 11.5.1956; <i>Täckholm</i> s.n. (CAI) – Wadi El-Arbain, St. Catherine, Sinai, 18.5.1988; <i>Kassas</i> s.n. (CAI).
<i>Anticharis arabica</i> Endl.	Gebel Elba, Wadi Aideib, 20.1.1962; <i>Täckholm et al.</i> s.n. (CAI) – Gebel Elba district, up stream part of Wadi Mawaw across Gebel Asotriba, 28.1.1962; <i>Täckholm et al.</i> 1039 (CAI).
<i>A. glandulosa</i> Asch.	Gebel Hamra Dom, 6.3.1967; <i>Osborn &amp; Helmy</i> s.n. (CAI) – Gebel Elba, 27.4.1932; <i>drar</i> s.n. (CAI).
<i>A. linearis</i> (Benth.) Hochst. ex Asch.	Gebel Hamata, Red Sea, 7.2.1961; <i>Täckholm et al.</i> 326 (CAI) – Gebel Elba, Wadi Haiteen, 27.1.1961; <i>Täckholm et al.</i> 757 (CAI).
<i>Lindenbergia indica</i> (L.) Vatke	Wadi Abar, Gebel Ataqa, 26.4.1958; <i>Täckholm et al.</i> s.n. (CAI) – Wadi Hangalia, Red Sea Coast, 4.3.1961; <i>Täckholm et al.</i> 42 (CAI).
<i>Bacopa monnieri</i> (L.) Pennell	San El-Hagar El-Gibliya, Sharkiya, 25.6.1983; <i>A. Amer</i> 2509 (CAI) – 20 Km North Tanta, 21.9.1993; <i>E. Shamsou</i> s.n. (CAI).
<i>Peplidium humifusum</i> Delile	Idfina, South of Rosetta, um El-Helkan, 23.7.1925; <i>Simpson</i> 3492 (CAIM).
<i>Limosella aquatica</i> L.	Giza, Zawiyat ElAryan, 9.2.1923; <i>Simpson</i> 1793 (CAIM).
<i>Lindernia parviflora</i> (Roxb.) Haines	Nile shore near Gebel Silsila, Kom ombo, 11.2.1964; <i>Täckholm et al.</i> 93 (CAI).
<i>Jamesbrittenia dissecta</i> (Delile) Kuntze	On the Nile Island near Khizan, 25.2.19; <i>G. Runkewitz</i> s.n. (CAI).
<i>Anarrhinum forskaohlilii</i> (J.E.Gmel) Cufod.	Along the stepway on Gebel Musa, 22.4.1961; <i>Täckholm et al.</i> s.n. (CAI) - Gebel El-Deir close to the Monastrey of St. Catherine, 11.5.1956; <i>Täckholm</i> s.n. (CAI).
<i>Misopates orontium</i> (L.) Raf.	Vicinity of Mersa Matruh, 1.4.1972; <i>Täckholm et al.</i> s.n. (CAI) - Sinnuris district, El Silien, 10.4.1983; <i>M. Abd El-Ghani</i> 3535 (CAI).
<i>Kickxia elatine</i> (L.) Dumort.	Dakhla Oasis, 11.2.1931; <i>Hassib</i> s.n. (CAI) - Hibis Temple, Kharga Oasis, 7.2.1952; <i>Täckholm &amp; Kassas</i> s.n. (CAI).
<i>K. floribunda</i> (Boiss.) Täckh. α <i>Boulos</i>	Wadi El-Maghara, 23.4.1959; <i>Boulos</i> s.n. (CAI) - Wadi Aber, Gebel Ataqa, South of Suez, 8.3.1954; <i>Boulos</i> s.n. (CAI).
<i>K. aegyptiaca</i> (L.) Nábélek	74 Km West of Mersa Matruh, 23.5.1963; <i>Täckholm et al.</i> s.n. (CAI) - Wadi Araba, 28.4.1995; <i>E. shamsou</i> s.n. (CAI).
<i>K. acerbiana</i> (Boiss.) Täckh. α <i>Boulos</i> .	179 Km E of Edfu, 10.2.1961; <i>Täckholm et al.</i> 699 (CAI) – Gebel Hamata, Red Sea Coast, 7.2.1961; <i>Täckholm et al.</i> 366 (CAI).

**Table (1):** Continued

Species	Locality
<i>K. nubica</i> (skan) Dandy	Wadi Digla, eastern desert, 25.3.1985; <i>M. Shaded</i> s.n. (CAI) - Gebel Hamara Dom, 6.3.1967; <i>Osborn &amp; Helmy</i> s.n. (CAI).
<i>K. macilenta</i> (Decne.) Danin	Wadi Feiran, Sinai, 24.4.1961; <i>Täckholm et al.</i> s.n. (CAI) - In the Vicinity of St Catherine Monastery, Sinai, 10.4.1963; <i>Boulos</i> s.n. (CAI).
<i>K. gracilis</i> (Benth.) D.A. Sutton	Gebel Elba district, Wadi Kansisrob, 3.2.1962; <i>Täckholm et al.</i> 1307 (CAI).
<i>K. pseudoscoparia</i> V.W. Smith & D.A. Sutton	Wadi Mera Kwan, 10.2.1962; <i>Täckholm et al.</i> 2000 (CAI) - At the Northern end of Wadi Allaqi, 5.3.1963; <i>Abdallah</i> 1339 (CAIM).
<i>K. hastata</i> (R. Br. ex Benth.) Dandy	Gebel Elba, G. Darwin, 4.3.1938; <i>shabetai</i> 25536 (CAIM).
<i>Linaria haelava</i> (Forssk.) F. Dietr.	El-Kharouba, El-Sheikh zowayed Village, 3.4.1988; <i>Hosni et al.</i> s.n. (CAI) - Mitla pass, 7.4.1990; El-Garf s.n. (CAI).
<i>L. joppensis</i> Bornm.	Rafah, El-Malaha, 9.4.1956; <i>Khatab</i> 55 (CAI).
<i>L. albifrons</i> (sm.) Spreng.	El Amiryra, 26.3.1954; <i>Boulos</i> s.n. (CAI) - El-Kharuba, El Sheikh Zowayed, 3.4.1988; <i>Hosni et al.</i> s.n. (CAI).
<i>L. simplex</i> Desf.	Wadi El Raha, 9.4.1967; <i>Chrtk &amp; Kosinova</i> s.n. (CAI).
<i>L. tenuis</i> (Viv.) Spreng.	El-Arish - Rafah road, at 5 Km before Rafah, 3.4.1988; <i>Hosni et al.</i> s.n. (CAI) - Wadi El-Arish, 18.3.1955; <i>Boulos</i> s.n. (CAI).
<i>Scrophularia arguta</i> Sol.	Gebel Hamata, Red Sea Coast, 7.2.1961; <i>Täckholm et al.</i> 442 (CAI) - Gebel Elba district, Wadi Kansis - rob, 3.2.1962; <i>Täckholm et al.</i> s.n. (CAI).
<i>S. deserti</i> Delile.	El Qattamia, Suez road, 27.3.1989; <i>El Garf</i> s.n. (CAI) - Sinai, Wadi zawaniig, 7.12.1989; <i>Hobbs</i> s.n. (CAI).
<i>S. sinaica</i> Benth.	Wadi Garawi, Helwan desert, 4.4.1960; <i>Täckholm et al.</i> s.n. (CAI) - Wadi Rishrash, affluent to the Wadi, 23.3.1982; <i>Hassan</i> 489 (CAI).
<i>S. canina</i> L.	2 Km east of sallum, 25.5.1963; <i>Täckholm et al.</i> s.n. (CAI).
<i>S. libanotica</i>	Below the summit of Gebel Musa, Sinai, 22.4.1961; <i>Täckholm et al.</i> s.n. (CAI) - Farsh Liifa (Gebel Abbas Pasha), Sinai, 7.12.1989; <i>Hobbs</i> s.n. (CAI).
<i>Veronica anagalloides</i> Guss.	El-Mahmudia; Minyet El Said, 14.8.1970; <i>Ibrahim et al.</i> s.n. (CAI) - Beheira provinces, Damanhur, 18.3.1988; <i>A. Amer</i> 16173 (CAI).
<i>V. anagallis - aquatica</i> L. var. <i>nilotica</i> R. Uechtr.	Nile bank at the cataract hotel Aswan, 2.7.1967; <i>El-Hadidi &amp; Ghabbour</i> s.n. (CAI).
<i>V. scardica</i> Griseb.	Kafr Mahfus & Beni Othman, El Fayoum, 20.11.1968; <i>El-Hadidi</i> s.n. (CAI) - Al Harra, Ain Glit, 13.4.1980; <i>M. Abd El-Ghani</i> 2612 (CAI).
<i>V. catenata</i> Pennell.	El-Gedia, Kafr El-Sheikh, 3.4.1993; <i>E. Shamso</i> s.n. (CAI) - Beheira province, Kon Hamada, 15.4.1988; <i>A. Amer</i> 6755 (CAI).
<i>V. cymbalaria</i> Bodard.	Samouha cultivations behind Nuzha gardens, Alexandria, 23.3.1956; <i>Täckholm &amp; El-Hadidi</i> s.n. (CAI).
<i>V. persica</i> Poir.	Beheira province, Mahmudiya, 17.3.1987; <i>A. Amer</i> 9501 (CAI).
<i>V. polita</i> Fr.	Beheira province, El-Mahmudia, 25.4.1987; <i>A. Amer</i> 10227 (CAI).
<i>V. campylopoda</i> Boiss.	Deir El Rabba at the entrance of Wadi El Arbaain, 23/25.4.1961; <i>Täckholm et al.</i> s.n. (CAI).
<i>Striga hermonthica</i> (Delile) Benth.	Banha, Ballana, 2.1.1964; <i>Boulos</i> s.n. (CAI).
<i>S. asiatica</i> (L.) Kuntze	Abu Zaabal, 14.8.1966; <i>El-Hadidi &amp; Khatab</i> s.n. (CAI).

Materials for examination with light microscopy (LM) were prepared using the acetolysis method described by Erdtman (1960).

Materials for SEM examination were mounted on stubs, coated with gold, examined and photographed by JEOL JSM – 5400 LV Scanning Electron Microscope at 15 KV in the Central Unit of Electron Microscopy, Assuit University, Assuit, Egypt.

Pollen descriptions are based on both optical examinations. The terminology follows Erdtman (1952), Praglowski & Punt (1973) and Praglowski & Raj (1979). A key to the pollen types, a comprehensive description and a photomicrograph for each pollen type are provided.

### **Results and Discussion**

Table (2) summarizes the main palynological features of the 47 species of Scrophulariaceae represented in the flora of Egypt.

The pollen grains varied from subspheroidal to prolate. The subspheroidal grains are either oblate-spheroidal (P/E ranges from 0.93-0.98) or prolate-spheroidal (P/E ranges from 1.00-1.14), subprolate pollen grains (P/E ranges from 1.15-1.28) and prolate grains (P/E ranges from 1.34-1.56).

The polar axis (P) of the species examined ranged from 12.6 µm (*Kickxia hastata*) to 39. µm (*Verbascum sinaiticum*); equatorial diameter (E) ranged from 12.0 µm (*Linaria halaeva*) and 36.0 µm (*Veronica persica*). The largest pollen grains among the examined species are those of the genera: *Bacopa*, *Verbascum* and *veronica* (P, 24-42 µm), and the smallest ones are those of the genera: *Jamesbrittania*, *Anarrhinum*, *Linaria* and *Kickxia* (P, 12-21 µm).

Pollen grains of all species examined have trizonocolpate or trizonocolporate apertures that are equally spaced around the equator. Colpae are fusiform (Plate III) or narrowly oblong (Plate ID), apocolpate (Plate IIA) or syncolpate (Plate IA), with membrane either smooth or granulated (*Veronica*, Plate IIC). The pore in trizonocolporate grain is either lolongate (Plate IVD) or circular (Plate IA).

SEM investigations showed that the surface of the tectum is striate (*Veronica*, Plate IIC&D), colliculate (*Striga*, Plates IIA&B), granulate (*Peplidium*, Plate IIIA). It is coarse reticulate (Plates ID & IVB) to micro-reticulate (Plate IVD).

Seven pollen types are recognized, which can be distinguished through the following key:

#### **Key to pollen types**

- 1.a. Pollen grains in tetrads ..... ***Anticharis type***
- b. Pollen grains in monads ..... 2
- 2.a. Pollen grains with 3-4(-5) zonocolpate apertures ..... 3
- b. Pollen grains with 3-zonocolporate apertures ..... 2
- 3.a. Pollen grains with 4(-5) colpate apertures, exine sculpture colliculate ..... ***Striga type***
- b. Pollen grains with 3- colpate apertures, exine sculpture reticulate, striate or granulate ..... 4
- 4.a. Exine sculpture reticulate ..... ***Bacopa type***
- b. Exine sculpture striate or granulate ..... 5
- 5.a. Mesocolpi striate with granules at colpus membrane ..... ***Veronica type***
- b. Mesocolpi granulate and smooth at colpus membrane ..... ***Peplidium type***

- 6.a. Pollen grains have narrow oblong colpi with rounded ends ..... *Kickxia type*  
b. Pollen grains have fusiform colpi with pointed ends, wide  
at equator ..... *Scrophularia type*

### 1. *Anticharis* type

Pollen grains united in tetrahedral or in decussate tetrads, and rarely in dyads. Single grains 3-syncolporate, prolate to subprolate, mean polar axis ranges from 18.3-27.6  $\mu\text{m}$ , equatorial diam. ranges from 12.6-24.0  $\mu\text{m}$ ; colpi long, fusiform, tapering to the poles and the three colpi are joined through anastomosis. Membrane thin and smooth, pore slightly annulate and operculate, circular; exine sculpture is striate-regulate (Plate IA&B).

Representative species: *Anticharis linearis*, *A. glandulosa*, and *A. arabica*.

### 2. *Striga* type

Pollen grains 4(-5) colpate, prolate-spheroidal to subprolate, mean polar axis ranges from 18.9-21.9  $\mu\text{m}$ , and mean equatorial diam. ranges from 18.0-18.6  $\mu\text{m}$ . Apocolpate, colpi long, narrow, oblong and  $\pm$  tapering at poles, membrane  $\pm$  thick, and stranded; exine sculpture colliculate (Plate IIA&B).

Representative species: *Striga hermonthica* and *S. asiatica*.

### 3. *Bacopa* type

Pollen grains vary from subspheroidal, mean polar axis ranges from 24.3-37.2  $\mu\text{m}$ , equatorial diam. ranges from 20.7-33.0  $\mu\text{m}$ , and prolate p. 18.6  $\mu\text{m}$  and E. 13.8  $\mu\text{m}$ , colpi long, narrow,  $\pm$  rounded at poles, membrane thin and smooth. Exine sculpture is coarse reticulate to microreticulate pattern (Plate ID).

Representative species: *Bacopa monnieri*, *Limosella aquatica*, *Jamesbrittenia dissecta* and *Verbascum fruticosum*.

### 4. *Veronica* type

Pollen mostly prolate-spheroidal, mean polar axis ranges from 29.1-37.8  $\mu\text{m}$ , and equatorial diam. ranges from 25.9-36.0  $\mu\text{m}$ , rarely prolate or subprolate, colpi wide, with densely coarse granules at the membrane and margins. Exine sculpture is striate (Plate IIC&D).

Representative species: *Veronica anagalloides*, *V. anagallis-aquatica var. nilotica*, *V. scardica*, *V. catenata*, *V. cymbalaria*, *V. persica*, *V. polita* and *V. campylopoda*.

### 5. *Peplidium* type

Pollen grains are prolate, mean polar axis is 23.4  $\mu\text{m}$  and equatorial diam. is 15.0  $\mu\text{m}$ , colpi long, narrow, rounded at poles and slightly equatorially constricted, membrane thin and smooth. Exine sculpture is granulate (Plate IIIA).

Representative species: *Peplidium humifusum*.

**Table (2):** Main pollen morphological features of the examined species of Scrophulariaceae represented in the flora of Egypt.

Taxon	Polar axis (µ)		Equatorial diameter		P/E	Colpus		Pollen shape	Aperture type	Colpus shape	Colpus fusion	Exine sculpture
	Range	Mean	Range	Mean		Range	Mean					
<b>I. Subfamily Verbascoideae</b>												
<b>1. Tribe Verbasceae</b>												
<i>Verbascaum sinaiticum</i>	36-42	39	30-36	31.6	1.23	27-36	32.4	Subprolate	Tricolporate	Fusiform	Apocolpate	Microreticulate
<i>V. sinaiticum</i>	30-36	33	24-36	28.8	1.13	18-24	21.0	Prolate-spheroidal	Tricolporate	Fusiform	Apocolpate	Microreticulate
<i>V. eremobium</i> var. <i>sublinguiflorum</i>	18-27	22.8	15-21	17.4	1.31	12-18	14.4	Subprolate	Tricolporate	Fusiform	Apocolpate	Microreticulate
<i>V. purulocolum</i>	24-27	24.3	18-24	20.7	1.19	12-18	14.7	Subprolate	Tricolporate	Narrowly oblong	Apocolpate	Coarse reticulate
<i>V. heteromaculii</i>	24-36	31.2	24-30	27.0	1.15	18-24	22.8	Subprolate	Tricolporate	Fusiform	Apocolpate	Coarse reticulate
<i>V. schimperianum</i>	24-30	26.4	24-30	24.6	1.07	18-24	19.8	Prolate-spheroidal	Tricolporate	Fusiform	Apocolpate	Coarse reticulate
<i>Celsia parviflora</i>	30-36	32.4	24-30	27.6	1.17	24-27	25.2	Subprolate	Tricolporate	Fusiform	Apocolpate	Coarse reticulate
<b>2. Tribe Aptosimeae</b>												
<i>A. nitidaris arabica</i>	24-30	27.5	ca. 24	24.0	1.14	21-24	22.8	Subprolate	Tricolporate	Fusiform	Syncolpate	Microreticulate
<i>A. glomululosa</i>	24-30	27.6	ca. 24	24.0	1.15	18-24	21.6	Subprolate	Tricolporate	Fusiform	Syncolpate	Microreticulate
<i>A. linearis</i>	18-21	18.3	12-15	12.6	1.45	ca. 18	18.0	Prolate	Tricolporate	Fusiform	Syncolpate	Microreticulate
<b>II. Subfamily Scrophularioideae</b>												
<b>3. Tribe Cratioleae</b>												
<i>Lindenbergia indica</i>	15-24	18.9	12-18	14.7	1.28	9-18	12.9	Subprolate	Tricolporate	Narrowly oblong	Apocolpate	Coarse reticulate
<i>Bacopa monnieri</i>	36-42	37.2	30-36	33.0	1.12	24-30	25.2	Prolate-spheroidal	Tricolporate	Narrowly oblong	Apocolpate	Coarse reticulate
<i>Pepilidium huwilianum</i>	21-24	23.4	12-18	15.0	1.56	15-18	17.4	Prolate	Tricolporate	Narrowly oblong	Apocolpate	Granular
<i>Limosella aquatica</i>	24-30	25.2	18-24	21.6	1.16	21-27	24.0	Subprolate	Tricolporate	Narrowly oblong	Apocolpate	Microreticulate
<i>Lindernia parviflora</i>	21-30	20.8	12-24	18.0	1.16	18-21	20.1	Subprolate	Tricolporate	Narrowly oblong	Apocolpate	Microreticulate
<b>4. Tribe Mameleae</b>												
<i>Jamesbrittenia dissecta</i>	12-21	18.6	12-15	13.8	1.34	12-15	12.6	Prolate	Tricolporate	Narrowly oblong	Apocolpate	Microreticulate
<b>5. Tribe Antirrhineae</b>												
<i>Antirrhinum forchhammerii</i>	15-18	17.4	15-18	17.7	0.98	12-15	13.5	Oblate-spheroidal	Tricolporate	Fusiform	Apocolpate	Microreticulate
<i>Mitrospora ornatum</i>	18-30	21.6	18-30	21.6	1.00	15-21	20.3	Prolate-spheroidal	Tricolporate	Fusiform	Apocolpate	Microreticulate
<i>Kickxia elatris</i>	21-27	24.3	18-21	18.9	1.28	15-18	15.9	Subprolate	Tricolporate	Narrowly oblong	Apocolpate	Microreticulate
<i>K. floribunda</i>	21-24	23.4	ca. 18	18.0	1.30	15-18	16.5	Subprolate	Tricolporate	Narrowly oblong	Apocolpate	Microreticulate
<i>K. aegyptiaca</i>	18-21	20.0	ca. 15	15.0	1.33	15-18	17.1	Subprolate/prolat	Tricolporate	Narrowly oblong	Apocolpate	Microreticulate
<i>K. acerbatana</i>	15-18	15.5	15-18	15.3	1.01	12-15	12.9	Prolate-spheroidal	Tricolporate	Narrowly oblong	Apocolpate	Microreticulate
<i>K. rubica</i>	12-18	15.1	ca. 15	15.0	1.00	9-12	9.7	Prolate-spheroidal	Tricolporate	Narrowly oblong	Apocolpate	Microreticulate
<i>K. maculenta</i>	12-18	14.8	12-15	14.5	1.00	9-12	11.1	Prolate-spheroidal	Tricolporate	Narrowly oblong	Apocolpate	Microreticulate
<i>K. gracilis</i>	12-15	14.3	12-15	14.3	1.00	6-9	7.5	Prolate-spheroidal	Tricolporate	Narrowly oblong	Apocolpate	Microreticulate
<i>K. pseudocoparia</i>	12-18	14.1	12-15	12.3	1.14	6-12	8.1	Prolate-spheroidal	Tricolporate	Narrowly oblong	Apocolpate	Microreticulate
<i>K. hirsuta</i>	12-15	12.6	12-15	12.3	1.02	9-12	9.6	Prolate-spheroidal	Tricolporate	Narrowly oblong	Apocolpate	Microreticulate
<i>L. invaria hussiana</i>	12-15	14.1	ca. 12	12.0	1.17	9-12	11.4	Subprolate	Tricolporate	Narrowly oblong	Apocolpate	Microreticulate

Table (2): Continued.

Taxon	Polar axis (μ)		Equatorial diameter		P/E	Colpus		Pollen shape	Aperture type	Colpus shape	Colpus fusion	Exine sculpture
	Range	Mean	Range	Mean		Range	Mean					
<i>L. joppensis</i>	12-15	13.2	12-15	12.6	1.04	9-12	10.8	Prolate-spheroidal	Tricolpate	Narrowly oblong	Apocolpate	Microreticulate
<i>L. aliphonae</i>	15-18	17.7	12-18	15.3	1.15	12-15	12.9	Subprolate	Tricolpate	Narrowly oblong	Apocolpate	Microreticulate
<i>L. simplex</i>	15-18	16.8	12-18	15.3	1.09	12-15	13.2	Prolate-spheroidal	Tricolpate	Narrowly oblong	Apocolpate	Microreticulate
<i>L. tenuis</i>	15-18	17.4	12-15	13.8	1.26	ca. 12	12.0	Subprolate	Tricolpate	Narrowly oblong	Apocolpate	Microreticulate
6. Tribe Scrophularieae												
<i>Scrophularia arguta</i>	24-30	28.8	30-36	30.6	0.93	21-27	23.4	Oblate-spheroidal	Tricolpate	Fusiform	Apocolpate	Coarse reticulate
<i>S. deserti</i>	ca. 24	24.0	18-24	21.3	1.12	15-18	17.4	Prolate-spheroidal	Tricolpate	Fusiform	Apocolpate	Coarse reticulate
<i>S. sinatica</i>	18-33	25.9	15-30	23.4	1.11	15-24	19.8	Prolate-spheroidal	Tricolpate	Fusiform	Apocolpate	Coarse reticulate
<i>S. canina</i>	21-24	22.5	18-24	19.5	1.16	12-18	13.2	Subprolate	Tricolpate	Fusiform	Apocolpate	Coarse reticulate
<i>S. libanotica</i>	ca. 24	24.0	18-24	19.8	1.21	15-18	17.4	Subprolate	Tricolpate	Fusiform	Apocolpate	Coarse reticulate
III. Subfamily Rhinanthoideae												
7. Tribe Veroniceae												
<i>Veronica anagallifolias</i>	27-30	28.5	24-27	24.3	1.17	21-24	22.8	Subprolate	Tricolpate	Narrowly oblong	Apocolpate	Striate
<i>V. anagallis-aquatica</i> var. <i>nilotica</i>	27-30	29.7	24-30	27.5	1.08	21-24	23.7	Prolate-spheroidal	Tricolpate	Narrowly oblong	Apocolpate	Striate
<i>V. scaridica</i>	27-30	29.1	21-30	25.9	1.12	21-24	23.1	Prolate-spheroidal	Tricolpate	Narrowly oblong	Apocolpate	Striate
<i>V. catenata</i>	30-36	33.6	27-33	30.3	1.10	24-30	27.6	Prolate-spheroidal	Tricolpate	Narrowly oblong	Apocolpate	Striate
<i>V. cymbalaria</i>	30-36	32.4	24-36	29.4	1.10	18-30	21.6	Prolate-spheroidal	Tricolpate	Narrowly oblong	Apocolpate	Striate
<i>V. persica</i>	36-42	37.8	ca. 36	36.0	1.05	24-30	31.4	Prolate-spheroidal	Tricolpate	Narrowly oblong	Apocolpate	Striate
<i>V. polita</i>	33-36	35.1	24-30	25.8	1.36	24-27	25.5	Subprolate	Tricolpate	Narrowly oblong	Apocolpate	Striate
<i>V. conopliopoda</i>	33-36	35.4	27-36	30.9	1.14	18-24	22.8	Prolate-spheroidal	Tricolpate	Narrowly oblong	Apocolpate	Striate
8. Tribe Buchneraeae												
<i>Striga hermonitica</i>	18-21	18.9	18-21	18.6	1.02	12-15	12.9	Prolate-spheroidal	Tetra(penta-) Colpate	Oblong	Apocolpate	Colliculate
<i>S. asariatica</i>	21-24	21.9	ca. 18	18.0	1.21	12-15	12.9	Subprolate	Tricolpate	Oblong	Apocolpate	Colliculate

## 6. *Kickxia* type

Pollens are subprolate, mean polar axis ranges from 14.1-24.3  $\mu\text{m}$ . and equatorial diam. 12.0-18.9  $\mu\text{m}$ , or prolate-spheroidal P. 12.6-16.8  $\mu\text{m}$  and E. 12.3-15.3  $\mu\text{m}$ ; apocolpate, colpi long, narrow or slightly wide, narrowly oblong with margins that are parallel and rounded at poles; pore rounded with thin membrane as in *Linaria* and *Lindenbergia* (Plate IIIB) or a thick one in the form of a bridge, formed by the extension of the lateral margins of the colpus as in *Lindernia* and *Kickxia* (Plate IIIC), lolongate rarely circular. Exine sculpture micro-reticulate.

Representative species: *Lindenbergia indica*, *Lindernia parviflora*, *Kickxia elatine*, *K. floribunda*, *K. aegyptiaca*, *K. acerbiana*, *K. nubica*, *K. macilentia*, *K. gracilis*, *K. pseudoscoparia*, *K. hastata*, *Linaria haelava*, *L. joppensis*, *L. albifrons*, *L. simplex* and *L. tenuis*.

**Table (3):** Distribution of the pollen types, with special reference to the number among the genera and their related species.

Taxon				Pollen type
Subfamily	Tribe	Genus	No. of species	
Verbascoideae	Verbasceae	<i>Verbascum</i>	6	<i>Scrophularia</i>
		<i>Celsia</i>	1	<i>Scrophularia</i>
	Aptosimeae	<i>Anticharis</i>	3	<i>Anticharis</i>
Scrophularoideae	Gratioleae	<i>Lindenbergia</i>	1	<i>Kickxia</i>
		<i>Lindernia</i>	1	<i>Kickxia</i>
		<i>Peplidium</i>	1	<i>Peplidium</i>
		<i>Bacopa</i>	1	<i>Bacopa</i>
		<i>Limosella</i>	1	<i>Bacopa</i>
		<i>Jamesbrittania</i>	1	<i>Bacopa</i>
	Manuleae Antirrhineae	<i>Kickxia</i>	9	<i>Kickxia</i>
		<i>Linaria</i>	5	<i>Kickxia</i>
		<i>Anarrhinum</i>	1	<i>Scrophularia</i>
	Scrophularieae	<i>Misopates</i>	1	<i>Scrophularia</i>
		<i>Scrophularia</i>	5	<i>Scrophularia</i>
Rhinanthoideae	Veroniceae	<i>Veronica</i>	8	<i>Veronica</i>
	Buchnerae	<i>Striga</i>	2	<i>Striga</i>

## 7. *Scrophularia* type

Pollen grains vary from prolate-spheroidal to oblate-spheroidal or subprolate; apocolpate, colpi long, wide, fusiform with the widest part near equator and tapering at poles; membrane thick and smooth, pores operculate, lolongate except in spp. of *Verbascum* & *Celsia* where it is circular. Exine sculpture coarse reticulate or micro-reticulate (Plate IVA-D).

Representative species: *Anarrhinum forskahlii*, *Misopates orontium*, *Celsia parviflora*, *Scrophularia arguta*, *S. deserti*, *S. sinaica*, *S. canina*, *S. libanotica*, *Verbascum sinaiticum*, *V. sinuatum*, *V. eremobium*, var. *subsinguliform*, *V. letourneuxii* and *V. schimperianum*.

The characters used to delimit the seven pollen morphotypes are relatively widely variable and are reliable for comparative purposes.

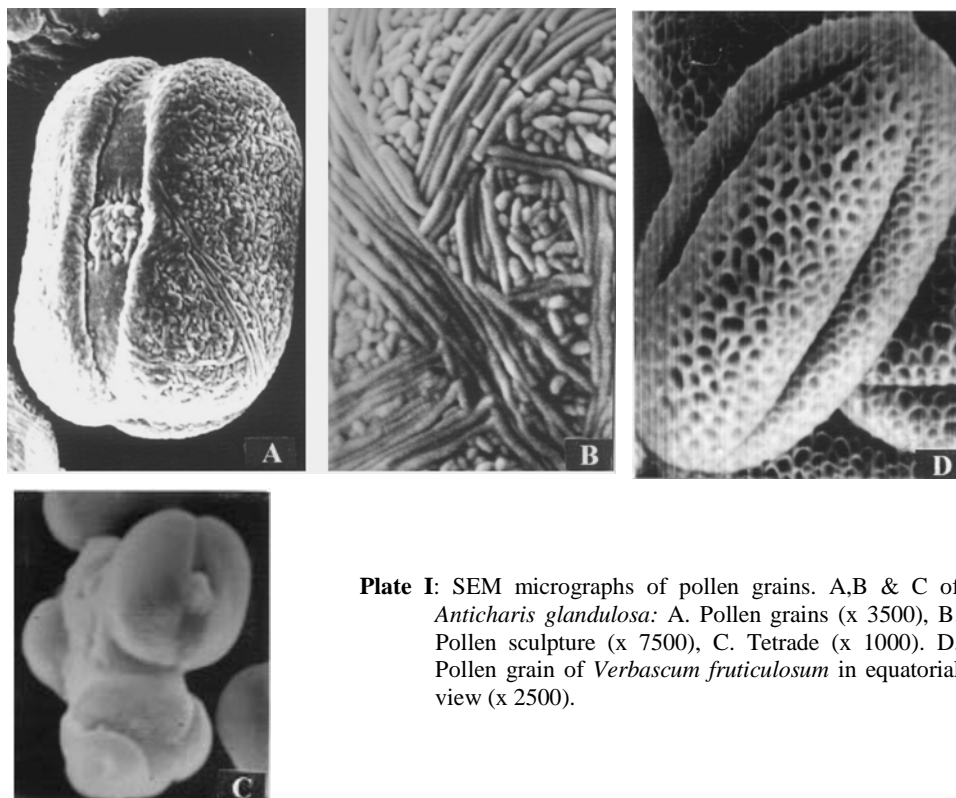


Table (3) gives the distribution of the pollen types among the investigated taxa, which can be followed through the numbers of the representative taxa.

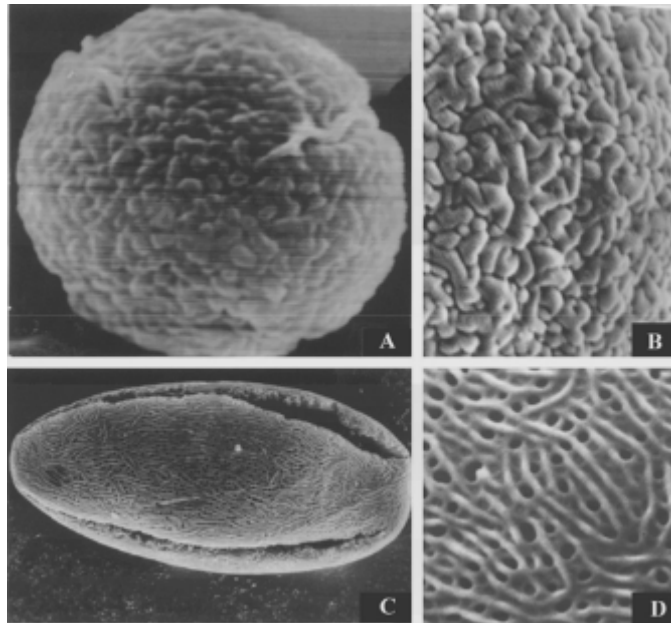
It will be noticed that *Kickxia*, *Scrophularia* and *Veronica* pollen types are represented by 16,14 and 8 species respectively. The greatest diversity is exhibited in *Scrophularia* pollen type with *Verbascum* and *Celsia* belonging to Verbascoideae; as well as *Anarrhinum* and *Misopates*; and *Scrophularia* of Scrophularoideae. Although represented by a higher number of 16 species, *Kickxia* pollen type is only represented by taxa belonging to Scrophularoideae viz. *Lindenbergia*, and *Lindernia* of Gratiroleae, as well as *Kickxia* and *Linaria* of Antirrhineae. The *Veronica* pollen type is only known among the *Veronica* species, tribe Veroniceae of Rhinanthoideae.

The other four pollen types are represented by 1-3 species each. *Anticharis* (tribe Aptosimeae) is characterized by the *Anticharis* pollen type which is characterized by pollen tetrads and syncolporate apertures (Plate IA,B&C). According to Verghese (1968), *Anticharis* is the only genus of tribe Aptosimeae that appears to be unique in the family in having tetrad pollen grains, which is considered as an advanced character in the family.

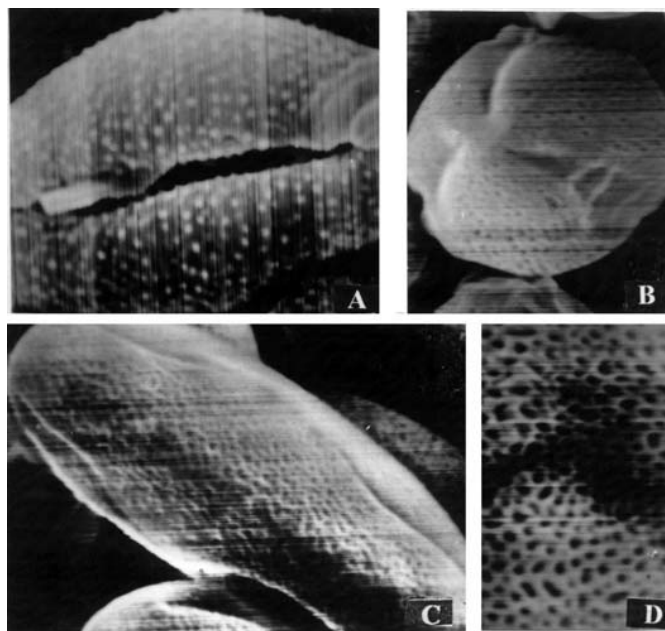
*Jamesbrittania* (tribe Manuleae), share *Bacopa* and *Limosella* (tribe Gratiroleae) in its pollen characters and are assigned to the *Bacopa* pollen type (including *Verbascum fruticosum*, Plate ID). The number of aperture and exine sculpture distinguish between *Veronica* and *Striga* pollen types. The *Veronica* pollen type is characterized by tricolpate grains with striate exine sculpture (Plate IIC&D); the *Striga* pollen type is characterized by tetra or penta colpate grains and colliculate exine sculpture (Plate IIA&B).



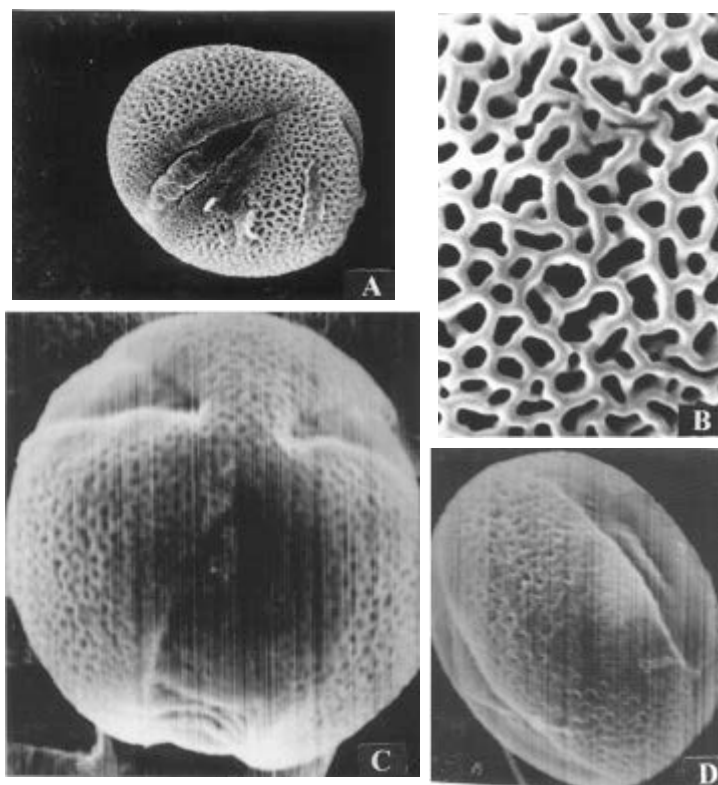
**Plate I:** SEM micrographs of pollen grains. A,B & C of *Anticharis glandulosa*: A. Pollen grains (x 3500), B. Pollen sculpture (x 7500), C. Tetrad (x 1000). D. Pollen grain of *Verbascum fruticosum* in equatorial view (x 2500).



**Plate II:** SEM micrographs of pollen grains: A & B of *Striga hermonthica*: A. Polar view (x 2500), B. Pollen sculpture (x 7500). C & D Pollen grain of *Veronica anagalloides*: C. Equatorial view (x 2500), D. Pollen sculpture (x 7500).



**Plate III:** SEM micrographs of pollen grains: A of *Peplidium humifusum* in equatorial view (x 2500). B. of *Lindenbergia indica* in polar view (x 2500), C & D. of *Kickxia aegyptiaca*: C. Equatorial view (x 2500), D. Pollen sculpture (x 7500).



**Plate IV:** SEM micrographs of pollen grains: A & B of *Scrophularia arguta*: A. Equatorial view (x 2500), B. Pollen sculpture (x 7500). C. of *Verbascum eremobium* in polar view (x 2500). D. of *Misopates orontium* in equatorial view (x 2500).

### **Acknowledgments**

The authors wish to acknowledge Prof. Dr. M. N. El-Hadidi, Cairo University, who kindly read the manuscript and gave useful comment.

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