

Palynological study on some species of Convolvulaceae and its taxonomic significance

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Pollen morphology of 34 species representing eight genera of Convolvulaceae was investigated using light and scanning electron microscopy. Three pollen types were recognized viz. Tricolpate pollen type, Pantocolpate pollen type and Pantoporate pollen type. Description of each type, a key to the investigated taxa as well as LM and SEM micrographs of pollen grains are provided.

Key Words: Convolvulaceae, Egypt, palynology, pollen morphology, taxonomy.

Introduction

According to Lawrence (1951), Convolvulaceae comprises 50 genera and 1200 species or more. It is represented in Egypt by 9 genera (excluding *Cuscuta*) with forty one species (Boulos 1995, 2002). The family Convolvulaceae is an eurypalynous family (Erdtman, 1952). Erdtman (1963) regarded that Convolvulaceae is one of many families which need further pollen morphological investigation for taxonomical studies. Large pollen grains of *Ipomoea* and allied genera would be particularly suitable for studies in morphogenetics, sporoderm stratification and fine structure.

One of the first palynological studies on the Convolvulaceae was made by Hallier (1893). He endeavoured to make a natural system of classification on the basis of external morphology and anatomy. However he accorded importance to the gross pollen morphological characters and divided the family into two groups: "Psiloconiae" and "Echinoconiae." The pollen grains in the "Psiloconiae" are either psilate or with granulated

surfaces, e.g., *Convolvulus*, *Evolvulus*, *Jacquemontia*, *Operculina*,...etc. The "Echinoconiae" group consists of genera such as *Argyreia*, *Ipomoea*,...etc., where the pollen grains possessed spines. He reported also the presence of tri- tetra- penta- hexa- pantocolpate and pantoporate grains in this family. In the division of Gamble (1923), the family was divided into two groups on the basis of echinate and non-echinate pollen grains with the genus *Convolvulus* included in the latter one. Sayeeduddin *et al.*, (1942) described the pollen morphology of *Ipomoea pulchella* Roth, and found that pollen grains are polyporate, with a thick nexine and echinate. Faegri and Iversen (1950, 1964) described some psilate pollen grains of *Convolvulus*. Erdtman (1952) described the pollen morphology of 20 genera and 50 species from this family. He divided the family into two groups: "*Ipomoea* type", the other group is broadly classified relative to Hallier's "Echinoconiae" and "Psiloconiae" groups. In the "*Ipomoea* type" the pollen grains are polyporate, very large in size, crassinexinous and spiniferous, e.g., *Argyreia*, *Ipomoea*, *Exogonium*, *Calonyction*,...etc. The pollen grains of "other types" are distinctly with punctate tectum and this group comprises the genera like *Aniseeia*, *Cardiochlamys*, *Convolvulus*,...etc. Natarajan (1957) observed smooth exine surface in *Evolvulus alsinoides* and *Merremia tridentata*, granulated surface in *Jacquemontia coerulea* and echinate surface in *Ipomoea*. Erdtman *et al.*, (1961), in their study of the Scandinavian pollen flora, described the pollen morphology of *Calystegia sepium* and *Convolvulus arvensis* in detail. Nair and Rehman (1963) described the pollen morphology of a few genera from this family. According to them pollen grains with excrescences were all pantoporate, whereas reticulate grains were either 3-zonocolpate or 5-zonocolpate or pantocolpate.

Nair (1965a) described the pollen morphology of *Ipomoea pilosa*, *I. purpurea* and *Operculina turpenthum*. Jain and Nanda (1966) described the pollen morphology of *Convolvulus pluricaulis*. Manitz (1969) examined several species from 42 genera of Convolvulaceae. According to him, in the basic type the infratectal bacula are not branched and the tectum is smooth and punctate. He showed that suprtectal processes are absent in the genera like *Dicranostyles*, *Dipteropeltis*, *Erycibe*,...etc. In a few exceptional cases the tectum possesses little spines. He considered *Cardiochlamys* the only type which acts as missing link between Hallier's "Psiloconiae" and "Echinoconiae".

The taxonomy of this family has been studied by many workers, among these studies are the systems of classification by Bentham and Hooker (1873), Hooker (1885), Hallier (1893), Peter (1897) and Van Ooststroom (1953). The aim of the present work is to study the pollen morphological characters of some members of this family (excluding *Cuscuta* spp.) which may prove its values in systematic treatments. Pollen will be studied according to different features (shape, size, apertures, wall stratification.....etc.). The significance of recognized pollen types will be taxonomically evaluated.

Material and Methods

Pollen materials were removed from the herbarium specimens (Table 1) that kept in Cairo University Herbarium (CAI) as well as those in the Herbarium of the Faculty of science in Sohag (SHG a proposed Acronym). Plant identification were according to Boulos (1995 & 2002). Light microscopy (LM) observations were carried out on acetolyzed pollen and prepared according to Erdtman (1952, 1960). SEM observations were made on acetolyzed grains coated with a thin layer of gold/palladium for 3 minutes using a EMITECH K550 sputter according to the Erdtman method (1969). Microscopic examinations were carried out with a JEOL-6300 SEM of the Central Lab., Faculty of Science, South Valley University, Qena, Egypt. The terminology and main morphological concepts were based on Potonié (1934), Wodehouse (1935), Chanda (1962, 1965), Erdtman (1952, 1969, 1970), Erdtman *et al.* (1961), Erdtman & Straka (1961), Dimon (1971) and Faegri & Iversen (1975).

Regarding the measurements, the following points are to be noted: the measurements were based on ten readings and in all cases the range of size was provided. In pantocolpate type of pollen grains, the mesocolpium distance was measured between two parallel colpi. In echinate type of pantoporate pollen grains, the length of the spines included the basal projections. Sexine thickness included the spine and columella length. The diameter of the echinate grain was measured including the length of the spines. In both pantocolpate and pantoporate pollen types measuring of the pollen grains took place only in one diameter due to spherical shape of pollen.

Table (1). List of the studied spp. with relevant information about their herbarium samples.

Taxon	Place of collections
<i>Convolvulus althaeoides</i> L.	Sand dunes of Abu Sir, Mariut (CAI), V. Täckh.
<i>C. arvensis</i> L.	Assiut Uni. Garden (CAI), N. El Hadidi.
<i>C. dorycnium</i> L.	Palaestina, Mt Carmel (SHG), K. Abdel khalik from (WAG).
<i>C. fatmensis</i> Kunze	Dakhla Oasis, Bed Kulo (SHG), K. N. Abdel khalik.
<i>C. glomeratus</i> Choisy	Gebel Elba, Wadi Mawaw (CAI), M. Hassib.
<i>C. humilis</i> Jacq.	Algerra, de Saida (SHG), K. Abdel khalik from (WAG).
<i>C. hystrix</i> Vahl	El-Kharga Oasis (CAI), S. El-Ngar. Paris,
<i>C. lanatus</i> Vahl	Mariut, Burgel Arab (CAI), M. Zareh.
<i>C. lineatus</i> L.	Gebel Akhdar, Wadi El Teir (CAI).
<i>C. oleifolius</i> Desr.	Ras El Hekma (CAI).
<i>C. pilosellifolius</i> Desr.	Siwa, Een El Saghier road (CAI).
<i>C. prostratus</i> Forssk.	Gebel Elba, Karam Elba (SHG), K. N. Abdel khalik.
<i>C. rhyniospermus</i> Choisy	Gebel Elba, Wadi Yahameib (SHG), K. N. Abdel khalik.
<i>C. scammonia</i> L.	7 km east of Al- Hemma (CAI).
<i>C. schimperii</i> Boiss.	Gebel El Asfar (CAI).
<i>C. secundus</i> Desr.	Palaestina, Tel-Aviv (SHG), K. Abdel khalik from (WAG).
<i>C. siculus</i> L.	Gebel Elba, Karam Elba (SHG), K. N. Abdel khalik.
<i>C. stachydifolius</i> Choisy	Turcomanniae in (SHG), K. N. Abdel khalik from (WAG).
<i>Cressa cretica</i> L.	El-Faiyum, El-Roda (CAI), Monier Abdel Ghani.
<i>Evolvulus alsinoides</i> (L.) L.	Gebel Elba, Wadi Merakwan (CAI), M. Kassas <i>et. al.</i>
<i>E. nummularius</i> (L.) L.	Zaire, de La Caramba (SHG), K. Abdel khalik from (WAG).
<i>Jacquemontia tammifolia</i> (L.) Griseb.	Kordofan-Sudan (CAI), J. R. Shabetai.
<i>Merremia aegyptia</i> (L.) Urb.	Gebel Elba, Wadi Shallal (CAI), V. Täckh. <i>et. al.</i>
<i>M. semisagittata</i> (Peter) Dandy	Saudi Arabia, Gedda (CAI), Khattab and Shabetai.
<i>Seddera arabica</i> (Forssk.) Choisy	Gebel Elba (SHG), K. N. Abdel khalik, M. Hassib.
<i>S. latifolia</i> Hochst. & Steud.	Gebel Elba, Wadi Yahameib (CAI), M. Hassib.
<i>Calystegia silvatica</i> (Kit.) Griseb.	Sweden, Uppland (CAI). Dr. A. El-Gazzar.
<i>Ipomoea carnea</i> Jacq.	Uni. Garden, Giza (CAI), V. Täckh.
<i>I. cairica</i> (L.) Sweet	Beheira, Shubra Khit (CAI), Alaa Amer
<i>I. eriocarpa</i> R. Br.	Behiera, Abu Qir (CAI) , Alaa Amer
<i>I. imperati</i> (Vahl) Griseb.	El Shahabiya-Baltim (CAI), N. El-Hadidi
<i>I. obscura</i> (L.) Ker Gawl.	Wadi Akaw, Gebel Elba (SHG), K. N. Abdel khalik.
<i>I. pes-caprae</i> (L.) R. Br.	Giza (CAI), V. Täckh.
<i>I. sinensis</i> (Desr.) Choisy	Gebel Elba, Wadi Yahameib (CAI), M. Hassib.

CAI = Cairo University Herbarium, SHG = Sohag University Herbarium, (proposed...), WAG = Wagnen herbarium (Holland).

Results

The palynological data of the investigated taxa were summarized in Tables 2 and 3. Based on the number and the distribution of apertures on the pollen surface, three main pollen types were distinguished: tricolpate, pantocolpate and pantoporate. The genera and species of each pollen type were arranged alphabetically.

1. Tricolpate pollen type

Pollen grains 3-zonocolpate, suboblate to subprolate ($P/E = 0.87-1.26$), $31.0-70.1 \times 35.5-70.8 \mu\text{m}$. Apocolpium diameter $5.5-13.5 \mu\text{m}$. Colpi $20.0-53.7 \mu\text{m}$ long, $4.0-11.9 \mu\text{m}$ wide, with tapered to pointed ends. Mesocolpium $8.3-33.3 \mu\text{m}$ wide. Exine $2.9-5.5 \mu\text{m}$ thick at centre of mesocolpia, decreasing fairly in thickness towards the aperture margins. Sexine thicker than nexine, tectate, with perforate to perforate-microreticulate sculpture; the intratectal elements thin, minute, radial and supported by fairly long, stout and dichotomously branched infratectal columellae except in *Cressa cretica* the intratectal elements supported by slightly long, thin and unbranched infratectal columellae. Nexine $1.0-2.0 \mu\text{m}$ thick, increasing in thickness towards the aperture margins (Plate 1, Figs. 1-5 and Plate 2, Figs. 2-4 & 8; Tables 2, 3).

This group included all the studied species of *Convolvulus* (17), *Merremia* (2), *Seddera* (2), *Cressa cretica* and *Jacquemontia tamnifolia*.

2. Pantocolpate pollen type

Pollen grains pantocolpate, spheroidal $33.0-36.0$ ($24.0-40.0$) μm . Colpi short, $9.0-11.0 \mu\text{m}$ long, $2.0-3.0 \mu\text{m}$ wide, more or less slit-like in appearance. Mesocolpium $17.0-19.0 \mu\text{m}$ wide. Exine $2.5-3.0 \mu\text{m}$ thick at centre of mesocolpia decreasing slightly in thickness towards the aperture margins. Sexine as thick as nexine, tectate, with perforate-microreticulate sculpture; sculpturing diameter decreased towards the aperture margins; the intratectal elements thin, minute, radial and supported by thin and short infratectal unbranched columellae. Nexine 1.5 ($1.0-3.0$) μm thick, increasing in thickness towards the aperture margins (Plate 1, Fig. 7 and Plate 2, Fig. 5; Tables 2 & 4).

This group included *Evolvulus alsinoides* & *E. nummularius*.

3. Pantoporate pollen type

Pollen grains pantoporate, spheroidal, 70.8-119.5 (50.0-130.0) μm . Pore circular, 5.6-7.2 (4.0-10.0) μm in diameter, provided with granulated pore membrane. Around each pore there was an extraporal spinulose ring-shaped area (margo) in *Ipomoea*, but in *Calystegia silvatica* pollen pore were irregular in shape, with granulated pore membrane, sometimes adjacent pores unite to form channels. Exine 6.8-18.9 μm thick at centre of mesoporia. Sexine as thick as nexine, tectate, with reticulate-echinate sculpture in *Ipomoea*, but in *Calystegia silvatica* sculpture is perforate with minute processes; the intratectal elements thin, minute, radial and supported by thin and short infratectal unbranched columellae. In *Ipomoea* spines broad at base, gradually tapering towards the apex with more or less rounded tip, but in *Calystegia silvatica* minute supracteal processes were present. In optical section the basal projections of spines and bacula seem to form an undulating surface at the spine base (Sengupta, 1972). Nexine 4.0-6.0 μm thick, increasing in thickness towards the aperture margins (Plate 1, Fig. 6 and Plate 2, Figs. 6-7; Tables 2 & 4).

This group included *Calystegia silvatica* and *Ipomoea* (7 species)..

Discussion

Palynological characters of the studied species of Convolvulaceae proved to be useful in the distinction between three groups. The pollen grains were usually 3-zonocolpate, pantocolpate or pantoporate with simple apertures (colpi or pores). According to pollen class three pollen types were distinguished, **The tricolpate pollen type**, is characteristic to *Convolvulus* (17 species), *Cressa cretica*, *Jacqmontia tamnifolia*, *Merremia* (2 species), and *Seddera* (2 species). **The pantocolpate pollen type**, in which the pollen grains with very short colpi (9.0-11.0 μm), with slit-like openings and arranged in a definite geometric pattern (Wodehouse, 1935), is characteristic to genus *Evolvulus* (2 species). **The pantoporate pollen type**, in which the pollen grains with circular pores spread over the surface forming a regular pattern, is characteristic to *Ipomoea* (7 species) or with pores which were irregular in pattern, sometimes adjacent pores unite to form channels as in *Calystegia silvatica*.

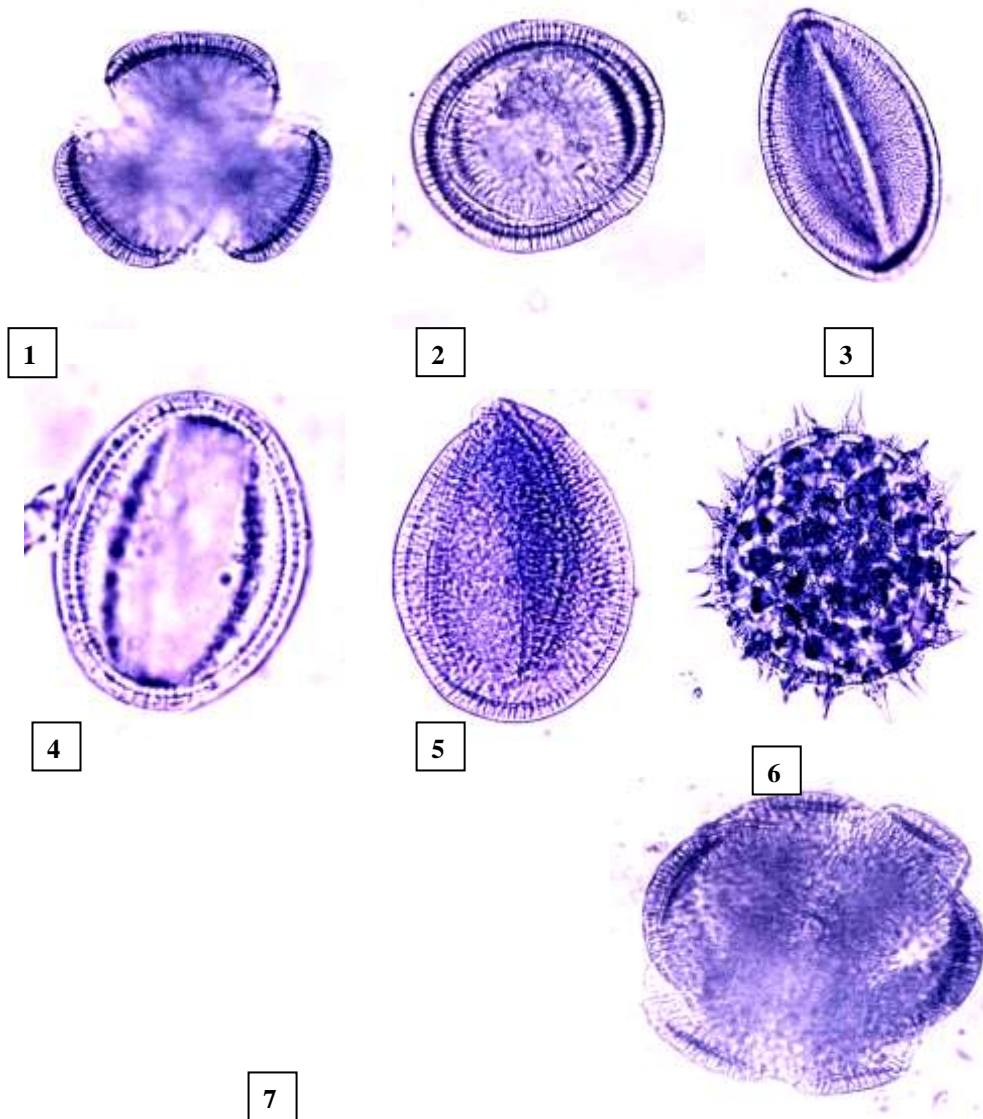


Plate 1: LM observations of acetolysed pollen grains.

1. *Convolvulus secundus* (polar view, x = 1000), 2. *Convolvulus dorycinum* (oblique equatorial view, x = 1000), 3. *C. scammonia* (equatorial view, x = 1000), 4. *Cressa cretica* (equatorial view, x = 1000), 5. *Merremia semisagittata* (equatorial view, x = 1000), 6. *Ipomoea carnea* (x = 400), 7. *Evolvulus alsinoides* (polar view, x = 1000).

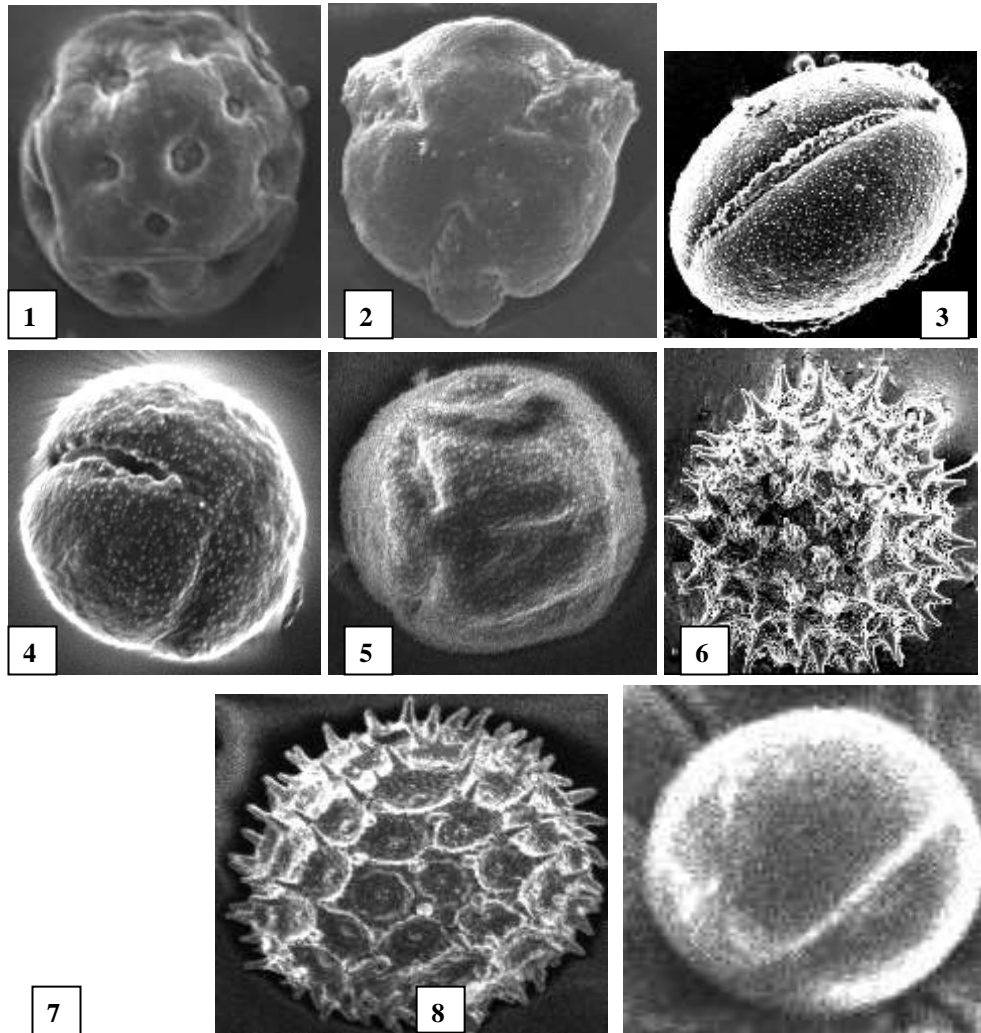


Plate 2: SEM observations of acetolyzed pollen grains

1. *Calystegia silvatica* (x = 1000), 2. *Convolvulus fatmensis* (polar view, x = 1300), 3. *Convolvulus arvensis* (equatorial view, x = 1300), 4. *Cressa cretica* (oblique polar view, x = 1700), 5. *Evolvulus alsinoides* (polar view, x = 2000), 6. *Ipomoea carnea* (x = 400), 7. *Ipomoea eriocarpa* (x = 1000), 8. *Seddera latifolia* (polar view, x = 1000).

Table (2). Tabular summary showing the Pollen Description of the studied Species.

Species	Pollen Class	Aper. No.	Colpi Ends	Pore Shape	Tectum ornam.	Sculp. Type	Columellae State	Sex./ Nex.
<i>Convolvulus althaeoides</i>	I	3	Tap.	—	Perf.	Mech.	Branched	1
<i>C. arvensis</i>	I	3	Tap.	—	Perf.	Mech.	Branched	1
<i>C. dorycnium</i>	I	3	Tap.	—	Perf.	Mech.	Branched	1
<i>C. fatmensis</i>	I	3	Tap.	—	Perf.	Mech.	Branched	1
<i>C. glomeratus</i>	I	3	Tap.	—	Perf.	Mech.	Branched	1
<i>C. humilis</i>	I	3	Tap.	—	Perf.	Mech.	Branched	1
<i>C. hystrix</i>	I	3	Tap.	—	Perf.	Mech.	Branched	1
<i>C. lanatus</i>	I	3	Tap.	—	Perf.	Mech.	Branched	1
<i>C. lineatus</i>	I	3	Tap.	—	Perf.	Mech.	Branched	1
<i>C. oleifolius</i>	I	3	Tap.	—	Perf.	Mech.	Branched	1
<i>C. pilosellifolius</i>	I	3	Tap.	—	Perf.	Mech.	Branched	1
<i>C. prostratus</i>	I	3	Tap.	—	Perf.	Mech.	Branched	1
<i>C. rhyniospermus</i>	I	3	Tap.	—	Perf.	Mech.	Branched	1
<i>C. scammonia</i>	I	3	Tap.	—	Perf.	Mech.	Branched	1
<i>C. schimperi</i>	I	3	Tap.	—	Perf.	Mech.	Branched	1
<i>C. secundus</i>	I	3	Tap.	—	Perf.	Mech.	Branched	1
<i>C. siculus</i>	I	3	Tap.	—	Perf.	Mech.	Branched	1
<i>C. stachydifolius</i>	I	3	Tap.	—	Perf.	Mech.	Branched	1
<i>Cressa cretica</i>	I	3	Tap.	—	Perf.- micr.	Mech.	Unbranched	1
<i>Jacquemontia tammifolia</i>	I	3	Tap.	—	Perf.	Mech.	Branched	1
<i>Merremia aegyptia</i>	I	3	Point.	—	Perf.	Mech.	Unbranched	1
<i>M. semisagittata</i>	I	3	Point.	—	Perf.	Mech.	Unbranched	1
<i>Seddera arabica</i>	I	3	Tap.	—	Perf.	Mech.	Branched	1
<i>Seddera latifolia</i>	I	3	Tap.	—	Perf.	Mech.	Branched	1
<i>Evolvulus alsinoides</i>	II	Pa. col.	S.-like	—	Perf.	Mech.	Unbranched	2
<i>E. nummularius</i>	II	Pa. col.	S.-like	—	Perf.	Mech.	Unbranched	2
<i>Calystegia silvatica</i>	III	Pa. por.	—	Circ.	Perf.	♣	Branched	1
<i>Ipomoea carnea</i>	III	Pa. por.	—	Circ.	Ret.	Echin.	Unbranched	2
<i>I. cairica</i>	III	Pa. por.	—	Circ.	Ret.	Echin.	Unbranched	2
<i>I. eriocarpa</i>	III	Pa. por.	—	Circ.	Ret.	Echin.	Unbranched	2
<i>I. imperati</i>	III	Pa. por.	—	Circ.	Ret.	Echin.	Unbranched	2
<i>I. obscura</i>	III	Pa. por.	—	Circ.	Ret.	Echin.	Unbranched	2
<i>I. pes-caprae</i>	III	Pa. por.	—	Circ.	Ret.	Echin.	Unbranched	2
<i>I. sinensis</i>	III	Pa. por.	—	Circ.	Ret.	Echin.	Unbranched	2

Aper. No. = apertures number, Circ. = circular, Echin. = echinate, Mech. = microechinate, Pa. col. = pantocolpate, Pa. por. = pantoporate, Per. = perforate, Per.-micr. = perforate-microreticulate, Point. = pointed, Ret. = reticulate, Sculp. Type = sculpture type, Sex./ Nex. = Sexine thickness/Nexine thickness, S. like = slit-like, Tap. = tapered, ♣ = tectum without processes. I = Pollen 3-zonocolpate, II = Pollen Pantocolpate, III = Pollen Pantoporate, 1 = Sexine thicker than nexine, 2 = Sexine as thick as nexine.

Table (3). Tabular summary showing the pollen grains dimensions for some Convolvulaceae species.

Species	P. (μ).	E. (μ).	P/E.	Pollen Shape	Sex. th. (μ).	Nex. th. (μ).	Colp. len. (μ).	Colp. wid. (μ).	Apo. diam. (μ).	Meso. diam. (μ).
<i>Convolvulus althaeoides</i>	67.0(60-71)	53.0(45-60)	1.26	Subpro.	4.5(3-6)	1.5(1-3)	42.0(27-50)	8.0(6-10)	10.0(5-12)	24.0(20-30)
<i>C. arvensis</i>	61.8(55-70)	62.3(55-70)	0.99	Ob.-Sh.	4.7(4-6)	2.0(1-3)	29.3(25-40)	10.0(9-11)	12.5(10-15)	32.8(30-35)
<i>C. dorycinum</i>	51.1(44-57)	49.6(47-55)	1.03	Pro.-Sh.	4.2(4-5)	1.5(1-3)	36.6(30-40)	9.0(7-10)	10.8(10-15)	29.0(20-35)
<i>C. fatmensis</i>	53.3(50-60)	52.9(50-56)	1.01	Pro.-Sh.	4.5(4-5)	1.5(1-3)	32.9(30-35)	10.3(7-17)	10.0(8-12)	30.4(28-35)
<i>C. glomeratus</i>	50.4(50-55)	56.3(55-60)	0.89	Ob.-Sh.	4.7(4-5)	1.5(1-3)	41.3(40-45)	9.3(8-10)	10.0(8-11)	29.4(25-35)
<i>C. humilis</i>	48.3(45-50)	45.0(40-50)	1.07	Pro.-Sh.	4.7(4-5)	1.0(1-2)	32.5(30-35)	10.0(8-11)	10.0(9-11)	31.0(25-35)
<i>C. hystrix</i>	52.7(45-60)	47.6(40-52)	1.11	Pro.-Sh.	4.2(3-5)	1.0(1-2)	35.7(30-40)	9.7(8-10)	13.3(10-15)	30.0(25-35)
<i>C. lanatus</i>	57.0(45-64)	54.0(45-60)	1.06	Pro.-Sh.	4.5(4-5)	1.0(1-2)	34.5(30-40)	8.0(5-10)	11.0(7-14)	25.0(20-30)
<i>C. lineatus</i>	52.0(45-62)	49.6(44-60)	1.05	Pro.-Sh.	4.8(4-7)	1.5(1-3)	37.2(30-43)	8.0(5-10)	10.8(10-15)	26.4(16-35)
<i>C. oleifolius</i>	48.6(45-50)	50.8(45-60)	0.96	Ob.-Sh.	4.2(4-5)	1.5(1-3)	38.3(35-40)	10.0(9-11)	9.25(7-10)	33.3(30-40)
<i>C. pilosefolius</i>	56.0(45-64)	51.4(45-60)	1.09	Pro.-Sh.	4.7(4-5)	2.0(1-3)	35.7(30-40)	8.3(5-10)	9.0(7-10)	25.6(20-30)
<i>C. prostratus</i>	50.5(40-60)	50.1(45-55)	1.01	Pro.-Sh.	4.6(4-5)	1.0(1-2)	37.2(35-40)	11.1(10-15)	11.5(10-15)	30.5(25-35)
<i>C. rhyniospermus</i>	44.8(40-48)	40.6(35-50)	1.10	Pro.-Sh.	4.0(3-5)	2.0(1-3)	30.0(25-40)	8.2(6-10)	9.0(5-10)	23.9(20-30)
<i>C. scammonia</i>	65.8(60-70)	62.0(52-65)	1.06	Pro.-Sh.	4.5(4-5)	2.0(1-3)	42.0(40-50)	10.0(5-15)	11.5(10-15)	32.5(30-35)
<i>C. schimperii</i>	50.0(48-55)	49.5(47-55)	1.01	Pro.-Sh.	5.0(4-6)	1.5(1-3)	40.5(37-44)	10.5(8-12)	10.0(9-11)	28.0(25-30)
<i>C. secundus</i>	55.5(48-65)	55.4(50-60)	1.00	Sh.	5.3(4-6)	2.0(1-3)	38.1(30-45)	11.9(10-15)	11.7(10-15)	30.8(22-35)
<i>C. siculus</i>	48.2(45-50)	47.6(45-50)	1.01	Pro.-Sh.	5.0(4-6)	1.5(1-3)	31.7(30-35)	7.9(5-10)	8.4(5-10)	30.7(30-35)
<i>C. stachydifolius</i>	46.0(43-50)	52.8(48-60)	0.87	Subob.	4.2(4-5)	1.5(1-3)	37.2(30-43)	8.7(6-10)	10.0(9-11)	21.9(15-27)
<i>Cressa cretica</i>	31.0(30-33)	35.5(35-37)	0.87	Subob.	2.9(2-3)	1.5(1-3)	20.0(18-22)	5.0(4-6)	10.0(9-11)	8.0(5-10)
<i>Jacquemontia tammifolia</i>	52.0(49-55)	42.0(39-49)	1.24	Subpro.	4.5(4-5)	1.0(1-2)	35.0(30-45)	4(2-6)	12.0(10-15)	29.0(26-35)
<i>Merremia aegyptia</i>	60.0(55-70)	60.0(54-70)	1.00	Sh.	5.5(4-6)	2.0(1-3)	37.5(35-40)	8.0(6-10)	10.0(9-11)	35.0(30-40)
<i>M. semisagittata</i>	39.25(35-42)	40.0(37-43)	0.98	Ob.-Sh.	3.0(2-4)	1.5(1-3)	30.0(27-35)	8.6(7-10)	5.5(5-7)	23.7(20-27)
<i>Seddera arabica</i>	70.1(65-75)	70.8(68-75)	0.99	Ob.-Sh.	5.4(5-7)	2.0(1-3)	53.7(50-60)	8.8(7-10)	13.5(10-15)	32.4(30-35)
<i>Seddera latifolia</i>	67.0(60-75)	68.3(62-75)	0.98	Ob.-Sh.	4.4(3-5)	1.0(1-2)	43.3(30-50)	10.0(8-11)	11.0(9-12)	31.1(20-35)

Apo. diam. = apocolpium diameter, Colp. Len.= colpus length, Colp. wid.=colpus width, E.= Equatorial diameter, Meso. diam.= mesocolpium diameter, Nex. th.= nexine thickness, Ob.-Sh. = oblate-spheroidal, P. = Polar axis, Pro.-Sh. = prolate-spheroidal, Sex. th. = sexine thickness, Sh. = spheroidal, Subob. = suboblate, Subpro. = subprolate, μ = micrometer.

Table (4). Tabular summary showing the pollen dimensions for spheroidal Convolvulaceae species.

Species	Pollen diameter	Sex. th. incl. Echin. (μ).	Ech. len. (μ).	Nex. th. (μ).	Colp. len. (μ).	Colp. wid. (μ).	Por. diam. (μ).	Meso. diam. (μ).
<i>Evolvulus alsinoides</i>	33.0(24-38)	2.5(2-3)	—	±1.0	9.0(7-11)	2.0(1-4)	—	17.0(15-20)
<i>E. nummularius</i>	36.0(27-40)	3.0 (2-4)	—	±1.0	11.0(9-13)	3.0(1-4)	—	19.0(17-21)
<i>Calystegia sepium</i>	83.5(70.2-100.0)	5.0(2-7)	—	1.5(1-3)	—	—	12.0(8-15)	—
<i>Ipomoea carnea</i>	92.5 (80-100)	18.0 (15-20)	12.1 (10-15)	5(3-6)	—	—	5.6 (4-7)	—
<i>I. cairica</i>	70.8 (50-90)	12.0 (10-15)	7.6 (6-10)	4(3-5)	—	—	7.2 (6-8)	—
<i>I. eriocarpa</i>	90.5 (85-100)	11.5 ((7-15)	8.5 (7-10)	5(3-6)	—	—	6.9 (5-10)	—
<i>I. imperati</i>	119.5 (100-130)	18.9 (15-25)	11.6 (10-13)	6(4-7)	—	—	6.3 (5-7)	—
<i>I. obscura</i>	78.3 (70-85)	9.8 (8-10)	7.25 (5-10)	4(3-5)	—	—	6.1 (5-7)	—
<i>I. pes-carpae</i>	85.5 (80-95)	12.5 ((7.5-15)	9.0 (7-11)	4.5(3-6)	—	—	5.7 (5-9)	—
<i>I. sinensis</i>	71.2(65-80)	6.8 (5-10)	7.3 (5-10)	4(3-5)	—	—	6.0 (5-7)	—

Colp. Len.= colpus length, Colp. wid.=colpus width, Ech. Len.= echinae length, Meso. diam.= mesocolpium diameter, Nex. th.= nexine thickness, Por. diam. = pore diameter, Sex. th. incl. echin.= sexine thickness includes echinae, Sh. = spheroidal, μ = micrometer.

The smallest pollen grains were those of *Cressa cretica* 31.0 (30.0-33.0) X 35.5 (35.0-37.0) μm and the largest were those of *Ipomoea imperati* 119.5 (100.0-130.0) μm. Pollen size of other taxa ranged between 33.0 (24-38) and 90.5 (85.0-100.0) μm. The shape of pollen grains was prolate-spheroidal, spheroidal, oblate-spheroidal, suboblate to subprolate.

Apertures were colpi in two of the three differentiated pollen types viz. tricolpate pollen type and pantocolpate pollen type. Colpi were short, more or less slit-like in appearance in both *Evolvulus* (2 species), long with pointed ends in both *Merremia* (2 species), long with tapered ends in the rest of the observed colpate species. In the third group, apertures were pores, with granulated pore membrane, this group has been subdivided into two subgroups on the basis of varying characters of the exine sculpture and nature of pore. The first subgroup is placed under “Perforoconiae”, i.e., the grains were perforate and pores were irregular in shape, elliptical, sometimes adjacent pores unite to form channels as in *Calystegia silvatica*. The second subgroup is placed under “Echinoconiae”, i.e., the grains of this subgroup is echinate and pores were circular, around each pore there is an extraporal spinulose ring-shaped area (margo). Spines broad at base,

gradually tapering towards the apex with more or less rounded tip as this subgroup includes all the studied species of *Ipomoea*.

The pollen grains tectum was perforate-microreticulate with microechinate sculpture in *Cressa cretica*, perforate with minute processes in *Calystegia silvatica*, reticulate with echinate sculpture in all *Ipomoea* species, perforate with microechinate sculpture in the rest of the investigated species.

The Convolvulaceae is essentially an europalynous family having a large variety of pollen morphotypes. Erdtman (1952) divided the family into two groups; 1. *Ipomoea* type (Echinoconiae), 2. other types (Psiloconiae). The pollen morphology confirmed this division, and partially congruent with it. All species of *Ipomoea* and *Calystegia silvatica* have a distinguished pollen type, all species of *Convolvulus* as well as the two studied species of both *Merremia* and *Seddera* species have a different one, whereas *Evolvulus* species have another pollen type.

Key to the genera

- 1.a. Pollen class tricolpate 4
- b. Pollen class otherwise 2
- 2.a. Pollen class pantocolpate *Evolvulus* spp.
- b. Pollen class pantoporate 3
- 3.a. Tectum reticulate with echinate sculpture *Ipomoea* spp.
- b. Tectum psilate without processes *Calystegia* sp.
- 4.a. Polar axis 31.0 (30-33) μm *Cressa* sp.
- b. Polar axis 39.0-70.1 μm 5
- 5.a. Columellae unbranched, colpus pointed *Merremia* spp.
- b. Columellae branched 6
- 6.a. Polar axis 70.1 (65-75) μm *Seddera* spp.
- b. Polar axis 44.8-67.0 μm 7
- 7.a. Colpus length 19.0 (17-22) μm *Jacquemontia* sp.
- b. Colpus length 29.3 (25-40) - 42.0 (27-50) μm *Convolvulus* spp.

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