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# SEED MORPHOLOGY OF SOME TAXA OF CARYOPHYLLACEAE

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## ABSTRACT

Seed morphology of 28 taxa belonging to 14 genera of Caryophyllaceae was studied utilizing stereoscopic and scanning electron microscopes, to determine the significance of seed coat features as taxonomic characters. Results of the present study concluded that there are significant variations in particular surface features within all the studied members of the Caryophyllaceae. The superficial ridges and tubercules exhibit patterns that could be helpful in determining relationships among the studied species. Seed shapes were orbicular, ovate, reniform, triangular, pyriform and asymmetrical shield-shaped. Seed colours were pale brown, brown, pinkish-brown, reddish-brown, dark brown and black. Seed length varied from 0.4-3.1 mm long. The dorsal surfaces were grooved, winged or flat. The periclinal walls were convex, granulate; convex, granulate with tubercle in the central area; convex, granulate with long papillae in the central area; convex, granulate with minute tubercle in the anterior area; flat, granulate or flat, smooth. The anticlinal walls were entire or sinuate with different shapes namely: S- sinuate, U- sinuate, V- sinuate and irregular sinuate. The great number of seed characters observed indicated that there is a large diversity among seeds which can provide good criteria for the identification and classification of the studied taxa.

***Key words:*** *Caryophyllaceae; seed morphology; taxonomy; periclinal and anticlinal walls.*

## 1. INTRODUCTION

Caryophyllaceae is a large, cosmopolite family of about 87 genera and about 2300 species of herbs and small shrubs distributed especially in temperate and warm northern hemisphere, but concentrated in the Mediterranean and Irano-Turanean region (Bittrich, 1993 and Heywood, 1998), of which 26 genera, including about 87 species, occur as native species in Egypt (Boulos, 1999 and 2009). Traditionally, Caryophyllaceae are subdivided into three subfamilies: Alsinoideae, Caryophylloideae and Paronychioideae. Alsinoideae are characterized by nectar glands located at the abaxial base of the episepalous stamens and Caryophylloideae are distinguished by a tubular calyx tube and jointed/clawed petals (Chrtek and Slavikova, 1987). Bittrich (1993) proposed that Alsinoideae and Caryophylloideae together form a monophyletic group based on caryophyllad-type embryology, as compared with solanad embryology in Paronychioideae. Understanding the relationships within the Caryophyllaceae has been difficult, in part because many of the genera are not well defined morphologically and are difficult to distinguish (Harbaugh *et al.*, 2010). Moreover, the complex and possibly homoplasious morphological characters within the family make taxa difficult to delimit and diagnose (Fior *et al.*, 2006).

Many studies have focused on the seed dimorphism, the production of two seed types by a single plant, in Caryophyllaceae. Telenius and Torstensson (1989, 1991 and 1999) reported that the seeds of the *Spergularia marina* differ both within and between individuals in that they either possess or lack a membranaceous border. Wagner (1986) documented that the seeds of *Spergula arvensis* L. exhibit a seed-coat polymorphism in which two primary forms exist papillate and non-papillate, and one intermediate form.

The variation in ornamentation of testa cells as well as their size and shape may provide useful diagnostic characters for separating taxa at the generic and specific level in Caryophyllaceae (Mahdavi *et al*., 2012). Seed micro-morphology of different genera of Caryophyllaceae has been applied in systematic

studies for example, Dadandi and Yildiz, 2015 and Keshavarzi *et al.*, 2015) *Minuartia* L. (Mostafavi *et al.*, 2013) Arman and Gholipour, 2013, and *Stellaria* (Miller and West, 2012) *Gypsophila* L. (Amini *et al.*, 2011); *Moehringia* L. (Minuto *et al*., 2011); *Silene* L. (Fawzi *et al.*, 2010).

The main purpose of the current work is to determine the seed micro-and macromorphological characters of some species of Caryophyllaceae and to assess their potential taxonomic value.

## 2. MATERIALS AND METHODS

In the current study, twenty eight taxa of the Caryophyllaceae were investigated. Seeds of these species were either received from Kew's Millennium Seed Bank or taken from the seed collection of Flora and Phyto-Taxonomy Research Department, Horticultural Research Institute, Agricultural Research Center, Egypt (CAIM) (Table 1.) The seed dimensions and the general exomorphological features of the seeds were measured by Leica stereoscopic microscope. The finer morphological details were examined using the Scanning Electron Microscope (SEM) Model Quanta FEG 250 at the electron Microscope Unit, National research center. The SEM-micrographs were taken after the mature seeds were coated with a thin layer of gold in fine coater and examined in different positions using different magnifications. A comparison of seed micromorphological characters in the studied taxa is presented in Table (2). The data of seed criteria were numerically analyzed using SPSS 22 program to construct a dendrogram (Fig.7). For creating the data matrix, characters were treated as multistate characters (Table 3). The terminology used to describe seed coat surface sculpturing followed Fawzi *et al.* (2010).

## 3. RESULTS AND DISCUSSION

Seeds were showed numerous morphological characters which could be used for taxonomic purposes. The ornamentation features of the seed coat differered from one species to another. A detailed examination of the seed ultra-structure morphological features of twenty eight taxa was carried out by light and scanning electron microscopes. The studied morphological characters were; seed shape, size, color, surface, peripheral ridges, cell pattern and anticlinal wall boundaries. Morphological features of the seeds are very various within Caryophyllaceae (Yildiz, 2002 and Zareh, 2005). Mahdavi *et al.* (2012) recorded that the variation in ornamentation of testa cells as well as their size and shape may provide useful diagnostic characters for separating taxa at the generic and specific level.

Seed shapes in subfamily Alsinoideae are generally triangular-cuneiform, except *Holosteum umbellatum* which is asymmetrical shield-shaped and *Stellaria media* is orbicular (Fig. 1). Seed shapes within subfamily Caryophylloideae are commonly reniform or reniform-orbicular (in all taxa of *Silene* and *Agrostemma githago*) and the ovate shape represented in genus *Dianthus* (Figs.2, 3 and 4). On the other hand, In subfamily Paronychioideae; seed shapes are pyriform or pyriform-reniform, except *Spergula arvensis* and *Spergularia media* are orbicular (Figs. 5 and 6). Fawzi *et al.* (2010) and Dadandi and Yildiz (2015) reported that seed shapes of most species of genus *Silene* are generally reniform with various degrees of deviation. Seed colour is brown, dark brown and brown with pinkish or reddish spotty in subfamily Alsinoideae. While in Caryophylloideae seed colour is greatly variable from pale brown, brown, pinkish-brown, reddish-brown, dark-brown or black. Paronychioideae seeds are pale brown, brown or dark brown.

Seed surfaces under light microscope are smooth, tuberculate and papillate. Seed dimorphism, in which a single plant produces two different seed types, was recorded in subfamily Paronychioideae. Whereas, *Spergularia diandra* and *Spergularia marina* showed two forms of seed surface, papillate and non-papillate (Fig. 6). This agrees with (Wagner, 1986) who studied the seed dimorphism in *Spergula arvensis*. Wang *et al.* (2012) showed that the morphological seed dimorphism is linked with a physiological dimorphism with regard to some requirements for germination. Seed dimorphism can playa role in seed migration by the presence or absence of membranous wing. Seed length varied between 0.5 to 1.1 mm in Paronychioideae and 0.4 to 0.9 mm in Alsinoideae. While, Caryophylloideae are characterized by the relatively large seeds with seed length up to 3.1 mm in *Agrostemma githago* (Table 2).

Dorsal sides of Alsinoideae seeds were shallow grooved or grooved .In Caryophylloideae ; seeds of *Dianthus* ,

**Table (1): List of the taxa used for seed micromorphological study.**

| Subfamily | Tribe | Taxa | Source |
|---|---|---|---|
| Alsinoideae | Alsineae | *Holosteum umbellatum* L. (Syn. *Holosteum umbellatum* subsp. *umbellatum* L.) | Kew |
| | | *Minuartia meyeri* (Boiss.) Bornm. | Kew |
| | | *Sagina apetala* Ard. | Kew |
| | | *Sagina maritima* G.Don | Kew |
| | | *Stellaria media* (L.) Vill. | CAIM |
| Caryophylloideae | Caryophylleae | *Dianthus barbatus* L. | CAIM |
| | | *Dianthus monadelphus* subsp. *judaicus* (Boiss.) Greuter & Burdet (Syn. *Dianthus judaicus* Boiss). | Kew |
| | | *Gypsophila capillaris* (Forssk.) C. Chr. subsp. *confusa* Zmarzty | Kew |
| | | *Saponaria cypria* Boiss. | CAIM |
| | | *Vaccaria hispanica* **(**Mill.**)** Rauschert var**.** *grandiflora* (Fisch. ex Ser.) J.Léonard (Syn. *Vaccaria segetalis* Garcke ex Asch. var. *grandiflora*) | CAIM |
| | Sileneae | *Agrostemma githago* L. | CAIM |
| | | *Silene aegyptiaca* (L.) L.f. | Kew |
| | | *Silene apetala* Willd. | Kew |
| | | *Silene burchellii* Otth ex DC. | Kew |
| | | *Silene colorata* Poir. | Kew |
| | | *Silene flos-cuculi* (L.) Greuter & Burdet (Syn. *Lychnis flos-cuculi* L. | CAIM |
| | | *Silene linearis* Decne. | Kew |
| | | *Silene longipetala* Vent. | Kew |
| | | *Silene nocturna* L. | Kew |
| | | *Silene villosa* var. *ismailitica* Schweinf. | CAIM |
| Paronychioideae | Paronychieae | *Herniaria hirsuta* L. | Kew |
| | Polycarpeae | *Polycarpaea corymbosa* (L.) Lam. (*Polycarpaea corymbosa* var. *corymbosa*) | Kew |
| | | *Polycarpaea repens* (Forssk.) Asch. & Schweinf. | Kew |
| | | *Spergula arvensis* L. (*Spergula sativa* Boenn.) | CAIM |
| | | *Spergularia bocconei* (Scheele) Asch. & Graebn. | Kew |
| | | *Spergularia diandra* (Guss.) Heldr. | CAIM |
| | | *Spergularia marina* (L.) Besser (Syn. *Spergularia salina* J.Presl & C.Persl | CAIM |
| | | *Spergularia media* (L.) C.Presl | Kew |

## Table (2): Seed micromorphological characters of the studied taxa.

| Subfamily, taxa | Characters | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Seed shape** | **Dorsal side** | **Seed colour** | **Seed length X width (mm)** | **Seed surface under light microscope** | **Cell ornamentations (Periclinal cell walls)** | **Cell margin outline (Anticlinal cell walls)** | **Cell length (μm)** | **Hylar zone** |
| **Alsinoideae:** | | | | | | | | | |
| *Holosteum umbellatum* | Asymmetrical shield-shaped | Shallow grooved | Brown with pinkish spotty | 0.9 x 0.8 | Wrinkly, tuberculate | Convex, granulate with tubercle in the central area | Sinuous; S-shaped | 65 | Recessed |
| *Minuartia meyeri* | Triangular or cuneiform | Grooved | Brown | 0.8 x 0,6 | Wrinkly, tuberculate | Convex, granulate | Sinuous; V-shaped | 70 | Slightly recessed |
| *Sagina apetala* | Triangular or cuneiform | Grooved | Dark brown | 0.4 x 0,3 | Tuberculate | Flat, granulate with tubercle in the central area | Sinuous; V-shaped | 70 | Slightly recessed |
| *Sagina maritima* | Triangular or cuneiform | Grooved | Dark brown with reddish spotty | 0.4 x 0,3 | Tuberculate | Convex, granulate | Sinuous; V-shaped | 70 | Recessed |
| *Stellaria media* | Orbicular | Shallow grooved | Dark brown | 0.9 x 0.9 | Papillate | Convex, granulate | Sinuous; V-shaped | 99 | Recessed |
| **Caryophylloideae:** | | | | | | | | | |
| *Dianthus barbatus* | Ovate | Flat | Dark brown-black | 2.6 x 1.8 | Wrinkly, minutely tuberculate | Convex, granulate | Slightly sinuous; S-shaped | 70 | Prominent |
| *Dianthus monadelphus* subsp. *judaicus* | Ovate to suborbicular | Flat | Black | 2.6 x 2.1 | Wrinkly, minutely tuberculate | Convex, granulate | Minutely sinuous; V-shaped | 55 | Prominent |
| *Gypsophila capillaris* | Reniform | Flat | Black | 2.1 x 1.8 | Tuberculate | Convex, granulate with tubercle in the central area | Sinuous; irregularly shaped | 220 | Recessed |
| *Saponaria cypria* | Orbicular | Flat | Dark brown | 2.4 x 2.4 | Tuberculate | Flat, granulate | Minutely sinuous; V-shaped | 100 | Recessed |
| *Vaccaria hispanica* var. *grandiflora* | Orbicular | Shallow grooved | Black | 2.4 x 2.4 | Smooth | Flat, granulate, wirnkled | Sinuous; V-shaped | 70 | Flat |
| *Agrostemma githago* | Reniform | Flat | Black | 3.1 x 2.5 | Papillate | Convex, granulate with long tubercle in the central area | Sinuous; irregularly shaped | 300 | Recessed |
| *Silene aegyptiaca* | Reniform | Shallow grooved | Black | 1.0 x 0.8 | Tuberculate | Convex, granulate with minute tubercle in the anterior area | Sinuous; V-shaped | 130 | Recessed |
| *Silene apetala* | Reniform | Grooved | Brown | 1.0 x 0.5 | Wrinkly, tuberculate | Convex, granulate | Sinuous; V-shaped | 80 | Recessed |
| *Silene burchellii* | Reniform-orbicular | Deeply grooved | Black | 1.2 x 0.9 | Wrinkly, smooth | Flat, granulate | Slightly sinuous; S-shaped | 80 | Recessed |

**Table (2): Cont.**

| Subfamily, taxa | Characters | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Seed shape** | **Dorsal side** | **Seed colour** | **Seed length X width (mm)** | **Seed surface under light microscope** | **Cell ornamentations (Periclinal cell walls)** | **Cell margin outline (Anticlinal cell walls)** | **Cell length (μm)** | **Hylar zone** |
| *Silene colorata*. | Reniform-orbicular | Deeply Grooved | Black | 1.1 x 0.9 | Wrinkly, smooth | Flat, granulate | Slightly sinuous; S-shaped | 110 | Recessed |
| *Silene flos-cuculi* | Reniform | Flat | Black | 1.0 x 0.5 | Papillate | Convex, granulate with tubercle in the central area | Sinuous; V-shaped | 90 | Recessed |
| *Silene linearis* | Pyriform | Grooved | Brown | 0.6 x 0.4 | Tuberculate | Flat, granulate | Sinuous, irregularly shaped | 105 | Slightly recessed |
| *Silene longipetala* | Reniform-orbicular | Deeply Grooved | Pale brown | 1.5 x 1.1 | Tuberculate | Flat, granulate | Slightly sinuous; S-shaped | 125 | Recessed |
| *Silene nocturna* | Reniform | Deeply Grooved | Pinkish-brown | 1 x 0.8 | Wrinkly, tuberculate | Flat, granulate | Slightly sinuous; S-shaped | 150 | Recessed |
| *Silene villosa* var. *ismailitica* | Reniform | Grooved | Brown | 1.0 x 0.6 | Tuberculate | Flat, granulate | Slightly sinuous; S-shaped | 110 | Recessed |
| **Paronychioideae:** | | | | | | | | | |
| *Herniaria hirsuta* | Pyriform | Flat | Dark brown | 0.5 x 0.4 | Smooth | Flat, smooth | Invisible | - | Prominent |
| *Polycarpaea corymbosa* | Pyriform-reniform | Shallow grooved | Pale brown | 0.5 x 0.3 | Wrinkled, smooth | Flat, smooth | Invisible | - | Prominent |
| *Polycarpaea repens* | Pyriform-reniform | Shallow grooved | Pale brown | 0.7 x 0.4 | Smooth | Convex, smooth | Entire | 20 | Prominent |
| *Spergula arvensis* | Orbicular | Winged | Dark brown | 1.1 x 1.1 | Papillate | Convex, granulate with long papillae in the central area | Deeply sinuous; V-shaped | 60 | Flat |
| *Spergularia bocconei* | Pyriform | Flat | Brown | 0.6 x 0.3 | Papillate | Convex, granulate with tubercle in the central area | Deeply sinuous; U-shaped | 80 | Prominent |
| *Spergularia diandra* | Pyriform | Flat | Dark brown | 0.7 x 0.4 | Smooth or papillate | Flat, granulate or Flat, granulate with tubercle in the central area | Deeply sinuous; irregularly shaped | 60 | Prominent |
| *Spergularia marina* | Pyriform | Flat | Brown | 0.7 x 0.4 | Smooth or papillate | Convex, smooth or Flat, granulate with tubercle in the central area | Entire or Deeply sinuous; U-shaped | 60 | Prominent |
| *Spergularia media* | Orbicular | Winged | Dark brown | 1.2 x 1 | Smooth | Flat, granulate | Deeply sinuous; U-shaped | 60 | Prominent |

**Table (3): List of seed characters, character states and codes used in numerical analysis.**

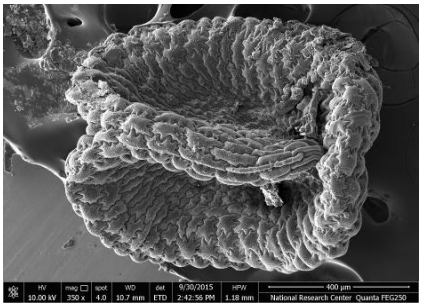
| No. | Characters | Character states and codes |
|---|---|---|
| 1 | Seed shape | Asymmetrical (1), Triangular (2), Circular (3), Pyriform or Pyriform-reniform (4), Ovate to suborbicular (5), Reniform or Reniform-orbicular (6). |
| 2 | Dorsal side | Flat (1), Grooved (2), Winged (3). |
| 3 | Seed colour | Pale brown (1), Brown (2), Pinkish or reddish-brown (3), Dark brown (4), Black (5). |
| 4 | Seed length | Less than 0.5 mm (1),0.6 to1 mm (2),1.1 to2 mm (3),more than 2m (4). |
| 5 | Seed surface | Smooth (1), Tuberculate (2), Papillate (3). |
| 6 | Hylar zone type | Prominent (1), Flat (2), Recessed (3). |
| 7 | Cell surface | Flat (1), Convex (2). |
| 8 | Cell surface | Smooth (1), Granulate (2). |
| 9 | Cell surface | Untuberculate (1), Tuberculate (2), Papillate (3). |
| 10 | Anticlinal cell walls | Entire (1),Minutely sinuous (2),Slightly sinuous (3),Deeply sinuous (4). |
| 11 | Sinuous shape | V-shaped (1), U-shaped (2), S-shaped (3), Irregular (4). |
| 12 | Cell length | Less than 50 µm (1), 0.51 to 100 µm (2), 101 to 200 µm (3), More than 200 µm (4). |
| 13 | Seed dimorphism | Absent (0), Present (1). |
| 14 | Sinuous level | Non sinuous (1), slightly sinuous (2), Sinuous (3), Deeply sinuous (4). |

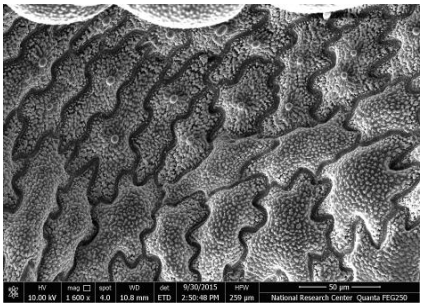
*Gypsophila*, *Saponaria* and *Silene flos-cuculi* have flat dorsal side. The remaining *Silene* species varied from shallow grooved to deeply grooved. In Paronychioideae; dorsal sides of the seeds are flat, shallow grooved or with conspicuous wings as in *Spergula arvensis* and *Spergularia media.* Hylar zone in all taxa belonging to Paronychioideae is prominent except *Spergula arvensis* which is flat. Whereas, Alsinoideae and Caryophylloideae are recessed except *Dianthus* (prominent) and *Vaccaria hispanica* (flat). The range of variation in dorsal side and hylar zone is in accordance with Yildiz (2002).

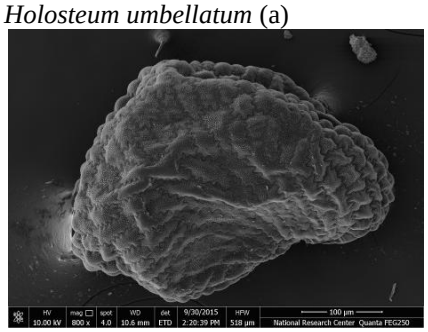
Testa cells showed great diversity in ornamentations of periclinal walls, anticlinal walls as well as size. The periclinal cell walls in Alsinoideae seeds are granulate or granulate with tubercle in the central area (Fig.1). Whereas, Caryophylloideae seeds have different shapes of periclinal cell walls, namely: granulate, granulate with tubercle in the central area, granulate with long tubercle in the central area and granulate with minute tubercle in the anterior area (Figs.2, 3 and 4). In Paronychioideae; periclinal cell walls varied from smooth, granulate, granulate with long papillae in the central area to granulate with tubercle in the central area (Figs. 5 and 6) The testa cells of *Herniaria hirsute* and *Polycarpaea corymbosa* are invisible due to the thickness of the cuticle layer. Anticlinal cell walls among the studied taxa were sinuous with different shapes, except *Polycarpaea repens* and *Spergularia marina* (Non papillae form) (Table 2). The range of variation in anticlinal walls is in accordance with Fawzi *et al.* (2010). The testa cells are relatively small with cell length ranged between 20 and 60 µm in Paronychioideae and varied from 65 and 99 µm. in Alsinoideae Whereas, the cells in Caryophylloideae were mostly large with cell length ranging between 55 and 300 µm (Table 2).

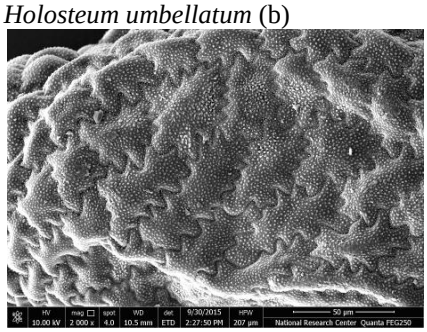
The great diversity in cell ornamentations as well as the shapes of anticlinal walls can be used as a significant tool for identification and classification, whereas each species has specific features which can easily differentiate it from other species. This finding agrees with the results obtained by (Fawzi *et al.*, 2010; Mahdavi *et al.*, 2012 and Arman and Gholipour, 2013).

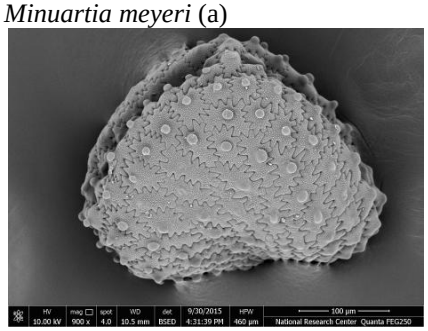
The numerical analysis of the applied 14 characters (Fig.7) showed that the taxa belonging to subfamily Caryophylloideae were

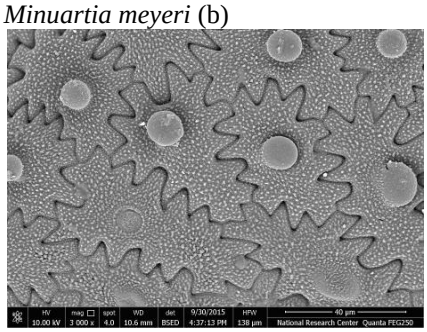

*Holosteum umbellatum* (a)


*Holosteum umbellatum* (b)

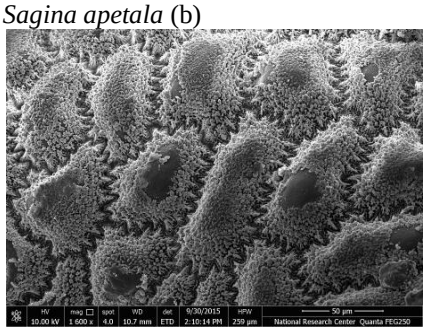

*Minuartia meyeri* (a)

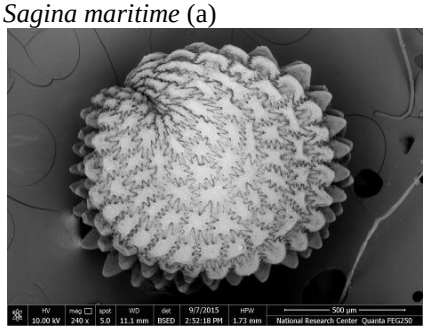

*Minuartia meyeri* (b)


*Sagina apetala* (a)


*Sagina apetala* (b)


*Sagina maritime* (a)


*Sagina maritime* (b)


*Stellaria media* (a)

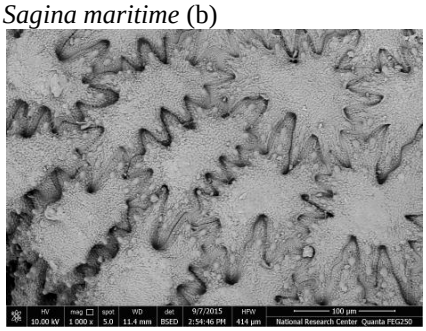
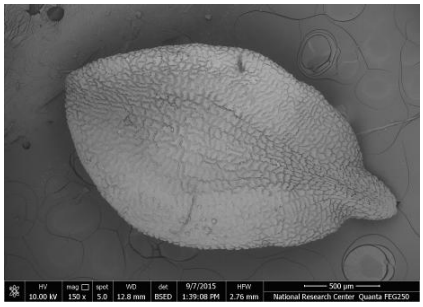
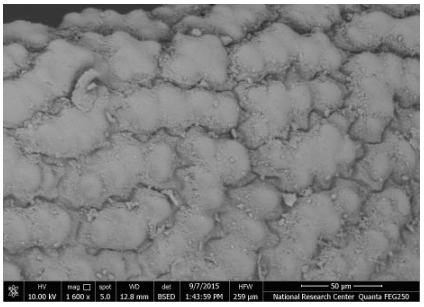
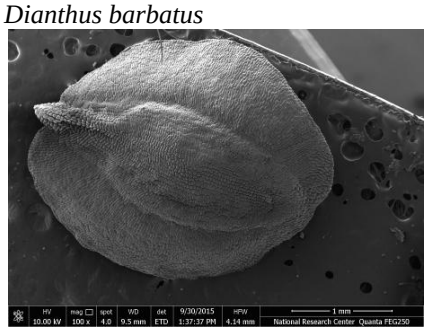
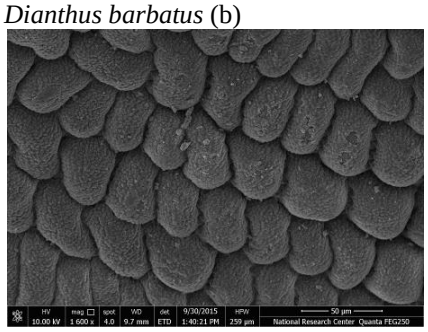

*Stellaria media* (b)

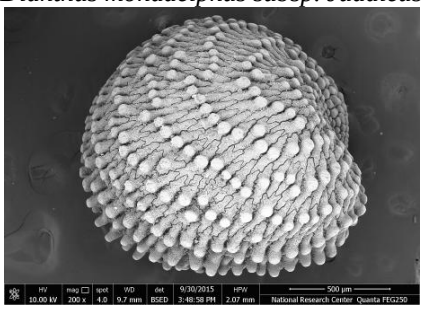
**Fig. (1): SEM micrographs of seed shape (a) and seed coat surface (b) in subfamily Alsinoideae.**

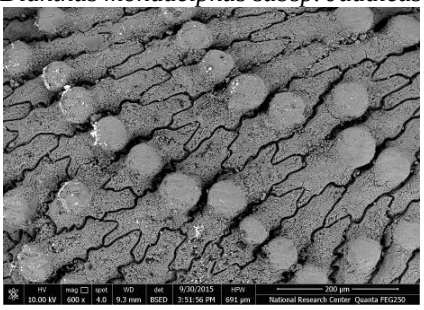

*Dianthus barbatus*

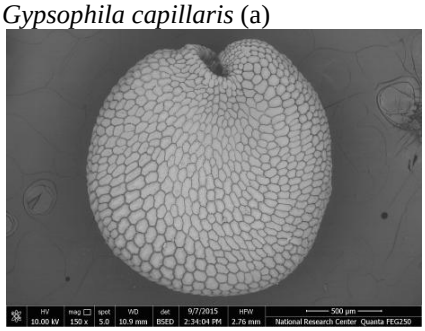

*Dianthus barbatus* (b)

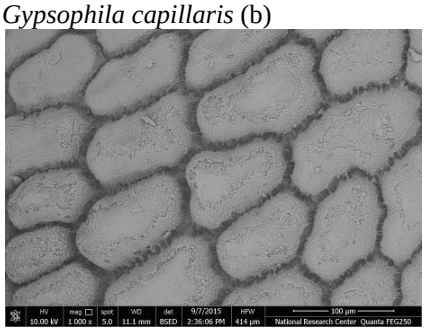

*Dianthus monadelphus subsp. Judaicus* (a)

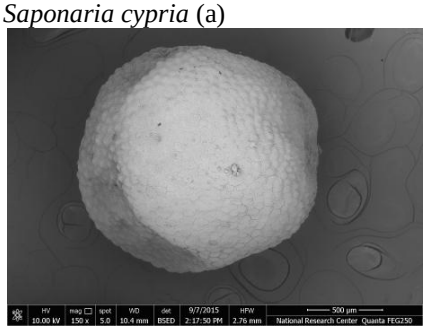

*Dianthus monadelphus subsp. Judaicus* (b)


*Gypsophila capillaris* (a)


*Gypsophila capillaris* (b)


*Saponaria cypria* (a)


*Saponaria cypria* (b)


*Vaccaria hispanica* (a)

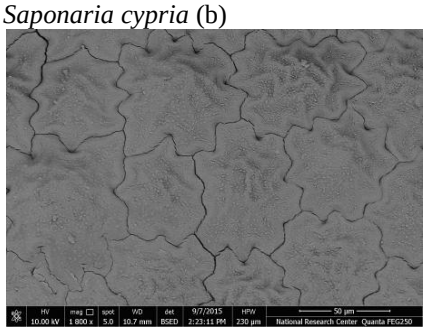
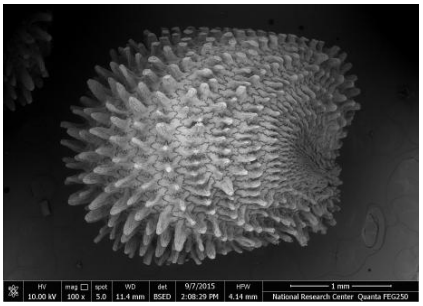
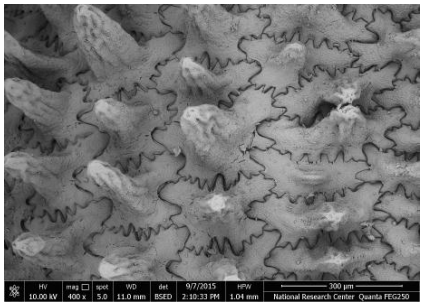
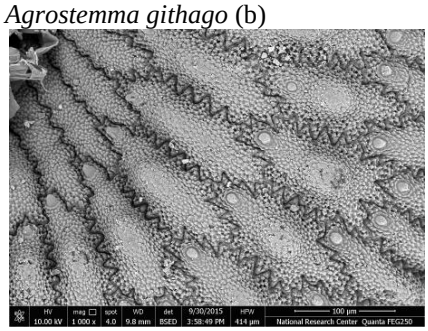

*Vaccaria hispanica* (b)

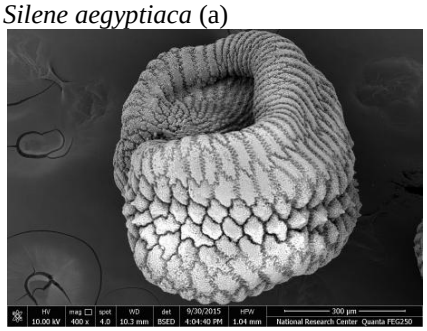
**Fig. (2): SEM micrographs of seed shape (a) and seed coat surface (b) in subfamily Caryophylloideae; tribe Caryophylleae.**

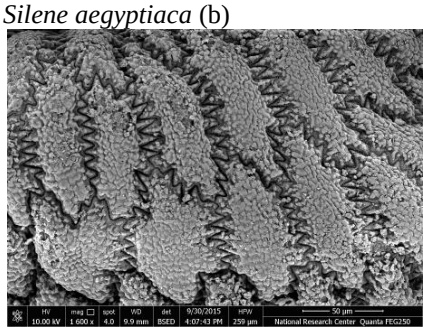

*Agrostemma githago* (a)

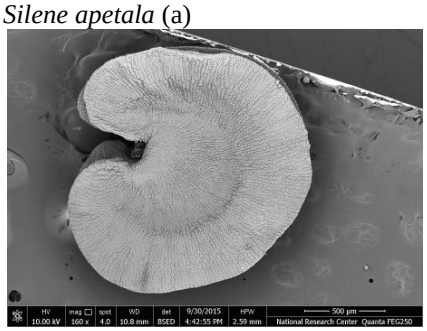

*Agrostemma githago* (b)

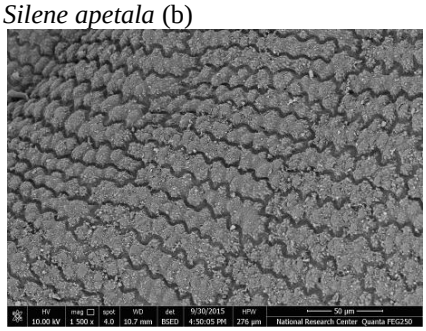

*Silene aegyptiaca* (a)

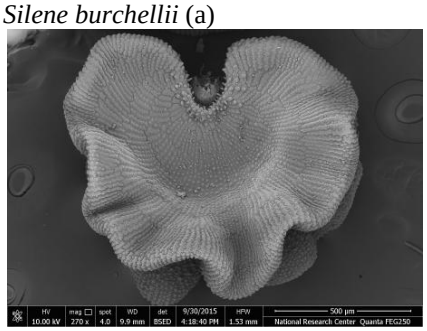

*Silene aegyptiaca* (b)


*Silene apetala* (a)


*Silene apetala* (b)


*Silene burchellii* (a)


*Silene burchellii* (b)


*Silene colorata* (a)

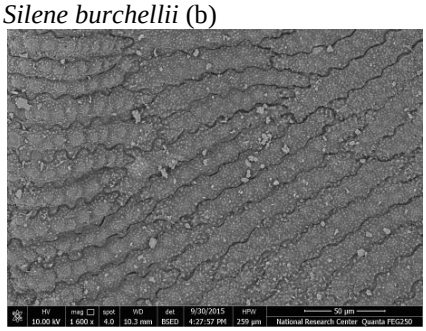
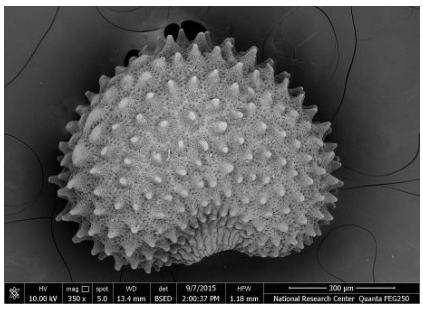
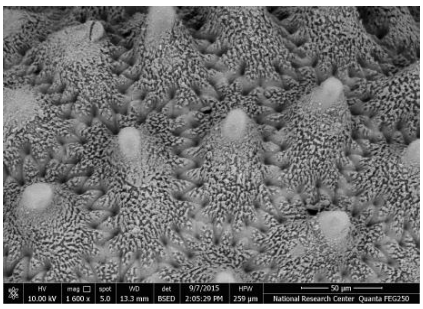
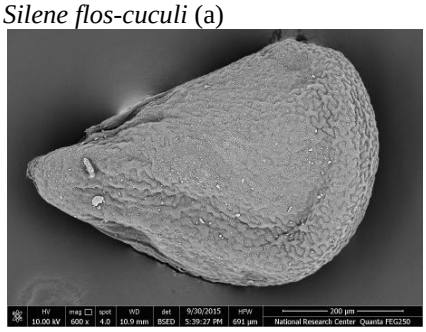
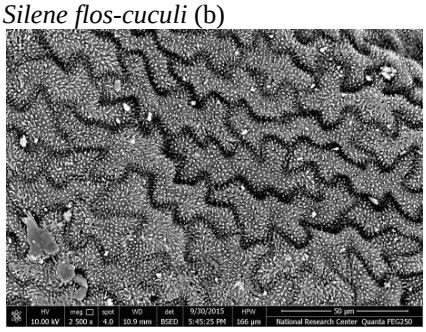

*Silene colorata* (b)

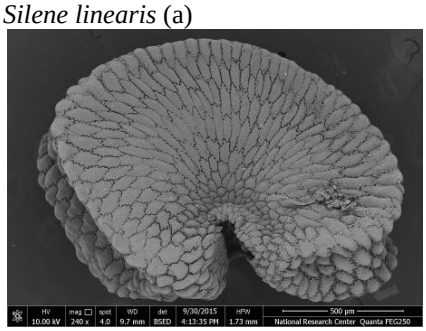
**Fig. (3): SEM micrographs of seed shape (a) and seed coat surface (b) in subfamily Caryophylloideae; tribe Sileneae.**

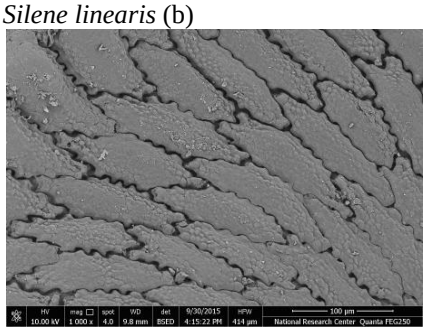

*Silene flos-cuculi* (a)

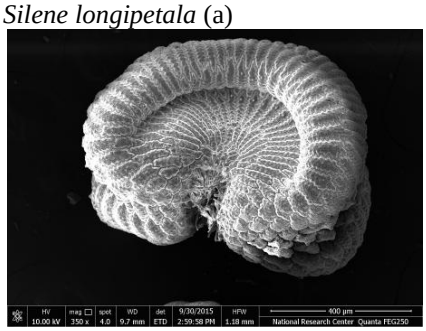

*Silene flos-cuculi* (b)

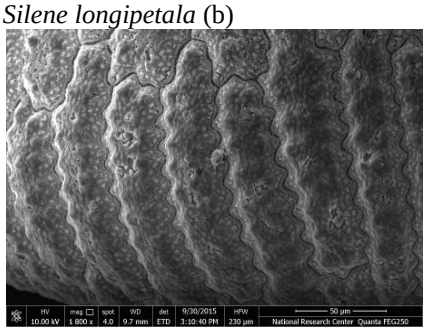

*Silene linearis* (a)

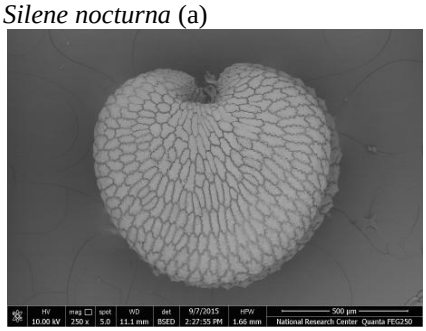

*Silene linearis* (b)


*Silene longipetala* (a)


*Silene longipetala* (b)


*Silene nocturna* (a)


*Silene nocturna* (b)


*Silene villosa* var. *ismailitica* (a)

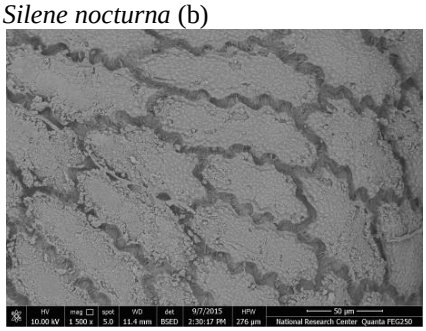
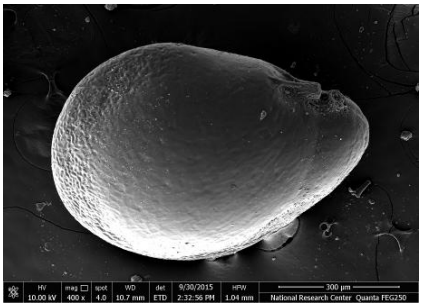
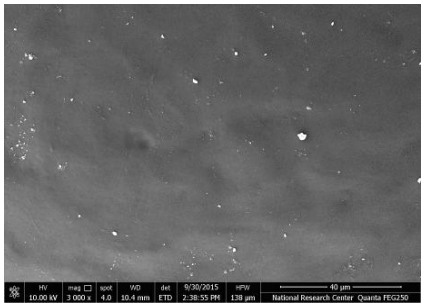
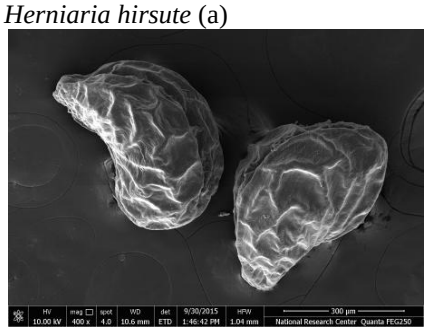
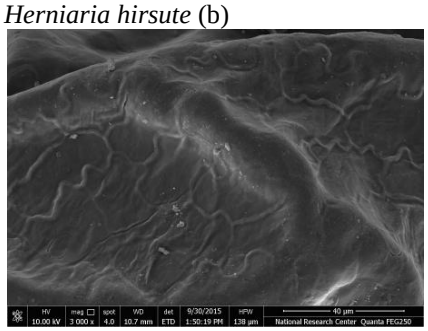

*Silene villosa* var. *ismailitica* (b)

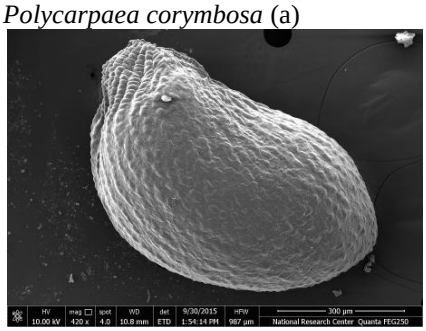
**Fig. (4): SEM micrographs of seed shape (a) and seed coat surface (b) in subfamily Caryophylloideae; tribe Sileneae.**

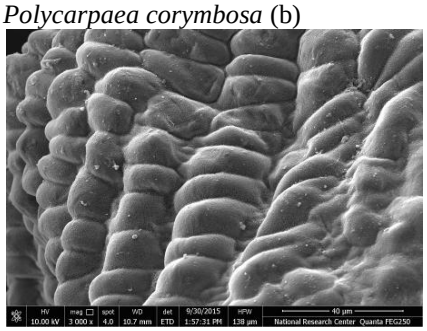

*Herniaria hirsute* (a)

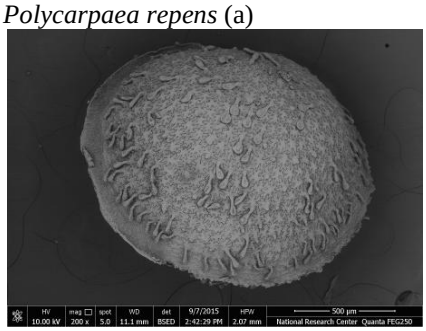

*Herniaria hirsute* (b)

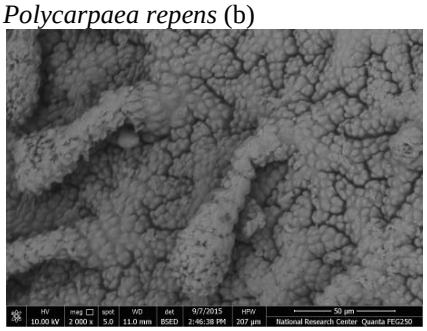

*Polycarpaea corymbosa* (a)

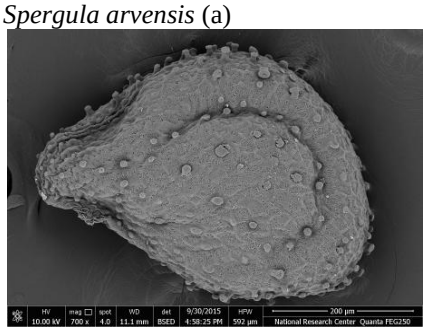

*Polycarpaea corymbosa* (b)


*Polycarpaea repens* (a)


*Polycarpaea repens* (b)


*Spergula arvensis* (a)


*Spergula arvensis* (b)


*Spergularia bocconei* (a)

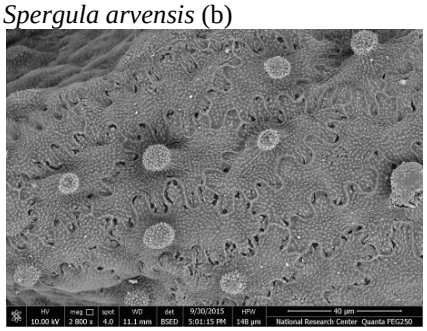
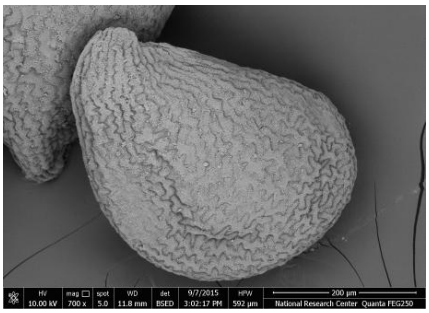
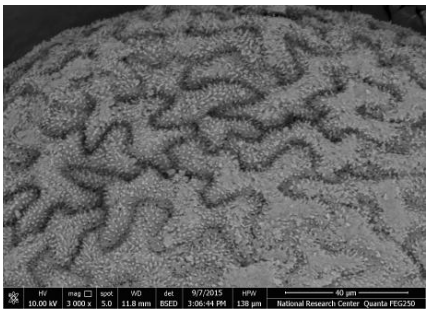
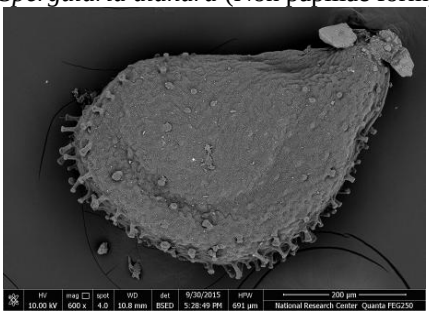
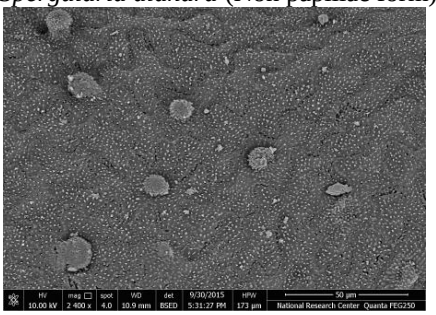

*Spergularia bocconei* (b)

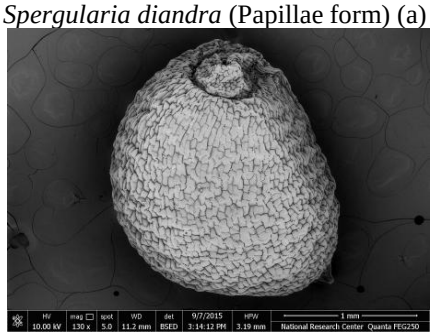
**Fig. (5): SEM micrographs of seed shape (a) and seed coat surface (b) in subfamily Paronychioideae.**

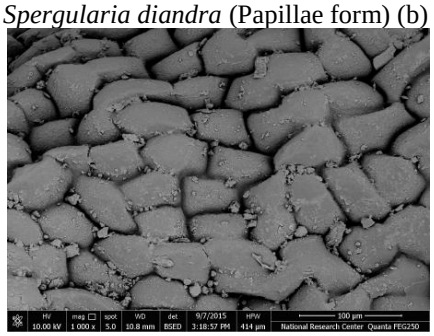

*Spergularia diandra* (Non papillae form) (a)

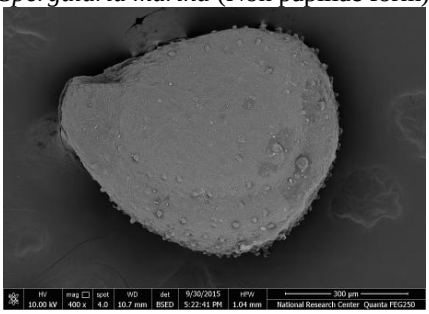

*Spergularia diandra* (Non papillae form) (b)

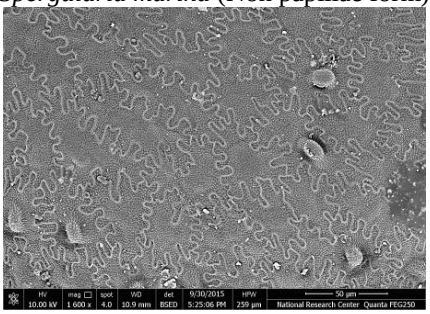

*Spergularia diandra* (Papillae form) (a)

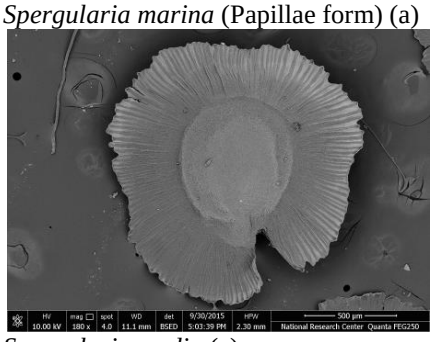

*Spergularia diandra* (Papillae form) (b)


*Spergularia marina* (Non papillae form) (a)


*Spergularia marina* (Non papillae form) (b)


*Spergularia marina* (Papillae form) (a)


*Spergularia marina* (Papillae form) (b)


*Spergularia media* (a)

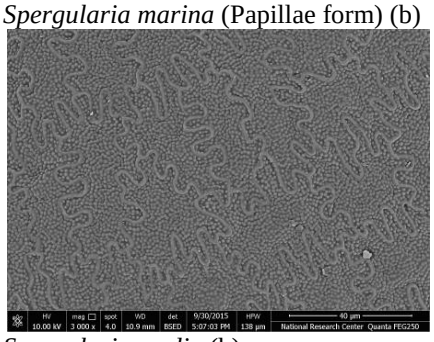

*Spergularia media* (b)

**Fig. (6): SEM micrographs of seed shape (a) and seed coat surface (b) in subfamily Paronychioideae.**

The numerical analysis of the applied 14 characters (Fig.7) showed that the taxa belonging to subfamily Caryophylloideae were grouped in one cluster. Also, the taxa belonging to subfamily Alsinoideae were grouped in one cluster. While, the taxa belonging subfamily Paronychioideae showed low affinity and separated into two clusters. This is due to the seeds of *Herniaria hirsuta*, *Polycarpaea corymbosa* and *Polycarpaea repens* being covered by thick cuticle layer fading cell characters as well as seed dimorphism which was recorded in Paronychioideae. The cluster analysis showed more affinity between Alsinoideae and Paronychioideae. Many authors recorded the significance of using the numerical analysis with seed characters in Caryophyllaceae such as (Fawzi *et al.*, 2010; Arman and Gholipour, 2013; Keshavarzi *et al.*, 2015 and Dadandi and Yildiz, 2015).

In conclusion, the large number of seed characters observed by light and SEM indicated that the studied seeds are very diverse. Seed characters can provide oreliable criteria for the identification and can be used with the other morphological characters to classify the species belonging to the family Caryophyllaceae.

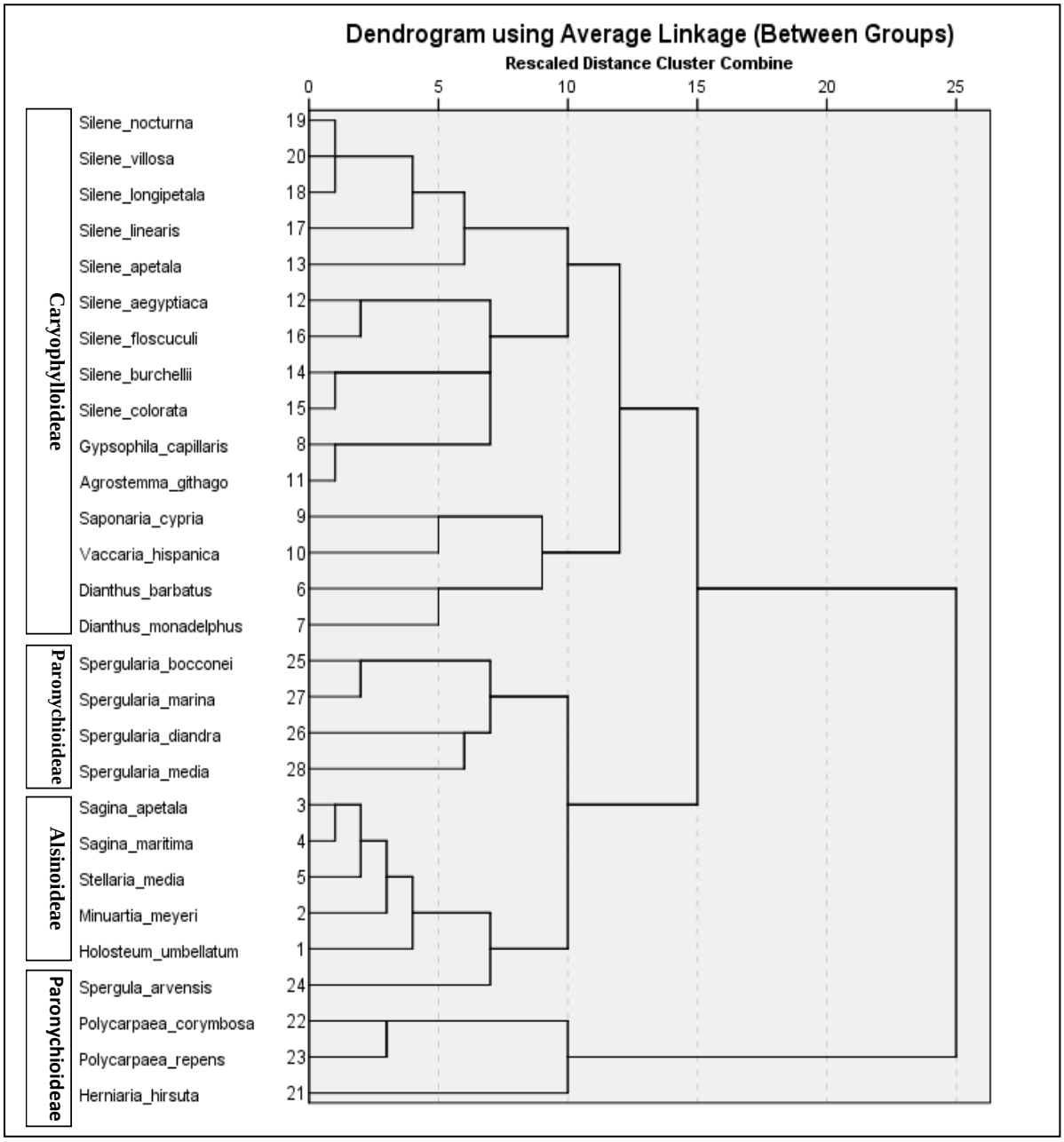



**Fig. (7): Dendogram illustrating the relationships among the studied species based on fourteen seed characters.**

**Acknowledgement**

We would like to thank the Flora & Phytotaxonomy Research Department, Horticultural Research Institute, Agricultural Research Center, Dokki, Egypt, and the Millennium Seed Bank, Kew, Royal Botanic Gardens, UK, for providing the seeds for the studied taxa.

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## الوصف الظاهري لبذور بعض الأنواع من الفصيلة القرنفلية

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**ملخص**

يتناول البحث دراسة خصائص الشكل الظاهرى للبذرة لثمانية وعشرين نوعا تمثل أربعة عشر جنسا من الفصيلة القرنفلية وذلك عن طريق استخدام المجهر الضوئى والمجهر الالكترونى الماسح. تهدف الدراسة إلي تقييم أهمية تلك الخصائص في إيضاح المزيد من العلاقات التصنيفية بين الأنواع محل الدراسة. أوضحت الدراسة تعدد الشكل العام للبذرة من دائرى، بيضاوي، كلوى، مثلثي، كمثري الي قوقعي غير متماثل. تفاوت لون البذرة بين بنى فاتح، بني، بني غامق، أسود أو متعدد الألوان مثل البني المزركش بالوردي أو البني المزركش بالأحمر. تراوح طول البذرة بين 0.4-3.1 مم. وكان السطح الظهري للبذرة إما مجوف، مستوي أو مجنح. كما تنوعت أنماط زركشة سطح خلايا القصرة ما بين محدب وحبيبي، محدب وحبيبي مع وجود درنة بالمنتصف، محدب وحبيبي مع وجود حليمة طويلة بالمنتصف، محدب وحبيبي مع وجود حديبة بمقدمة الخلية أو مستوي وحبيبي أو مستوي وأملس. أظهرت الجدر الجانبية للخلايا تنوع كبير فمنها المستوي ومنها ما يشكل طرز مختلفة من النتوءات المفيدة جدا فى تحديد العلاقات التصنيفية بين الأنواع المدروسة. ويؤكد العدد الكبير المتحصل عليه من الصفات الظاهرية للبذور علي أهمية استخدامها في تعريف وتصنيف الأنواع في الفصيلة القرنفلية.

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