Malvaceae in the flora of Egypt
2. Pollen morphology and its taxonomic significance

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The pollen grains of 22 species bolonging to 10 genera of Malvaceae which are represented in the flora of Egypt were studied using light microscope (LM). The pollen grains are spheroidal, relatively large with numerous pores scattered irregularly all over the grain, sculpturing is echinate. Pollen morphological differences were found useful when combined with other gross morphological characters to distinguish between certain taxa.

Key words: Flora of Egypt, Malvaceae**,** pollen morphology; taxonomy

Introduction

The indigenous taxa of Malvaceae in Egypt were the subject of a recent study carried out by El-Hadidi *et al.* (1999). A total of 25 species belonging to 11 genera are recorded, of which *Malvella sherardiana* is new to the flora of Egypt.

Saad (1960), gave an account of the pollen morphology of 35 indigenons and cultivated species, belonging to 17 genera of Malvaceae growing in Egypt. Keys for the identification of *Hibiscus* and *Gossypium* species based on pollen morphology were provided. He pointed out (op. cit., 1960), that generic and specific differences include variations in pollen size, shape and length of spines, nature and number of pores and relative thickness of sexine and nexine. He also stated that pollen characters confirm the affinities of morphologically and cytologically related genera.

Christensen (1986), described the pollen morphology of 120 species belonging to 40 genera of Malvaceae and compared the results with the recent classification of the family (Hutchinson, 1967) with special reference to phylogeny, cytology and the evolutionary trends in pollen morphology. He pointed out that Malvaceae seems to be an ancient family with the tribes Malveae and Abutileae as to have had a long and distinct evolutionary history while Hibisceae and Ureneae are closely allied tribes and can be regarded as the most advanced within the family. However, he admitted that the generic delimitation, based on pollen morphology is rather difficult among the studied species of the family.

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Materials and Methods

Pollen materials belonging to 22 species and 10 genera of a total of 25 species which are native to the Flora of Egypt, are the subject of the present study. Collecting localities for the examined specimens are given in table (1).

Pollen samples, were obtained from anthers of mature, fresh flowers, or from herbarium specimens kept in Cairo University Herbarium, (CAI) and the Herbarium of Agricultural Research Centre, Flora and Phytotaxomy section (CAIM).

Polleniferous materials were boiled for about 30 seconds in an aquous 5% NaOH, washed several times with distilled water, spread on a clean slide in a drop of lactic acid and gently heated until the boiling point. The pollen grains were examined using a Nikon 140 Research microscope with an attatched Fx 35 photograph equipment; photopraphs are taken at magnifications ranging between x 250 – 1000.

Mature undamaged pollen grains were obtained from pollen samples (2–3 samples/specimen, Table 1). Seven-ten pollen grains/slide representing a sample, were used for the measurements of the grain diameter (in μm), apertures' number and diameter, spine characters including shape, length and density of spines. In order to quantify the density of spines, the number was scored in 16 cm^2 area of 1000 magnification prints (representing actual area of 1600 μm^2). Pollen terminology is that of Erdtman (1963).

Results and Discussion

Microscopic examination of pollen grains of the studied species of Malvaceae showed apparent uniformity. One pollen type was recognized: pollen grains are spheroidal with tectate exine, numerous pores scattered irregularly all over the grain surface (polypantoporate); sculpturing is echinate, spines are irregularly distributed, triangular with acute – acuminate or blunt apices and pulvinous bases, each is sometimes provided with cushion at the base.

Table (2), summarizes the available information of the pollen features among the studied species. It will be noticed that the size of pollen grains varied considerably among the different taxa. It ranged between 50 – 140 μm (spines are not included). The smallest grains are those of *Malvella sherardiana*, *Malva neglecta* and *Abutilon pannosum* (mean diameter 50–60 μm) the largest grains are those of *Hibiscus sabdariffa* and *H. trionum* (mean diameter 140 μm). The apertures are either few in number (18 – 40) in most of the examined taxa, or numerous (up to 110) among the examined species of tribe *Malveae*. The apertures are narrow (0.5 – 4.5 μm) in the species of tribes *Malveae* and *Abutileae*, wider apertures (5– 7.5 μm) were observed in *Sida alba, Malvastrum coromandelianum* and *Malva nicaeensis*. The apertures of *Hibiscus trionum* and *H. vitifolius* are the widest among the examined taxa being 7.5 – 12 μm diameter and 6.5 – 12 μm diameter respectively.

All the examined taxa possess numerous, mostly triangular irregularly distributed spines. The spines are either very crowded (more than 40 / 1600 μm^2) in the studied species of tribe *Malveae* and *Sida alba* or are widely spaced in the other examined species. The spines varied considerably in length at the generic and even at the specific level. The spines are relatively long (10 – 25 μm) in the examined species of tribes *Hibisceae* and *Ureneae*; they are shorter (0.5 – 10 μm) among the remaining species. The

spines are dimorphic i.e. long with acute apices and short with blunt apices in the pollen grains of tribe *Malveae*. Spines of the examined pollen grain of the species of *Abutileae* are provided by basal cushions.

The exine of the examined pollen grains is generally thick (4 – 10 μm), it is thin (1 μm) in *Malvella sherardiana*. The sexine is as thick as nexine in the studied taxa of *Malveae*; it is relatively thinner in tribe *Hibisceae*; nexine is four times as thick as sexine in the examined pollen grains of *Ureneae*.

Table (2) provides useful data, for pollen morphological differences, which can be used as key characters for the distinction of certain taxa. The pollen grains of the studied species of *Hibisceae* are characterized by relatively large (up to 150 μm diameter) pollen grains with long conical spines (up to 19 μm). Apertures are frequently with larger diameter (up to 10 μm). The pollen morphology of the examined species of *Pavonia* (tribe *Ureneae*) showed great similarity in its features with those of the species of *Hibisceae.* Christensen (1986), pointed out that the resemblence in pollen characters of both tribes could be explained by parallel evolution.

According to Hutchinson (1967), *Abutileae* comprises the subtribes *Abutilinae* and *Sidinae*. The pollen grains of the species of this tribe are readily distinguished by spines with basal cushions. The number of apertures are relatively high (30 – 50) in subtribe *Sidinae* than in *Abutilinae* (18 – 30). This is an evidence (Christensen, op. cit.: 112) that the species of *Sidinae* are more advanced than those of *Abutilinae*. Thus, it seems appropriate, with reference to pollen morphology that the subdivision of *Abutileae* into *Abutilinae* and *Sidinae* is in agreement with Hutchinson (op. cit.).

Tribe *Malveae* is represented in Egypt by subtribe Malvinae, the size of pollen grains among the examined species varied between 60 μm (mean diameter) in *Malva neglecta* to 137 μm (mean diameter) in *Alcea striata*. The number of apertures is the highest among the examined Egyptian taxa; it ranged between 50 – 116 / grain.

Species of *Malveae* also differs from those belonging to the other tribes in having crowded dimorphic spines: long (1.7 – 12 μm) with acute apices and short (0.5 – 7 μm) with blunt apices. The length of spines was found useful as a key character for the separation between the studied species of *Malva*.

In conclusion, the pollen morphology of the species of *Malvaceae* in Egypt suggests that some features can be useful in assessing taxonomic relationships between the studied species. These include the diameter of pollen grains, number and diameter of apertures as well as the shape and length of spines.

These features were found useful, when combined with other macro-morphological characters (e.g. bracteoles, fruit and floral characters) to distinguish between certain taxa. This is for instance the case of *Althaea* which differs from *Alcea* regards the number of mericarps, the pollen grain size and the number of pores. The number of mericarps is less (8 – 10) in *Althaea* than in *Alcea* (20). The pollen grains are smaller in *Althaea* (mean diameter 82 μm) with a larger number of pores (60 – 70). These are larger in *Alcea* (mean diameter 137 μm) with fewer number of pores (50 – 60).

Table (1): Specimens investigated.

Taxa	Localities
Hibiscus trionum	El Fayium, Ibshwai, 5.11.1985; *Abdel Ghani* 4288 (CAI) – Baltim, 13.7.1977; *Abdel Maqsud* s.n. (CAI) – Ganzour, Menoufia, 15.9.1967; *V. Täckhnolm et al.* s.n. (CAI).
H. micranthus	Elba district, Gebel Gogart, 7.2.1962; *V. Täckholm et al.* 1782 (CAI) – Wadi kansisrob, Elba, 3.2.1962; *V. Täckholm* 1290 (CAI).
H. vitifolius	Elba, Wadi Kansisrob, 23-27.1.1929; *G. Täckholm* s.n. (CAI) – Across Gebel El shallal, Elba, 24.1.1962; *V. Täckholm et al.* 550 (CAI).
H. sabdariffa	Faculty of science garden, Giza, 5.11.1991; *S. Araffa* s.n. (CAI) – North garden, El Saff, 27.10.1961; *V. Täckholm* s.n. (CAI).
Abutilon theophrasti	3 km S of Tanta, 11.9.1991; *S. Araffa* s.n. (CAI) – San El Hagar, Sharkiya, 10.8.1983; *Amer et al.* 4557 (CAI) – Bircher's garden, El Saff, 14.11.1961; *V. Täckholm et al.* s.n. (CAI).
A. bidentatum	Wadi Angabiya, Suez road, 28.1.1956; *Imam* s.n. (CAI) – El Dakhla Oasis, Ain Fatima, 9.6.1961; *V. Täckholm et al.* s.n. (CAI).
A. fruticosum	Gebel Elba, 7.2.1962; *V. Täckholm* s.n. (CAI) – Gebel Hamata, Red Sea Coast, 7.2.1961; *V. Täckholm et al.* s.n. (CAI).
A. pannosum	Abu Simbel, 14.2.1963; *V. Täckholm et al.* s.n. (CAI) – Kharga Oasis, Doush village, 24.11.1983; *Barakat* s.n. (CAI).
A. figarianum	Wadi Ghweibba, RSC, 9.6.1960; *V. Täckholm et al.* s.n. (CAI).
Sida alba	Bahr El Ezz, El Mansoura, 27.10.1967; *V. Täckholm et al.* s.n. (CAI) – Sinnuris, Fayium, 23.3.1991; *S. Araffa* s.n. (CAI) – Beni Suef, 1.7.1952; *Boulos* s.n. (CAI).
Malvella sherardiana	Dakhla Oasis, 6.3.1934; *Shabetai* Z 4363 (CAIM).
Malvastrum Coromandelianum	El Saff, 15.5.1971; *Bircher* s.n. (CAI). Zohria Garden, 15.5.1927; *G. Täckholm* s.n. (CAI).
Malva aegyptia	Burg El Arab, 20.3.1953; *El Hadidi* s.n. (CAI) – El Daba, 16.3.1991; *S. Araffa* s.n. (CAI) – N of El Arish, 18.3.1955; *El Hadidi* s.n. (CAI).
M. parviflora	Saqqara fields, 15.3.1992; *S. Araffa* s.n. (CAI) – El Amriya, 7.3.1991; *S. Araffa* s.n. (CAI) – Itsa, El Fayium, 9.3.1983; *Abdel Ghani* 5664 (CAI).
M. nicaeensis	Burg El Arab, 1.4.1952; *Bot. Dept. Excurs.* s.n. (CAI) – Burg El Arab, 25.1.1978; *Abdel Wahab* s.n. (CAI).
M. neglecta	Deir El Arbaeen, Sinai, 7.5.1980; *Abbas* s.n. (CAI) – The graden of st. Katherine, 11.4.1967; *Kosinova'* s.n. (CAI).
M. sylvestris	Mersa Matrouh, 1.4.1972; *V. Täckholm et al.* s.n. (CAI) – Maruit, Amriya, 14.3.1991; *S. Araffa* s.n. (CAI) – Ismailia, 18.3.1927; *G. Täckholm* s.n. (CAI).
Althaea ludwigii	Cairo – Suez road, 15.1.1960; *V. Täckholm* s.n. (CAI) – N Galala, 11.4.1924; *Simpson* 2743 (CAIM).
Alcea striata	Deir El Arbain, Sinai, 12.5.1956; El Hadidi s.n. (CAI).
Lavatera cretica	Rosetta, 20.4.1973, *Ibrahim et al.* s.n. (CAI) – Burg El Arab, 22.3.1956; *El Hadidi* s.n. (CAI).
Pavonia kotschyi	Wadi Kansisrob, G. Elba, 25.1.1929; *Shabetai* 2677 (CAIM).
P. triloba	Gebel Elba, 13.2.1932; *Drar* 334 (CAIM) – Karam Elba mountain, 7.2.1962; *V. Täckholm et al.* 1720 (CAI).

Table (2): Pollen morphology of examined species of Malvaceae.

Species	Diameter of Pollen μm (mean in brackets)	Aperture		Spine	
		Number	Diam. μm (mean in brackets)	Length μm (mean in brackets)	No. of spines / 1600 μm
***Hibisceae**:*					
Hibiscus trionum	110-150 (130)	20-25	7.5-12 (10)	10-18 (14)	4-5
H. micranthus	70-100 (85)	20-24	6.5-7.5 (7)	10-19 (15)	5-6
H. vitifolius	120-150 (135)	30-36	6.5-12 (9)	12-18 (15)	10
H. sabdariffa	120-160 (140)	20-26	7-9 (8)	11.5-18 (14.8)	8-10
Abutileae-Abutilinae					
Abutilon theophrasti	46-75 (60)	18-20	1.5-2.5 (2)	6.5-7.5 (7)	14-15
A. bidentatum	63-75 (69)	24-30	0.5-1.5 (1)	0.5-1 (0.8)	24-25
A. fruticosum	62-87 (75)	20-30	0.5-3 (1.8)	3-6.5 (4.8)	20-22
A. pannosum	50-65 (55)	22-30	1-2.5 (1.8)	4-6 (5)	22-23
A. figarianum	60-80 (70)	20-24	1.5-4.5 (3)	3-6.5 (4.5)	13-14
Abutileae - Sidinae					
Sida alba	60-80 (70)	44-50	4.5-6.5 (5.5)	3-10 (6)	56-64
Malvella sherardiana	40-60 (50)	30-35	0.5-1.5 (1)	3-6 (4)	15-16
Malvastrum coroman-delianum	69-87 (78)	25-30	6.3-7.5 (6.9)	6.3-8 (7)	18-20
Malveae					
Malva aegyptia	81-106 (94)	80-90	0.5-1.5 (1)	7-10 (8.5)	40-47
M. parviflora	70-80 (75)	110-115	3-5 (4)	0.2-1.7 (1.1)	60-62
M. nicaeensis	60-80 (70)	100-105	5-7 (6)	3-12 (7.5)	35-40
M neglecta	45-60 (50)	100-110	0.5-2 (1.3)	1.5-3 (2.3)	12-15
M. sylvestris	44-112 (103)	90-100	0.5-2 (1.3)	3-12 (7.5)	40-45
Althaea ludwigii	65-100 (82)	60-70	1.5-5 (3.3)	3-9 (6)	58-60
Alcea striata	119-156 (137)	50-60	1.5-3 (2.3)	3-9.9 (6.2)	30-32
Lavatera cretica	100-140 (122)	2-4.5	2-4.5 (2.3)	3-8 (5.5)	60-70
Ureneae					
Pavonia kotschyi	61-94 (77)	24-30	3-6.5 (4.8)	10-25 (17.5)	4-5
P. triloba	110-135 (130)	30-40	6.5-7.5 (7)	12-15 (13.5)	13-15

The following key is constructed to distinguish between the studied species. It combines both of gross – morphologic and palynological characters.

1. a. Style branches and stigmas the same number as the carpels, or style undivided; spines of exine 0.5 – 19 μm long ……..……..…… 2
   b. Style branches and stigmas twice the number of the carpels; spines of exine 13 – 25 μm long (tribe Ureneae) ……..……..... 22
2. a. Fruit a loculicidal capsule; spines of exine 10 – 19 μm long (tribe Hibisceae) ..……..……..……..... 3

b. Fruit schizocarpic; spines of exine 0.5 – 10 μm long (tribe Malveae *and* Abutileae) 7

3. a. Bracteoles (epicalyx) 3, broadly ovate – cordate, apically toothed, styles undivided ..... ***Gossypium arboreum***
   b. Bracteoles (epicalyx) numerous, filiform – linear, entire; styles divided 4
4. a. Fruit ovoid not included in calyx; pollen grains less than 100 μm diameter ..... ***Hibiscus micranthus***
   b. Fruit included in persistent calyx; pollen grains more than 100 μm diameter 5
5. a. Epicalyx segments linear – lanceolate; seeds hispid ..... ***Hibiscus sabdariffa***
   b. Epicalyx segments filiform; seeds tuberculate 6
6. a. Fruit spheroidal, 1 cm diameter, beaked and winged; pollen grains with crowded spines (10 / 1600 μm^2) ..... ***Hibiscus vitifolius***
   b. Fruit oblong – ovoid, 1.5 x 1 cm, obtuse, wingless; pollen grains with sparsely spaced spines (4 – 5 / 1600 μm^2) ..... ***Hibiscus trionum***
7. a. Stigmas decurrent on the style branches; spines of exine dimorphic without a basal cushion (Tribe Malveae) 8
   b. Stigmas apical, capitate, larger than the remainder of the style branches; spines of exine homomorphic with basal cushions (Tribe Abutileae) 15
8. a. Bracteoles 6 – 10 9
   b. Bracteoles 2 – 3 10
9. a. Mericarps more than 20; pollen grains more than 100 μm diameter, number of aperture less than 60 ..... ***Alcea striata***
   b. Mericarps ca. 10; pollen grains less than 100 μm diameter, number of apertures more than 60 ..... ***Althaea ludwigii***
10. a. Bracteoles connate at base ..... ***Lavatera cretica***
    b. Bracteoles free 11
11. a. Epicalyx of 2 bracteoles ..... ***Malva aegyptia***
    b. Epicalyx of 3 bracteoles 12
12. a. Fruit 7 – 10 mm diameter ..... ***Malva sylvestris***
    b. Fruit up to 7 mm diameter 13
13. a. Bracteoles linear; mericarps with elevated margins ..... ***Malva parviflora***
    b. Bracteoles elliptic, ovate or oblong; mericarps without elevated margins 14
14. a. Mericarps smooth on the dorsal surface; spines of exine 1.5 – 3 μm long, diameter of aperture 0.5 – 2 μm ..... ***Malva neglecta***
    b. Mericarps deeply reticulate on the dorsal surface; spines of exine 7–12 μm long, diameter of aperture 6 μm ..... ***Malva nicaeensis***
15. a. Bracteoles absent; mericarps ± dehiscent into two valves 16
    b. Bracteoles present; mericarps indehiscent 21
16. a. Mericarps one – seeded; pollen grains ca. 90 μm diameter, number of apertures more than 30, aperture diameter over 3 μm ..... ***Sida alba***
    b. Mericarps 2 – 3 -seeded; pollen grains 55 – 85 μm diameter, number of aperture less than 30, apertures diameter less than 3 μm 17
17. a. Mericarps with rounded apex 18

b. Mericarps with acute – acuminate apex ……………..………………..…………….. 19

18. a. Petals 10 – 25 mm long, yellow with purple base; spines of exine 4–5 µm long ……………………………..……………………………………...………..… ***Abutilon pannosum***

b. Petals 7 – 9 mm long, yellow without purple base; spines of exine 6–7 µm long ………………………...……………………...…………… ***Abutilon figarianum***

19. a. Mericarp 2 – awned ………………..……………………...…………… ***Abutilon theophrasti***

b. Mericarp not awned with acute – acuminate apex …………...…………………..… 20

20. a. Mericarps 10; fruit 12 mm diameter, spines of exine 3–6.5 µm long ………………….. ………………...……………………...……………………...…………………….***Abutilon fruticosum***

b. Mericarps 20; fruit 7 mm diameter, spines of exine 0.5 – 1 µm long ………………….. ………………...……………………...……………………...………………… ***Abutilon bidentatum***

21. a. Mericarps inflated; spines of exine 0.5 – 1.5 µm long ……..… ***Malvella sherardiana***

b. Mericarps not inflated; spines of exine 6.5 – 8 µm long ………………...……………… ……………...……………………...………………………… ***Malvastrum Coromandelianum***

22. a. Fruit glabrous; mericarps broadly winged; pollen grains less than 100 µm diameter, number of aperture less than 30 ……………...………….. ***Pavonia kotschyi***

b. Fruit pubescent; mericarps wingless or narrowly winged; pollen grains over 100 µm diameter, number of aperture more than 30 ………………..…***Pavonia triloba***

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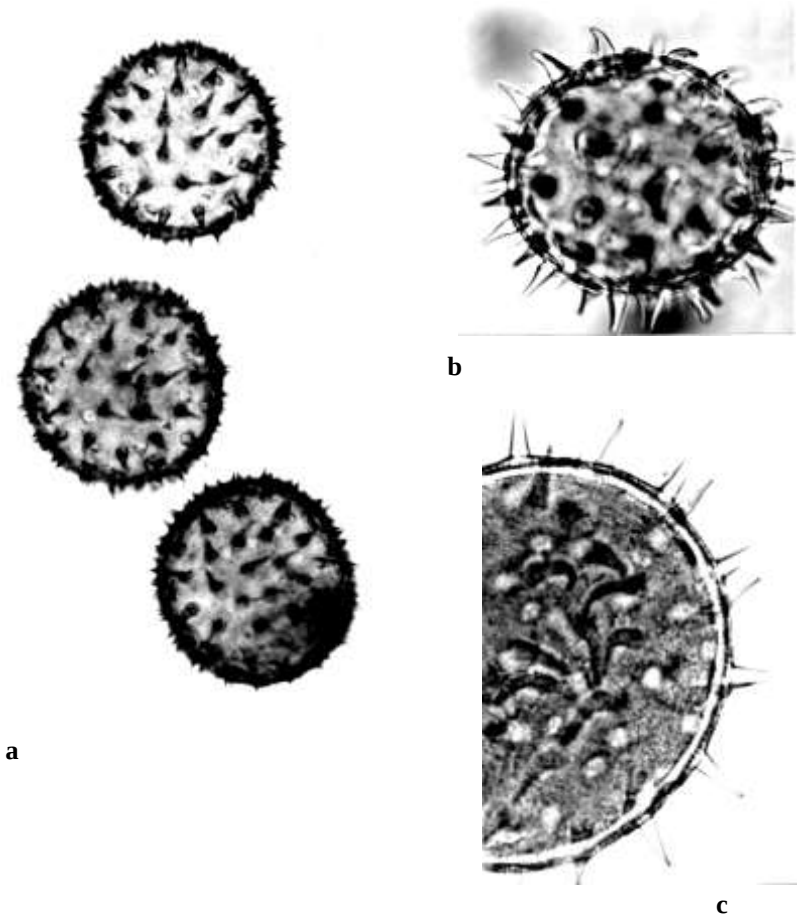

Fig. (1). Pollen morphology of representative species of *Hibisceae*:
a. *Hibiscus trionum*, x250. b. *Hibiscus micranthus*, x1000
c. *Hibiscus vitifolius* , x1000
Pollen grains large with few wide apertures and long, conical, widely spaced spines.

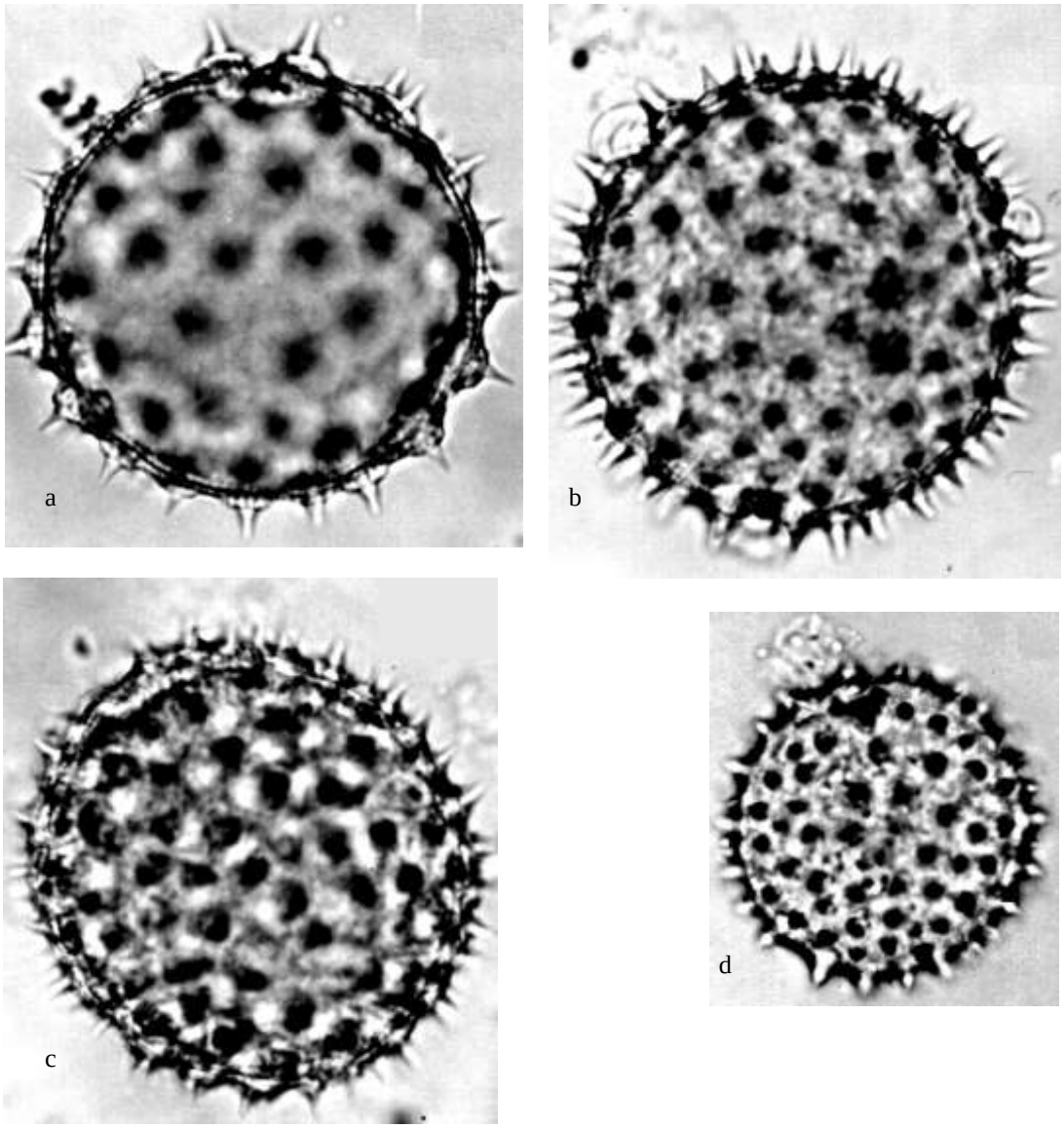

Fig. (2). Pollen morphology of representative species of *Abutileae* (all x1000):
a. *Abutilon theophrasti* b. *Abutilon pannosum* c. *Sida alba*
d. *Malvella sherardiana*
Pollen grains small, with few (*Abutilon*) or numerous (*Sida, Malvella*) apertures and short crowded spines with basal cushions.

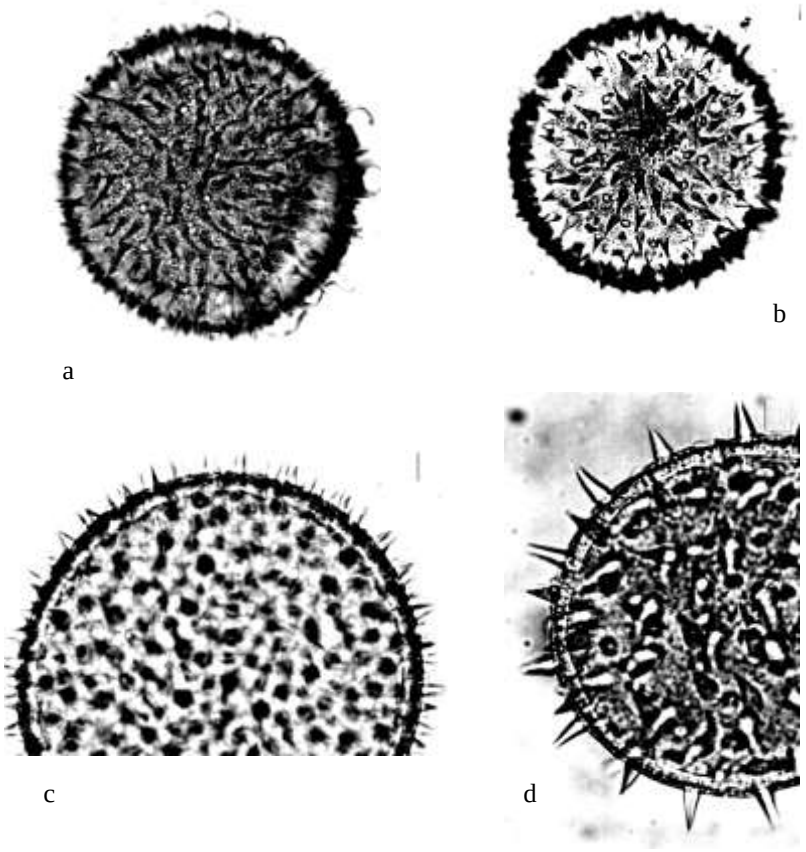

Fig. (3). Pollen morphology of representative species of *Malveae* and *Ureneae*:
a. *Malva aegyptia*, x1000. b. *Malva parviflora*, x1000 c. *Lavatera cretica*, x500 c. *Pavonia trioba*, x500
Pollen grains large (*Lavatera, Pavonia*), with few wide apertures, or moderate (*Malva*) with numerous narrow apertures; and short crowded spines (*Malva, Lavatera*) or widely spaced (*Pavonia*) spines.