

## On the Pollen Morphology of Some Egyptian Caryophyllaceae

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**Abstract.** Pollen size, type, number of apertures and exine thickness are reported for 67 species from 21 genera of Egyptian Caryophyllaceae. The palynological study supports the division of the subfamily Paronychioideae into two distinct groups. Within the subfamily Alsinoideae, the genus *Stellaria* can be easily distinguished from the genus *Spergula* by their pollen characters, while the genera *Arenaria* and *Minuartia*, which have the same pollen type, supposed to be lumped together. Section Rhodalsine from genus *Minuartia*, which shows a great similarity with some *Spergularia* species, has pollen of the same type like tribe Sperguleae which support the separation of the Rhodalsine from the subfamily Alsinoideae to the Paronychioideae, tribe Sperguleae. Genera within the subfamily Silenoideae have more uniform pollen types whereas the tribe Lychnideae and Diantheae can be easily separated by their pollen characters.

### Introduction

The Caryophyllaceae, which is one of the main centrospermous families is characterised by having herbaceous or small shrubby species with opposite, rarely alternate, decussate leaves with scarious stipules in the subfamily Paronychioideae or without stipules in the subfamilies Alsinoideae and Silenoideae. The taxonomic status of the genera within the family have been faced with many proposals. Davis & Cullen, Davis and Hutchinson [1-3] separated the genera *Scleranthus*, *Paronychia*, *Herniaria* and *Corrigiola* into a new family Illecebraceae. These genera are distinguished from the rest by the perigynous, apetalous flowers and the one-seeded indehiscent fruit. Chater *et al.* [4] have grouped the genera *Herniaria*, *Paronychia* and *Corrigiola* with the genera *Spergula*, *Spergularia* and *Polycarpon* in the subfamily Paronychioideae, while the genus *Scleranthus*, with exstipulate leaves, was placed in the subfamily Alsinoideae.

Generic delimitations are also a matter of discussion. Scopoli [5] has lumped the genera *Arenaria*, *Minuartia*, *Spergula* and *Stellaria* in one genus *i.e.* *Stellaria*. Bentham [6] separated *Arenaria* and *Minuartia* from *Spergula* and *Stellaria*. Genera

of both Paronychioideae and Alsinoideae were very confused until Gaertner [7] realised the importance of the capsule dehiscence in the clasification of the genera. Apart from the earlier studies [6; 8-12] there was no revision of the family at species level until Williams [13-15] published a detailed classification of *Arenaria* with full enumeration of species.

In the last sixty years, there have been eight notable contributions to the taxonomy of the family: The first was the enumeration of the Chinese taxa by Handel-Mazzetti [16] which to some extent drew together the numerous species published in 1895, 1897 and 1898 by Williams [13-15]. Schisckin [17] made an account of the Caryophyllaceae in the Flora U.S.S.R. and in this some new infra-generic groups of *Arenaria* were proposed, but without validating Latin diagnosis. Pax and Harms [18] divided the family into three subfamilies: Alsinoideae, Paronychioideae and Silenoideae. Maguire [19] has studied the North-American members of the family. Contributions on the pollen studies include the works of Zinderen-Bakker [20] on South African representatives, Ikuse [21] has studied the Japanese representatives, Chanda [22] studied the Scandinavian species, Vishnu-Mittre and Gupta [23] have studied the Indian species, Candau [24] made an account of the Spanish pollen grains within the subfamily Alsinoideae and El-Ghazaly [25] presented a pollen flora of Quatar. Goyder [26] produced a detailed study of the *Arenaria* section Plinthine and revised the works of Montserat Recoder, Rocha Afonso and Smythies [27-29], while Gonzalez and Feliner [30] made some comments on Goyder's study.

The present work is mainly on the pollen morphology of some Egyptian Caryophyllaceous species. Sixty-seven species, distributed over twenty one genera have been studied by using light and scanning electron microscopes and the bearing of the results on the taxonomy of the group is discussed. The clasification of the family here is according to Pax and Harms [18].

### Materials and Methods

Pollen samples were obtained from herbarium specimens deposited in the Alexandria University herbarium. These were acetolyzed according to Erdtman [31] and mounted in glycerine jelly, examined and measured under Zeiss light microscope. At least 30 pollen grains from each species were measured. Acetolyzed pollen grains were dehydrated in acetone series and placed onto cleaned, labelled stubs and coated with 30 nm gold, examined and photographed with Jeol JSM T-20 scanning electron microscope at 15 Kv. The terminology used here is generally based on that of Faegri [32].

## Results

Pollen grains among the Egyptian members of the Caryophyllaceae are either pantoporate, trizonocolpate or pancolpate. The pores are usually circular with well defined membranes which are either psilate, faintly granulate or with well defined granules. The colpi are long with tapering ends and granulate membrane. Pollen grains are mostly spheroidal, but oblate, subprolate and prolate forms also occur. Sexine is either thicker or of the same thickness as nexine, and tegillate, punctitegillate or reticulate. The tectum is either papillate, granulate or bacculate. The results obtained are summarized in Table 1. Within the three basic pollen groups, subgroups can be recognized as distinct types.

### GROUP 1: Pantoporate

A large majority of the representatives of the Caryophyllaceae have porate pollen grains. They show a great variation in pore size, number, diameter and ornamentation. They can easily be separated into five types:

#### i) *Gymnocarpus decandrum* type

Pollen spheroidal in optical view; of small diameter never exceeding 20  $\mu\text{m}$ ; pores 6-8, smaller than lumina; pore membrane granulate; exine tegillate with granulate or bacculate tectum; sexine is of the same thickness as nexine. See Table 1.

#### ii) *Herniaria hemistemon* type

Pollen spheroidal in optical view; of small diameter never exceeding 20  $\mu\text{m}$ ; pores 9-12, smaller than lumina; pore membrane granulate; exine tegillate with granulate or bacculate tectum; sexine is of the same thickness as nexine. (Table 1).

#### iii) *Stellaria pallida* type

Pollen spheroidal in optical view; of medium diameter from 22 to 37  $\mu\text{m}$ ; pores 8-16, smaller than lumina; pore membrane granulate; exine tegillate with granulate or bacculate tectum; nexine is very thin or indistinguishable. (Table 1).

#### iv) *Vaccaria pyramidata* type

Pollen spheroidal in optical view; of larger diameter, over 37  $\mu\text{m}$ ; pores 8-16, smaller than lumina; pore membrane covered with well developed flecks; exine tegillate with granulate tectum, sometimes reticulate; sexine is of the same thickness as nexine. (Table 1).

#### v) *Silene aegyptiaca* type

Pollen spheroidal in optical view; of medium diameter, over 30  $\mu\text{m}$ ; pores 18-25, smaller than or equal to lumina, surrounded by smooth annulus; pore membrane is either faintly granulate or with well developed granules; exine semitectate with bacculate or faintly reticulate tectum; nexine is very thin. (Table 1).

Table 1. Morphological characters of pollen grains (Plates 1-5)

| TAXA                                      | 1 | 2 | 3 | 4         | 5         | 6   | 7         | 8       | 9 |
|-------------------------------------------|---|---|---|-----------|-----------|-----|-----------|---------|---|
| Subfamily:Paronychioideae                 |   |   |   |           |           |     |           |         |   |
| Tribe:Paronychieae                        |   |   |   |           |           |     |           |         |   |
| Subtribe:Paronychienae                    |   |   |   |           |           |     |           |         |   |
| <i>Sphaerocoma hookeri</i>                |   |   |   |           |           |     |           |         |   |
| T. Anders.                                | 2 | 6 | 1 | 12.5-17.5 | -         | 3   | 7.5-10.0  | 1.8-2.2 | 1 |
|                                           |   |   |   | 15.0      |           |     | 9.0       | 2.0     |   |
| <i>Gymnocarpus decandrum</i> Forssk.      | 1 | 1 | 1 | 16.0-18.7 | -         | 6-8 | 6.0-8.5   | 2.8-3.5 | 1 |
|                                           |   |   |   | 17.2      |           |     | 7.0       | 3.0     |   |
| <i>Paronychia argentea</i> Lam.           | 1 | 1 | 1 | 9.5-12.0  | -         | 6-8 | 2.5-4.0   | 2.0-2.5 | 1 |
|                                           |   |   |   | 11.0      |           |     | 3.5       | 2.3     |   |
| <i>P. arabica</i> DC.                     | 1 | 2 | 1 | 9.5-12.5  | -         | 9   | 2.5-3.3   | 1.3-2.0 | 1 |
|                                           |   |   |   | 10.25     |           |     | 2.7       | 1.5     |   |
| <i>P. nivea</i> DC.                       | 1 | 2 | 1 | 11.3-16.6 | -         | 10  | 2.3-3.6   | 2.0-2.3 | 2 |
|                                           |   |   |   | 15.4      |           |     | 2.5       | 2.2     |   |
| <i>Herniaria hemistemon</i>               |   |   |   |           |           |     |           |         |   |
| J. Gay                                    | 1 | 2 | 1 | 12.5-18.0 | -         | 10  | 3.8-5.0   | 2.0-2.5 | 3 |
|                                           |   |   |   | 14.3      |           |     | 4.2       | 2.3     |   |
| <i>H. fontanesii</i> J. Gay               | 1 | 1 | 1 | 9.7-13.3  | -         | 8   | 2.0-2.3   | 2.1-2.5 | 3 |
|                                           |   |   |   | 12.5      |           |     | 2.2       | 2.3     |   |
| <i>H. hirsuta</i> v. <i>cinerea</i> Herm. | 1 | 2 | 1 | 12.0-14.3 | -         | 12  | 2.0-3.0   | 1.3-2.5 | 5 |
|                                           |   |   |   | 13.5      |           |     | 2.7       | 2.3     |   |
| Tribe:Pterantheae                         |   |   |   |           |           |     |           |         |   |
| <i>Cometes abyssinica</i> R.Br.ex Wall    | 2 | 6 | 1 | 35.0-45.0 | -         | 3   | 30.0-35.0 | 4.8-6.0 | 5 |
|                                           |   |   |   | 40.5      |           |     | 33.0      | 5.0     |   |
| <i>C. surathensis</i>                     | 2 | 6 | 1 | 37.5-40.0 | -         | 3   | 27.5-32.5 | 3.5-4.7 | 5 |
|                                           |   |   |   | 39.0      |           |     | 30.0      | 4.3     |   |
| <i>Pteranthus dichotomus</i> Forssk.      | 2 | 6 | 1 | 25.0-30.0 | -         | 3   | 20.0-22.5 | 3.0     | 5 |
|                                           |   |   |   | 28.5      |           |     | 22.0      |         |   |
| Tribe:Polycarpeae                         |   |   |   |           |           |     |           |         |   |
| <i>Polycarpon tetraphyllum</i>            | 2 | 7 | 3 | 16.3-17.5 | 12.5-13.8 | 3   | 10.0-11.3 | 1.25    | 2 |
|                                           |   |   |   | 16.8      | 13.0      |     | 10.5      |         |   |
| <i>P. succulentum</i> (Del.)J.Gay         | 2 | 7 | 2 | 12.7-14.3 | 11.7-13.3 | 3   | 7.5-8.3   | 0.8-1.7 | 1 |
|                                           |   |   |   | 13.8      | 12.5      |     | 8.2       | 1.3     |   |
| <i>P. alsinifolium</i> (Biv.)DC.          | 3 | 8 | 2 | 17.5-19.2 | 15.0-16.7 | 6   | 13.2-15.2 | 1.7-2.5 | 1 |
|                                           |   |   |   | 18.5      | 15.8      |     | 14.8      | 2.3     |   |
| <i>P. prostratum</i> (Forssk.) Pax.       | 2 | 7 | 4 | 14.6-15.4 | 16.6-19.2 | 3   | 12.2-13.6 | 1.3-2.0 | 2 |
|                                           |   |   |   | 14.9      | 17.3      |     | 12.9      | 1.8     |   |
| <i>Polycarpaea repens</i> (Forssk.)Asch.  | 2 | 7 | 2 | 12.5-15.0 | 10.0-12.5 | 3   | 7.5-10.0  | 1.25    | 2 |
|                                           |   |   |   | 14.3      | 11.8      |     | 9.3       |         |   |

Table 1. (Cont.)

| TAXA                                   | 1 | 2 | 3 | 4                 | 5                 | 6  | 7                 | 8              | 9 |
|----------------------------------------|---|---|---|-------------------|-------------------|----|-------------------|----------------|---|
| <i>P. spicata</i> Wight ex Arn.        | 2 | 7 | 3 | 18.2-21.5<br>20.5 | 14.8-16.2<br>15.2 | 3  | 14.0-17.2<br>16.0 | 2.5            | 5 |
| <i>P. corymbosa</i> Lam.               | 2 | 7 | 4 | 15.8-16.7<br>16.3 | 20.8-23.7<br>21.3 | 3  | 10.0-12.0<br>10.8 | 1.3-1.8<br>1.7 | 5 |
| <i>Loeflingia hispanica</i>            | 2 | 6 | 1 | 15.8-17.5<br>16.7 | -                 | 3  | 10.5-12.2<br>11.6 | 0.8-1.9<br>1.3 | 2 |
| Tribe: Sperguleae                      |   |   |   |                   |                   |    |                   |                |   |
| Subtribe: Spergulinae <i>Spergula</i>  |   |   |   |                   |                   |    |                   |                |   |
| <i>fallax</i> E.H.L.                   | 3 | 8 | 1 | 21.3-25.0<br>23.8 | -                 | 6  | 12.5-15.0<br>13.0 | 2.0-2.5<br>2.4 | 5 |
| <i>S. arvensis</i>                     | 3 | 8 | 2 | 29.2-30.8<br>30.0 | 28.3-29.2<br>28.8 | 4  | 21.0-24.2<br>22.9 | 1.7-2.9<br>2.5 | 2 |
| <i>Spergularia diandra</i> Boiss.      | 3 | 8 | 1 | 17.5-20.8<br>19.5 | -                 | 6  | 11.3-12.5<br>12.0 | 2.0-2.3<br>2.2 | 2 |
| <i>S. bocconii</i> Asch. et Graebn.    | 3 | 8 | 3 | 20.2-25.5<br>21.0 | 16.0-20.8<br>16.5 | 8  | 18.0-24.5<br>20.0 | 1.3-2.5<br>2.2 | 2 |
| <i>S. media</i>                        | 4 | 9 | 2 | 17.3-17.7<br>17.6 | 15.8-16.5<br>16.1 | 8  | 13.8-14.5<br>14.2 | 1.0-1.5<br>1.3 | 4 |
| <i>S. rubra</i> J. & C. Pre.           | 3 | 8 | 2 | 22.5-25.0<br>23.8 | 21.6-22.5<br>22.1 | 8  | 12.2-14.3<br>13.2 | 1.3-2.5<br>2.3 | 2 |
| <i>S. marina</i> Griseb.               | 3 | 8 | 3 | 22.5-25.2<br>23.5 | 16.5-20.0<br>18.5 | 8  | 12.5-15.0<br>13.2 | 1.5-2.5<br>2.3 | 2 |
| Subtribe: Telephiinae                  |   |   |   |                   |                   |    |                   |                |   |
| <i>Telephium sphaerospermum</i> Boiss. | 2 | 7 | 4 | 20.0-25.0<br>22.5 | 25.0-27.5<br>26.0 | 3  | 15.0-17.5<br>16.0 | 2.0-2.5<br>2.4 | 2 |
| Subfamily: Alsinoideae                 |   |   |   |                   |                   |    |                   |                |   |
| Tribe: Alsineae                        |   |   |   |                   |                   |    |                   |                |   |
| <i>Arenaria serjyllifolia</i>          | 2 | 6 | 1 | 12.1-14.5<br>12.9 | -                 | 3  | 6.0-7.0<br>6.8    | 1.3-2.3<br>2.0 | 2 |
| <i>A. deflexa</i> Decne                | 1 | 3 | 1 | 21.8-30.5<br>22.9 | -                 | 14 | 4.2-5.0<br>4.8    | 1.8-2.7<br>2.5 | 2 |
| <i>Holosteum umbellatum</i>            | 1 | 3 | 1 | 27.5-32.1<br>30.0 | -                 | 12 | 3.5-4.5<br>4.0    | 2.7-3.7<br>3.5 | 4 |
| <i>Stellaria media</i> Vill.           | 1 | 3 | 1 | 32.0-37.5<br>35.0 | -                 | 14 | 4.5-5.5<br>4.9    | 3.0-4.5<br>3.3 | 2 |
| <i>S. pallida</i> (Dumortier) Pire     | 1 | 3 | 1 | 32.0-38.6<br>36.5 | -                 | 14 | 4.0-4.8<br>4.5    | 3.0-4.5<br>3.3 | 2 |
| <i>Cerastium viscosum</i>              | 1 | 3 | 1 | 28.9-31.6<br>30.2 | -                 | 16 | 3.0-4.6<br>4.3    | 2.7-3.6<br>3.0 | 3 |

Table 1. (Cont.)

| TAXA                                        | 1 | 2 | 3 | 4                 | 5                 | 6  | 7                 | 8              | 9 |
|---------------------------------------------|---|---|---|-------------------|-------------------|----|-------------------|----------------|---|
| <i>C. dichotomum</i>                        | 1 | 3 | 1 | 28.2-32.0<br>31.0 | -                 | 14 | 3.1-3.9<br>3.8    | 2.1-2.9<br>2.5 | 3 |
| <i>Bufonia multiceps</i> Decne.             | 1 | 1 | 1 | 15.6-23.5<br>18.2 | -                 | 6  | 3.5-4.8<br>4.5    | 2.5-3.7<br>3.5 | 5 |
| <i>Minuartia geniculata</i> (Poirot) Thell. | 2 | 7 | 3 | 17.8-20.5<br>18.0 | 14.0-16.5<br>16.0 | 3  | 10.0-15.0<br>13.2 | 1.0-1.5<br>1.4 | 2 |
| <i>M. procumbens</i> Graebn.                | 2 | 7 | 3 | 20.0-22.5<br>21.0 | 12.8-16.0<br>15.3 | 3  | 15.0-17.5<br>15.5 | 1.8-2.0<br>1.9 | 2 |
| <i>M. tenuifolia</i> Hiern                  | 1 | 3 | 1 | 28.8-32.0<br>30.5 | -                 | 12 | 3.5-4.5<br>3.8    | 2.8-3.5<br>3.4 | 2 |
| <i>M. meyeri</i> Bornm.                     | 1 | 3 | 1 | 25.5-33.7<br>30.5 | -                 | 10 | 4.2-4.8<br>4.5    | 3.0-3.5<br>3.4 | 2 |
| <i>M. picta</i> Bornm.                      | 1 | 3 | 1 | 30.0-32.3<br>31.5 | -                 | 12 | 4.5-6.5<br>5.0    | 3.2-3.5<br>3.3 | 2 |
| Subfamily: Silenoideae                      |   |   |   |                   |                   |    |                   |                |   |
| Tribe: Lychnideae                           |   |   |   |                   |                   |    |                   |                |   |
| Subtribe: Sileninae                         |   |   |   |                   |                   |    |                   |                |   |
| <i>Silene rubella</i>                       | 1 | 5 | 1 | 37.0-45.0<br>42.0 | -                 | 25 | 4.5-6.0<br>5.5    | 2.8-3.3<br>3.0 | 3 |
| <i>S. succulenta</i> Forssk.                | 1 | 5 | 1 | 39.5-45.0<br>42.5 | -                 | 23 | 4.8-6.2<br>6.0    | 2.8-3.3<br>3.0 | 4 |
| <i>S. tridentata</i> Desf.                  | 1 | 5 | 1 | 37.5-41.2<br>39.3 | -                 | 22 | 4.2-5.0<br>4.8    | 2.8-3.3<br>3.0 | 4 |
| <i>S. conoidea</i>                          | 1 | 5 | 1 | 40.0-43.8<br>42.0 | -                 | 22 | 4.2-5.0<br>4.8    | 2.8-3.3<br>3.0 | 5 |
| <i>S. nocturna</i>                          | 1 | 5 | 1 | 35.0-42.5<br>40.0 | -                 | 22 | 3.1-4.0<br>3.5    | 2.8-3.3<br>3.0 | 4 |
| <i>S. colorata</i> Poirot                   | 1 | 5 | 1 | 32.5-46.0<br>40.5 | -                 | 25 | 3.5-4.0<br>3.6    | 2.0-2.8<br>2.5 | 4 |
| <i>S. burchellii</i> Otth. ex DC.           | 1 | 5 | 1 | 30.0-37.5<br>35.0 | -                 | 22 | 4.2-5.0<br>4.8    | 3.7-4.2<br>4.0 | 4 |
| <i>S. pseudotocion</i> Desf.                | 1 | 5 | 1 | 35.0-40.0<br>37.0 | -                 | 18 | 3.8-4.0<br>3.9    | 2.0-2.5<br>2.3 | 4 |
| <i>S. biappendiculata</i> Rohrb.            | 1 | 5 | 1 | 42.5-50.0<br>48.0 | -                 | 26 | 4.5-5.6<br>5.2    | 2.0-2.8<br>2.3 | 3 |
| <i>S. gallica</i>                           | 1 | 5 | 1 | 34.8-42.5<br>41.3 | -                 | 22 | 4.2-5.2<br>5.0    | 2.0-2.5<br>2.3 | 4 |
| <i>S. palaestina</i> Boiss.                 | 1 | 5 | 1 | 35.0-45.0<br>40.0 | -                 | 22 | 4.5-5.2<br>5.0    | 2.5-3.0<br>2.8 | 4 |

Table 1. (Cont.)

| TAXA                               | 1 | 2 | 3 | 4                 | 5 | 6  | 7              | 8              | 9 |
|------------------------------------|---|---|---|-------------------|---|----|----------------|----------------|---|
| <i>S. villosa</i> Forssk.          | 1 | 5 | 1 | 40.0-42.0<br>41.0 | - | 18 | 5.0-6.0<br>5.8 | 2.1-2.8<br>2.5 | 5 |
| <i>S. apetala</i> Willd.           | 1 | 5 | 1 | 27.5-37.5<br>34.8 | - | 18 | 3.0-3.5<br>3.2 | 2.3-3.1<br>2.8 | 4 |
| <i>S. longipetala</i> Vent.        | 1 | 5 | 1 | 40.0-42.5<br>41.5 | - | 22 | 6.0-7.0<br>6.8 | 2.3-3.0<br>2.8 | 4 |
| <i>S. behen</i>                    | 1 | 5 | 1 | 40.0-47.5<br>43.0 | - | 20 | 6.0-7.2<br>6.5 | 3.8-4.2<br>4.0 | 4 |
| <i>S. vulgaris</i> Garcke          | 1 | 5 | 1 | 45.0-56.3<br>50.0 | - | 20 | 5.5-6.8<br>5.8 | 2.8-3.3<br>3.0 | 3 |
| <i>S. arabica</i> Boiss.           | 1 | 5 | 1 | 32.5-40.0<br>37.5 | - | 20 | 4.2-5.0<br>4.8 | 2.0-2.5<br>2.3 | 4 |
| <i>S. setacea</i> Vivn             | 1 | 5 | 1 | 35.0-45.0<br>40.5 | - | 25 | 6.5-7.2<br>7.0 | 2.3-3.0<br>2.5 | 4 |
| <i>S. oliveriana</i> Otth.         | 1 | 5 | 1 | 42.5-50.0<br>45.0 | - | 20 | 3.5-4.2<br>4.0 | 2.2-2.5<br>2.3 | 4 |
| <i>S. aegyptiaca</i>               | 1 | 5 | 1 | 42.5-47.5<br>45.0 | - | 20 | 6.2-7.5<br>7.0 | 2.2-2.5<br>2.3 | 5 |
| <i>S. linearis</i> Decne           | 1 | 5 | 1 | 30.0-35.0<br>32.0 | - | 20 | 4.5-5.5<br>5.0 | 2.5-3.5<br>3.0 | 4 |
| Tribe: Diantheae                   |   |   |   |                   |   |    |                |                |   |
| <i>Dianthus cyri</i> Fisch. & Mey  | 1 | 4 | 1 | 40.0-45.0<br>43.0 | - | 8  | 6.0-7.5<br>6.0 | 2.2-2.8<br>2.5 | 4 |
| <i>D. strictus</i> Banks et Sol.   | 1 | 4 | 1 | 50.0-60.0<br>55.0 | - | 8  | 6.5-7.5<br>7.0 | 2.8-3.8<br>3.2 | 3 |
| <i>Gypsophila viscosa</i> Murr.    | 1 | 3 | 1 | 32.5-40.0<br>36.0 | - | 8  | 5.0-6.5<br>5.9 | 2.5-2.8<br>2.7 | 3 |
| <i>G. capillaris</i> Forssk.       | 2 | 6 | 1 | 12.5-15.5<br>13.5 | - | 3  | 6.0-6.8<br>6.5 | 0.9-1.3<br>1.2 | 2 |
| <i>Vaccaria pyramidata</i> Medicus | 1 | 4 | 1 | 37.5-42.5<br>39.0 | - | 14 | 4.5-5.2<br>4.5 | 2.0-3.8<br>3.5 | 2 |
| <i>V. oxyodonta</i> Boiss.         | 1 | 4 | 1 | 37.5-40.0<br>38.5 | - | 12 | 4.5-5.2<br>5.0 | 2.1-2.5<br>2.3 | 2 |

**Key to table 1.**

|                                                                                            |                                                                                                 |
|--------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|
| Col.1 Pollen group: 1-pantoporate<br>2-trizonocolpate 3-pantocolpate<br>4-mixed apertures. | Col.5 Length of the equatorial axis.                                                            |
| " 2 Pollen types: from 1 to 9 according to the text.                                       | " 6 Number of apertures.                                                                        |
| " 3 Pollen shape in optical cross section: 1-spheroidal 2-subprolate 3-prolate 4-oblate    | " 7 Aperture length or diameter.                                                                |
| " 4 Length of the polar axis.                                                              | " 8 Exine thickness.                                                                            |
|                                                                                            | " 9 Sexine pattern: 1-papillate<br>2-granulate 3-bacculate 4-reticulate<br>5-faintly reticulate |

\*\*\* All measurements in micron.

**GROUP 2: Trizonocolpate**

This group occurs more frequently within the subfamily Paronychioideae and sometimes in the subfamily Alsinoideae, but it does not occur in the subfamily Silenoideae. (Table 1)

**vi) Cometes abyssinica type**

Pollen spheroidal in optical view; variable in diameter, from 12 to 45  $\mu\text{m}$ ; colpi wide with tapering ends, colpi membrane granulate; exine semitectate with bacculate or reticulate tectum; sexine is of the same thickness or slightly smaller than nexine. (Table 1)

**vii) Polycarpon tetraphyllum type**

Pollen oblate in optical view, sometimes subprolate or even prolate with different sizes, polar axis varies from 12 to 25  $\mu\text{m}$  while equatorial axis varies from 10 to 27.5  $\mu\text{m}$ ; colpi narrow and long, colpi membrane granulate; exine tegillate with papillate or granulate tectum; sexine is of the same thickness as nexine. (Table 1)

**GROUP 3: Pancolpate**

This group occurs only in the subfamily Paronychioideae, tribe Sperguleae. (Table 1)

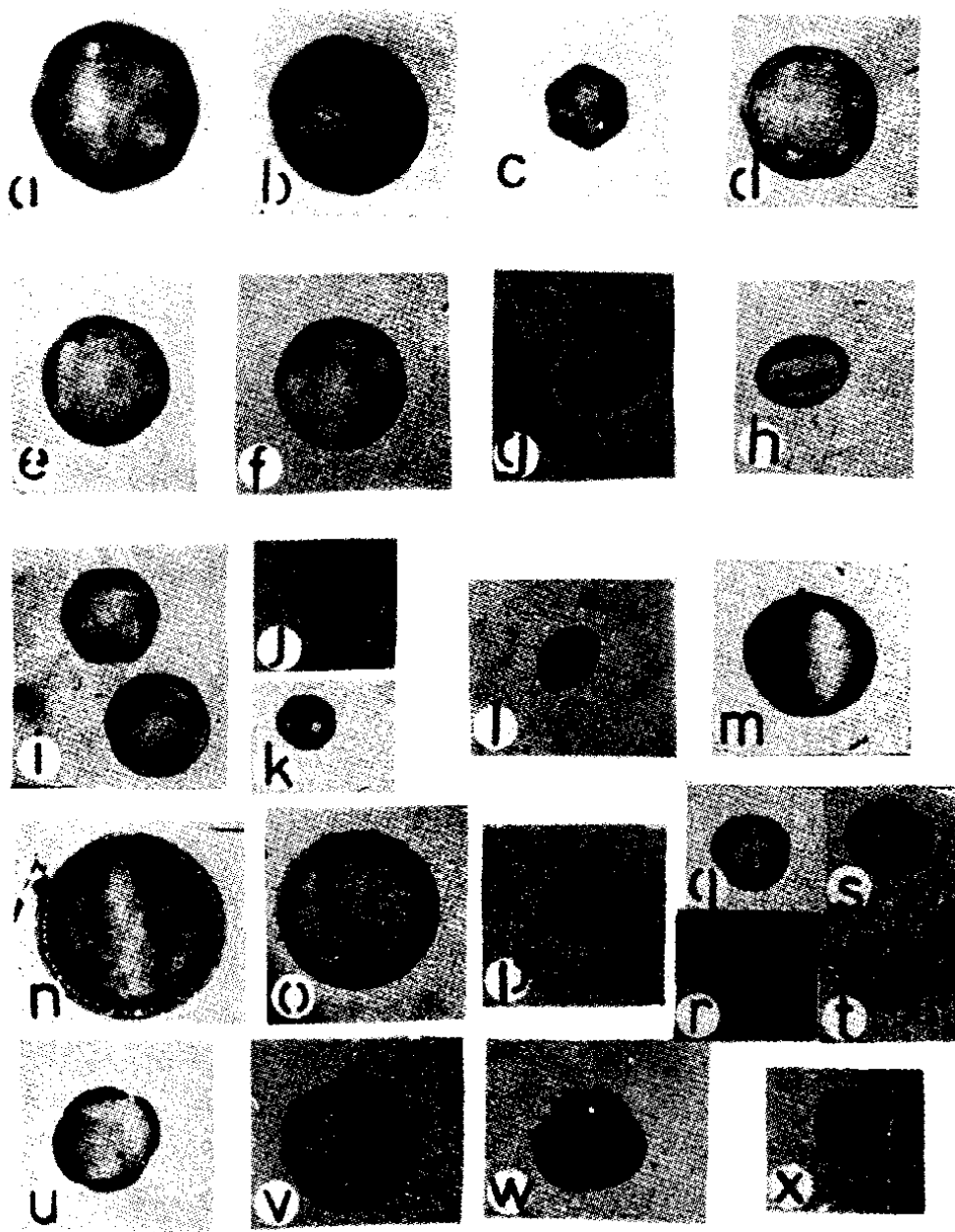
**viii) Spergularia marina type**

Pollen spheroidal, subprolate or prolate in optical view; polar axis varies from 17 to 31  $\mu\text{m}$  and the equatorial axis varies from 15 to 29  $\mu\text{m}$ ; colpi 4, 6 or 8 with granulated membrane; exine tegillate with granulate tectum; sexine is of same thickness as nexine.

**GROUP 4: Mixed apertures**

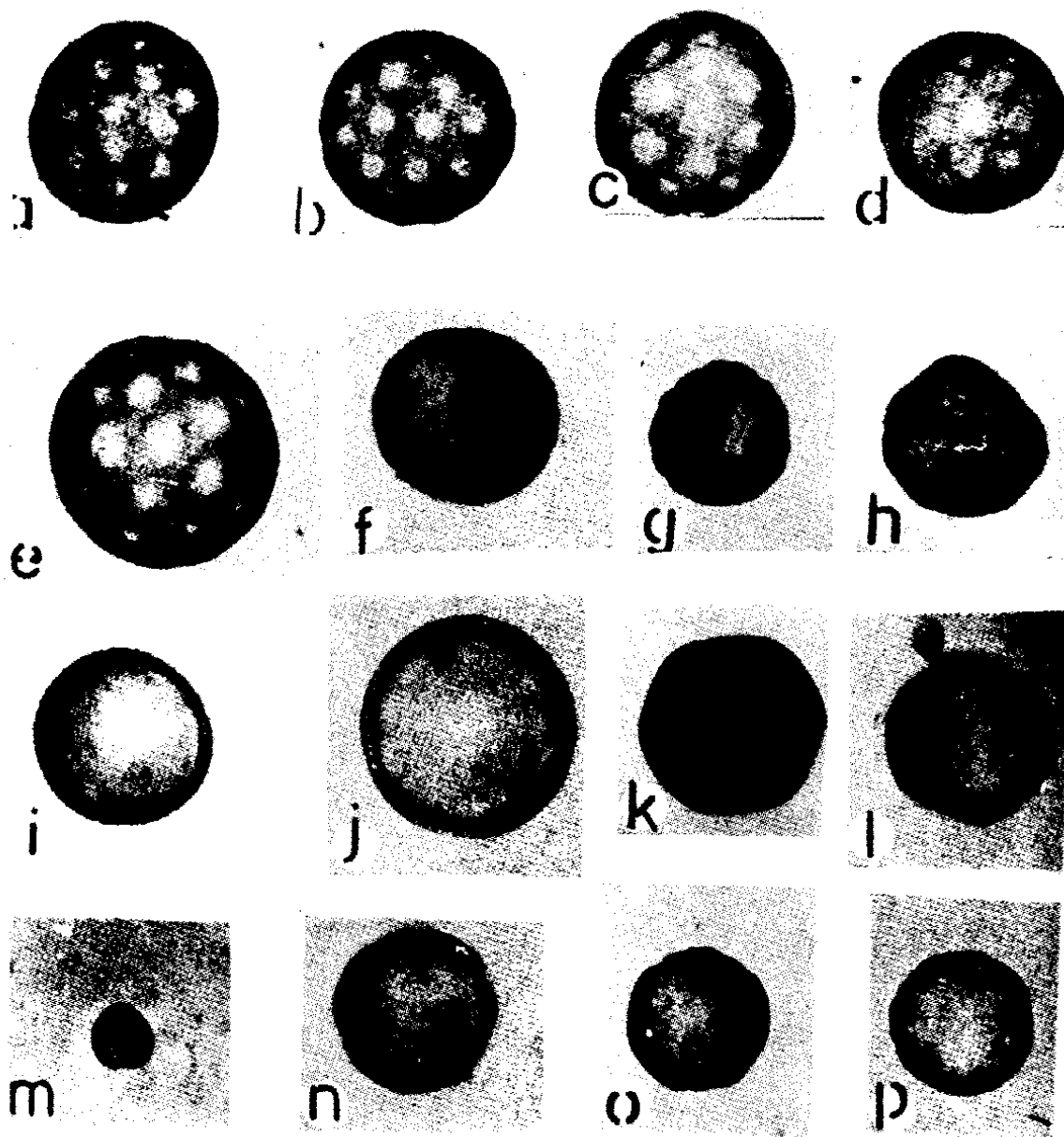
Mixed apertures condition among members of the Caryophyllaceae is of rare occurrence and is confined to one species of the genus *Spergularia*.





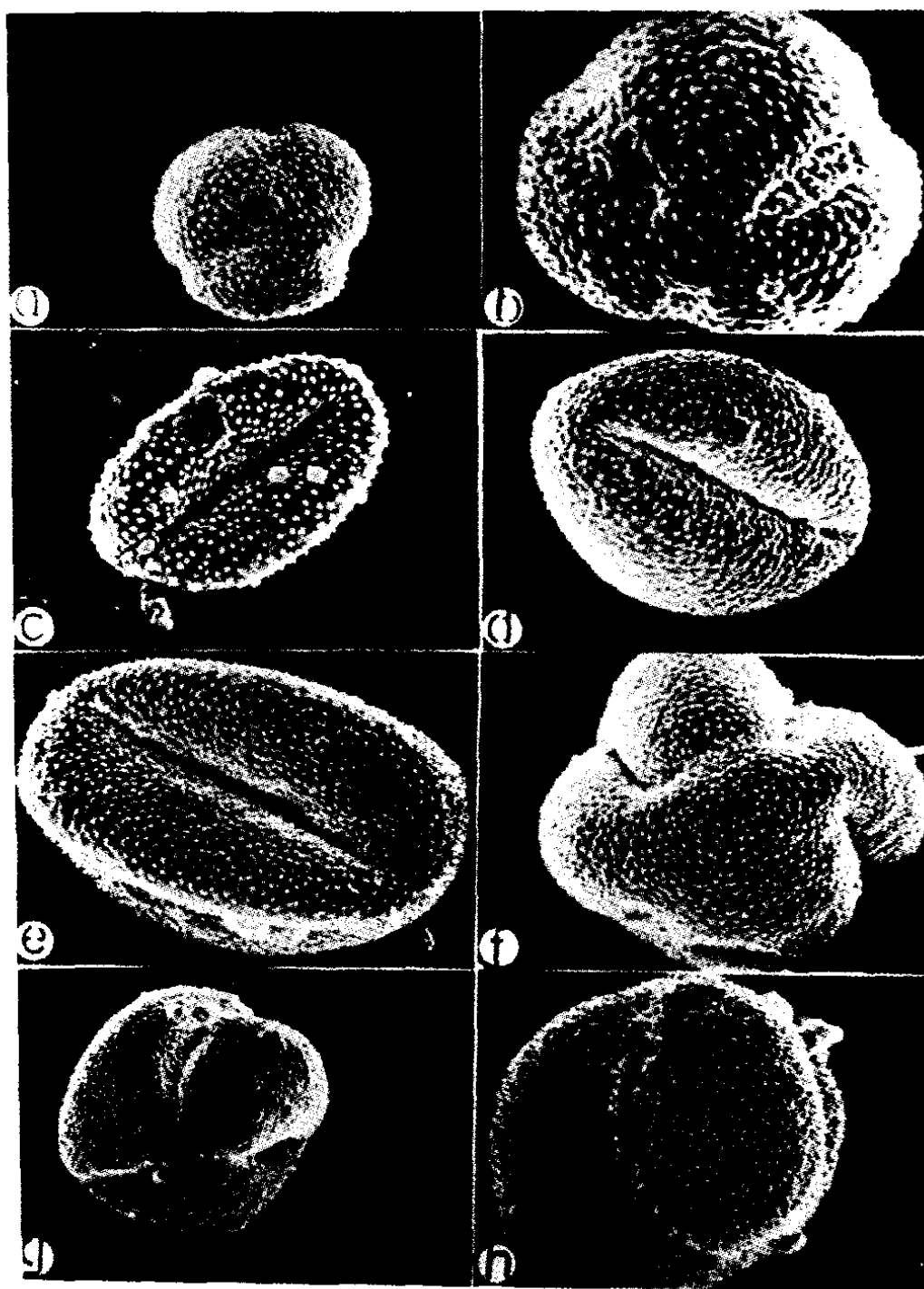
um  
20

**Plate 1.** a) *Stellaria media* b) *Stellaria pallida* c) *Bufonia multiceps* d) *Minuartia tenuifoli* e) *Minuartia meyeri* f) *Minuartia picta* g) *Minuartia geniculata* h) *Minuartia procumbens* i) *Gymnocarpus decandrum* j) *Herniaria hemistemon* k) *Herniaria fontanesii* l) *Sphaerocoma hookeri* m) *Pteranthus dichotomus* n) *Cometes abyssinica* o) *Cometes surathensis* p) *Polycarpae corymbosa* q) *Polycarpon tetraphyllum* r) *Polycarpon succulentum* s) *Polycarpon alsinifolium* t) *Polycarpon prostratum* u) *Spergularia rubra* v) *Spergula arvensis* w) *Telephium sphaerosperm* x) *Loeflingia hispanica*.



20  
μm

Plate 2. a) *Silene tridentata*, b) *Silene rubella*, c) *Silene succulenta*, d) *Silene gallica*, e) *Silene setacea*, f) *Silene palaestina*, g) *Silene apetala*, h) *Silene linearis*, i) *Dianthus cyri*, j) *Dianthus strictus*, k) *Vaccaria pyramidata*, l) *Gypsophila viscosa*, m) *Gypsophila capillaris*, n) *Holosteum umbellatum*, o) *Cerastium dichotomum*, p) *Cerastium viscosum*.



$\mu\text{m}$  6 g       $\mu\text{m}$  4 acd       $\mu\text{m}$  3 b  
 4 efh

Plate 3. a) *Polycarpaea repens* (5000x), b) *Polycarpaea repens* (7500x), c) *Paronychia nivea* (5000x), d) *Spergularia media* (5000x), e) *Spergularia rubra* (5000x), f) *Spergularia rubra* (5000x), g) *Spergularia marina* (3500x), h) *Spergularia marina* (5000x).

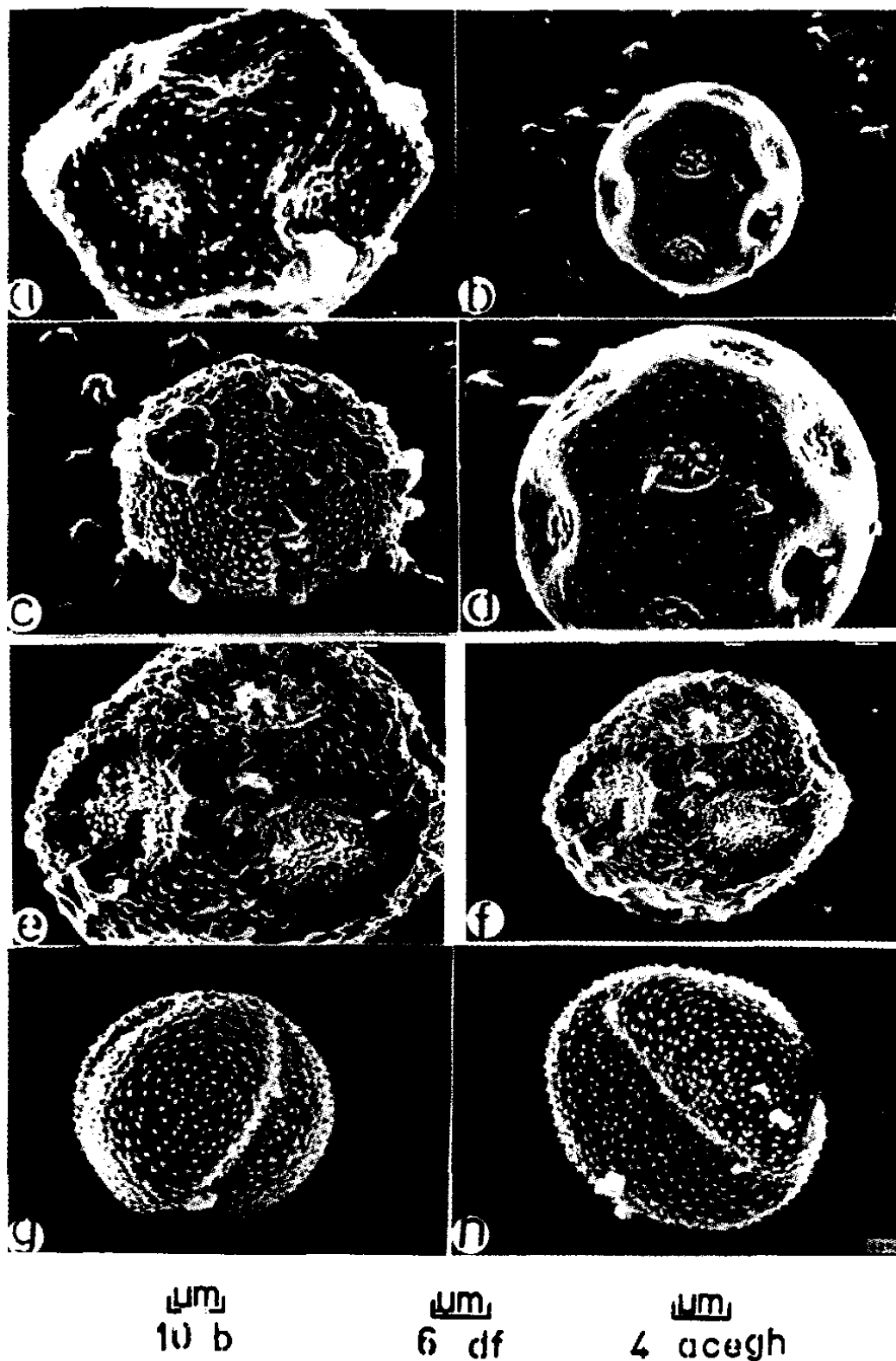


Plate 4. a) *Bufoia multiceps* (5000x), b) *Minuartia picta* (2000x), c) *Minuartia geniculata* (5000x), d) *Minuartia picta* (3500x), e) *Gymnocarpus decandrum* (5000x), f) *Gymnocarpus decandrum* (3500x), g) *Sphaerocoma hookeri* (5000x), h) *Polycarpon tetraphyllum* (5000x).

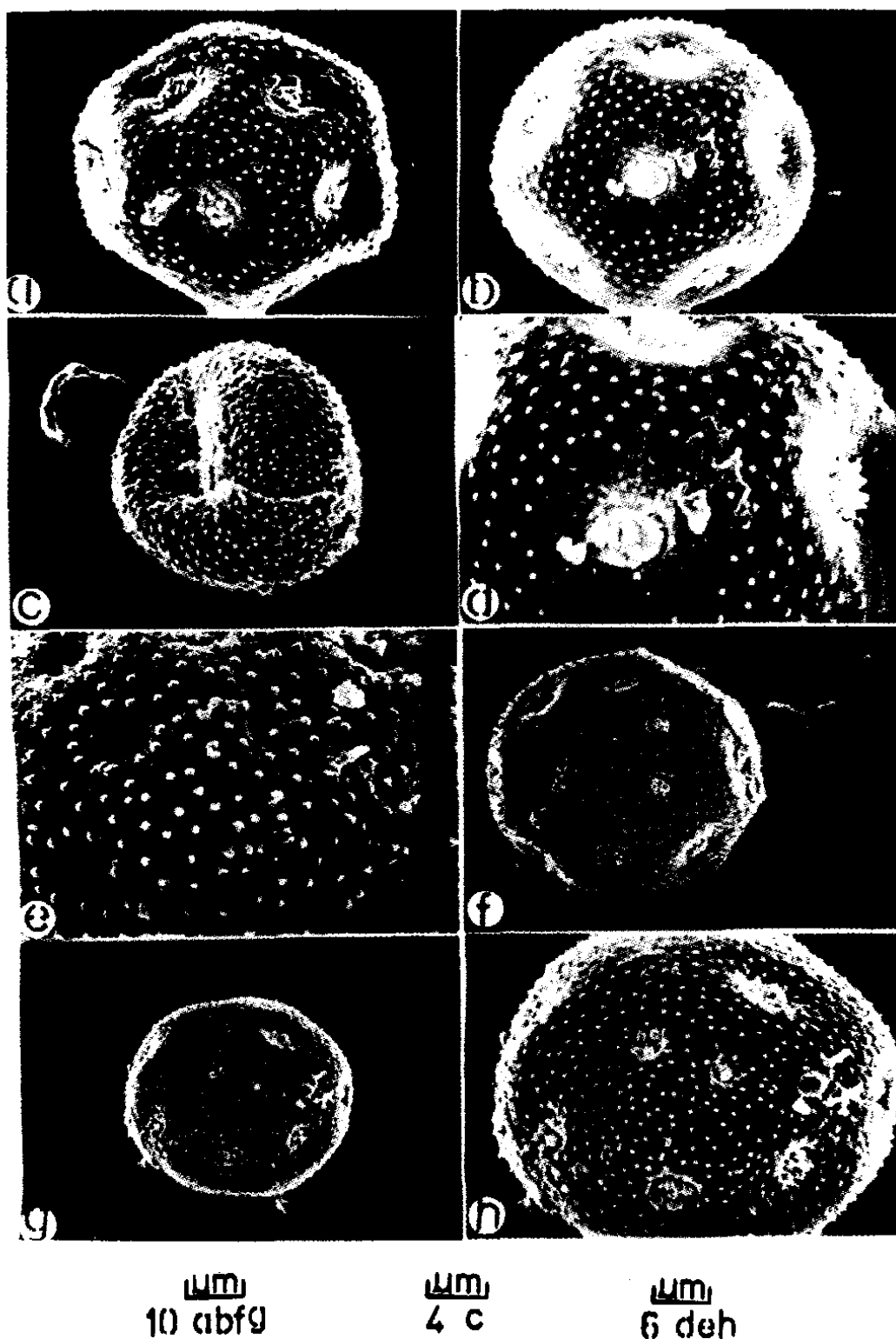


Plate 5. a) *Vaccaria pyramidata* (2000x), b) *Vaccaria oxyodonta* (2000x), c) *Gypsophila capillaris* (5000x), d) *Vaccaria oxyodonta* (3500x), e) *Stellaria pallida* (3500x), f) *Stellaria pallida* (2000x), g) *Minuartia meyeri* (2000x), h) *Minuartia meyeri* (3500x).

### ix) *Spergularia media* type

Pollen subprolate in optical view, polar axis varies from 17.3 to 7.7  $\mu\text{m}$  and the equatorial axis varies from 15.9 to 16.5  $\mu\text{m}$ , with 4 or 6 colpi together with small pores; pores hidden by granulated operculum; colpi membranes granulated; exine tegillate with granulate tectum; sexine is thicker than nexine.

## Discussion and Conclusion

The palynological results obtained from this study reveal that, within the subfamily Paronychioideae there are two major groups of pollen grains, the porate and the colpate. Members of the porate group are genera restricted to tribe Paronychieae, except for *Sphaerocoma* which has trizonocolpate pollen grains. The remaining genera of the Paronychieae i.e. *Paronychia*, *Herniaria* and *Gymnocarpus* which are the members of the porate group, are characterised by: absence of corolla, perigynous flowers and usually single-seeded indehiscent capsule. The second type of pollen grains, the colpate, is common among the remaining genera of the Paronychioideae, irrespective of the variation in the number of colpi. These are characterised by: presence of corolla, hypogynous flowers and usually a several- to manyseeded capsule. These results obtained are in accordance with the results from earlier studies of vegetative and floral characters [1-3; 33, pp. 67-69] and support the division of the subfamily Paronychioideae into two groups, or separating those with porate pollen as members of the family Illecebraceae.

Subfamily Alsinoideae is characterised by the pantoporate pollen, except for *Arenaria serpyllifolia*; *Minuartia geniculata* and *Minuartia procumbens*. The genera *Stellaria* and *Spergula* which have been taxonomically united by Bentham [6] and separated on the presence or absence of stipules, is further easily distinguished by their different pollen. The genera *Arenaria* and *Minuartia* which have been treated as a single genus by Maguire [19] and have been separated by McNeill [34; 35]. He evaluated the generic limits in the Alsinoideae and considered the number of teeth opening in the capsule as a character for the separation of the two genera. The palynological results obtained do not support their separation. The colpate species of *Minuartia* section Rhodalsine show remarkable similarity in habit to some species of *Spergularia* (pink petals, a basic chromosome number of 9) which are unusual in the Alsinoideae. The results obtained support the separation of the Rhodalsine group from the Alsinoideae and transfer to the Sperguleae as proposed by McNeill and Basset [36], the only group without stipules.

Subfamily Silenoideae has more uniform pollen grains (all spheroidal, pantoporate) except for *Gypsophila capillaris* which has colpate pollen. The two closely related tribes Lychnideae and Diantheae can be easily distinguished by their pollen characters.

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## دراسة مورفولوجية لحبوب لقاح بعض الأجناس المصرية التابعة للفصيلة القرنفلية

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ملخص البحث. تمت دراسة حبوب لقاح ٦٧ نوعاً من ٢١ جنساً تابعين للفصيلة القرنفلية العامة في الفلورا المصرية. ومن دراسة حجم حبوب اللقاح ونوعها وعدد الثقوب بها تم تدعيم تقسيم تحت الفصيلة البارونخية إلى مجموعتين متميزتين كما أصبح الجنس ستيلاريا متميزاً عن الجنس سبرجيولا بينما الجنسين اريناريا ومنوارتيا وجد أنهما لهما الخصائص الباليولوجية نفسها مما يدعم الاقتراح المفترض بضم هذه الأنواع في جنس واحد. بينما القسم رودالذين التابع للجنس منوارتيا له الخصائص الباليولوجية نفسها للجنس سبرجيولا وهذا يعضد الرأي المفترض بضم هذا القسم إلى جنس سبرجيولا. بينما الأجناس التابعة لتحت الفصيلة السيلينية له حبوب لقاح متماثلة إلى حد كبير وبالرغم من هذا فإنه يمكن تمييز القسمين دايتشي ولكنيدي بسهولة.