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Seed Morphological Studies on Some Species of *Silene* L. (Caryophyllaceae)

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Abstract: The seed morphology of 11 species of *Silene* was studied, utilizing light and scanning electron microscopes, to determine the significance of seed coat features as taxonomic characters. There are variation in particular surface features within some members of the genus. The superficial ridges and tubercles exhibit patterns are very helpful in determining relationships among some species. Seed shapes are reniform or reniform-circular. The colour of seeds is greenish or brown. Seed size varies from the 0.5-1.2 mm long. The lateral surface is flat or concave. The dorsal surface is concave grooved in all examined taxa except *S. longiflora* is convex. The periclinal walls are convex, granulate with tubercle in the central area; convex, granulate; flat, granulate or flat, smooth. The anticlinal walls are straight, S-undulate, U-undulate or V-undulate. The data of seed characters were numerically analyzed using SPSS program.

Key words: Seed morphology, seed coat, taxonomy, *Silene*, Caryophyllaceae, SEM

INTRODUCTION

Silene L. is a large (ca. 700 species) genus belonging to the tribe *Sileneae* DC. ex Ser. in the family Caryophyllaceae which are distributed mainly in the northern hemisphere, but native species can be found on all continents except Australia (Chowdhuri, 1957; Bittrich, 1990). There are two major centers of diversity: one in the Mediterranean/Middle East and one in Central Asia. The genus consists mainly of herbaceous plants and, more rarely, subshrubs. According to Bittrich (1990) the Caryophyllaceae seeds are small or very small (0.4-3 mm long), black, brown or nearly white; reniform, pyriform, or orbicular, they are mostly laterally compressed. The testa is often variously sculptured by more or less papilliform cells, rarely completely smooth; the anticlinal walls are straight or more or less undulated.

The morphological seed characters are important devices for taxonomic purposes, they have been successfully used for the identification and classification of the taxa belonging to the family Caryophyllaceae in Egypt (Abdallah and Saad, 1980; Hosny and Zareh, 1993). Barton (1967) and Corner (1976) discussed in detail the role of the seed structure in plant classification.

SEM has been particularly useful in studying seed coat microsculpturing in the Caryophyllaceae due to the wide variation in seed coat structure and the small size of the seeds (Crow, 1979; Wofford, 1981; Wyatt, 1984; Chung and Lee, 1988; Taia, 1994; Yildiz, 2002; Zareh, 2005).

Seed morphology of *Silene* has been described in several studies (Berggren, 1981; El-Oqlah and Karim, 1990; Hong *et al.*, 1999; Yildiz, 2006). Thus studies of seed morphology are of taxonomic value, providing information that facilitates identification of species and genera.

This study describes the amount of variation within taxa of *Silene* and assesses the value of seed morphology in determining interrelationships.

MATERIALS AND METHODS

In the present study, eleven taxa of the *Silene* have been investigated. Seeds of these species were either collected from various habitats in Egypt during 2008 or received from the foreign seed collection of Flora and Phyto-Taxonomy Research Department, Horticultural Research Institute, Agricultural Research Center, Egypt, Table 1.

Table 1: The collection data giving the different sources of the taxa studied

Taxa	Sources
1- <i>Silene behen</i> L.	Egypt
2- <i>Silene conica</i> L.	Hungaria
3- <i>Silene conoidea</i> L.	Egypt
4- <i>Silene cserei</i> Baumg.	Hungaria
5- <i>Silene cucubalus</i> Wibel	USA
6- <i>Silene dichotoma</i> Ehrh.	Canada
7- <i>Silene longiflora</i> Bory	Egypt
8- <i>Silene nocturna</i> L.	Egypt
9- <i>Silene otites</i> (L.) Wibel	Hungaria
10- <i>Silene rubella</i> L.	Egypt
11- <i>Silene villosa</i> Forssk.	Egypt

The identification of the local species was determined by the morphological comparison between the examined species and referral specimens kept at the Herbarium of Flora and Phytotaxonomy Research Department, Horticultural Research Institute, Agricultural Research Center, Egypt. Additionally the foreign species were obtained as identified mature seeds.

The seed dimensions were measured by Nikon Stereoscopic microscope model SMZ 800 using image analysis software NIS-ELEMENTS D. In addition, the general exomorphological features of the seeds were examined using the same microscope.

The finer morphological details were examined using the Scanning Electron Microscope (SEM) Model JEOL JSM-5600 at the electron Microscope Unit, United Arab Emirates University. The SEM-micrographs were taken after the mature seeds were coated with a thin layer of gold in JEOL JFC-1200 Fine Coater and examined in different positions using different magnifications.

The data of seed criteria were numerically analyzed using SPSS 10 program for creating the data matrix. The presence or the absence of each of all characters was treated as a binary character in a data matrix (i.e., coded 1 and 0, respectively). The similarity of pattern was measured according to the Jaccard's coefficient as defined by Sneath and Sokal (1973) and Dunn and Everitt (1982).

RESULTS AND DISCUSSION

In this study, a relatively large number of seed characters were recorded in an attempt to use these characters in assessing taxonomic relationships among the taxa investigated. The seed morphology and sculpture patterns are shown in Fig. 1a-k, for seed shape and Fig. 2a-k, for seed coat surface. The magnification ranged between 65 $\times$ and 130 $\times$ for seed shape and ranged between 300 $\times$ and 1500 $\times$ for seed coat surface. Comparative

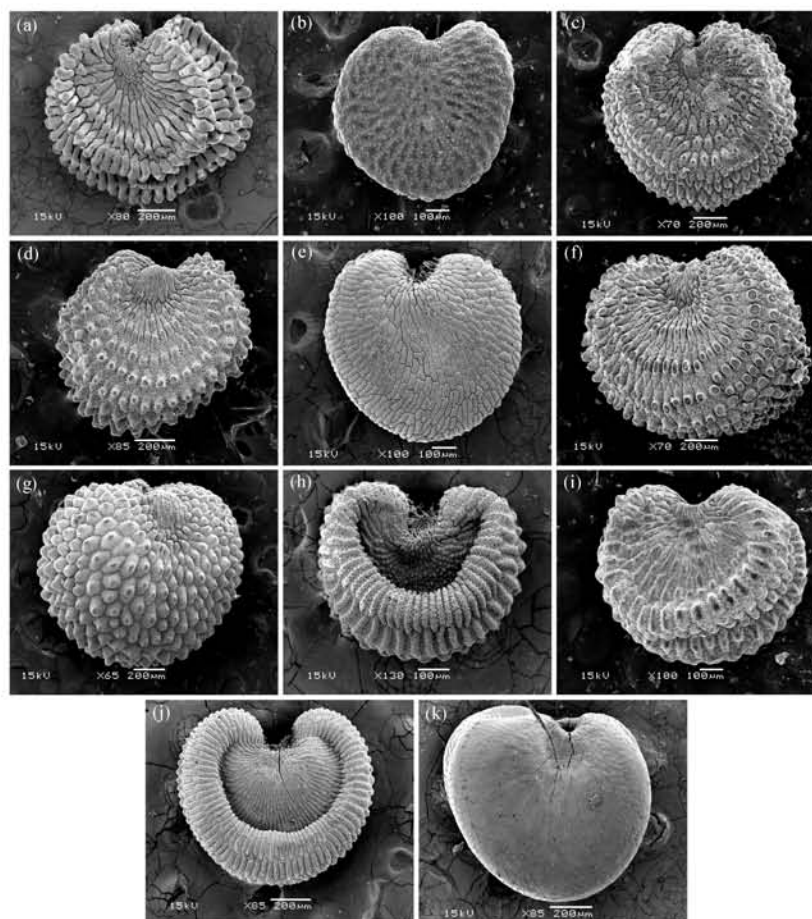


Fig. 1: SEM photographs of seed shape: (a) *S. behen*, (b) *S. conica*, (c) *S. conoidea*, (d) *S. cserei*, (e) *S. cucubalus*, (f) *S. dichotoma*, (g) *S. longiflora*, (h) *S. nocturna*, (i) *S. otites*, (j) *S. rubella* and (k) *S. villosa*

features, including seed shape, colour, size, surface, cell pattern and anticlinal wall, of the studied species are shown in Table 2. The morphological characters used in computer analysis are indicated in Table 3. The numerical analysis of the seed characters was illustrated by the dendrogram shown in Fig. 3. The similarity indices of seed characters among the studied taxa are indicated in Table 4. The similarity indices ranged between 22.2%, with *S. longiflora* and *S. conica* and 100%, with *S. conoidea* and *S. dichotoma* as well as *S. nocturna* and *S. rubella*.

Seed shapes are generally reniform or reniform-circular. The colour of seeds is greenish or brown. Seed size varies from the 0.5-1.2 mm long. The lateral surface is

flat in *S. conica*, *S. cucubalus*, *S. longiflora* and *S. villosa* (Fig. 1) while in the remaining examined taxa is concave. The dorsal surface is concave grooved in all examined taxa except *S. longiflora* is convex. The testa cell length varies from the 0.11-0.2 mm long. From all examined seeds, the seeds of *S. longiflora* appeared with polygonal testa cell in outline while in the remaining examined taxa is elongate polygonal (Fig. 2). The anticlinal walls are straight in *S. villosa*, S-undulate in *S. longiflora*, U-undulate in *S. cucubalus* and V-undulate in the remaining studied taxa (Fig. 2). The periclinal walls are generally convex, granulate, with tubercle in the central area; convex, granulate; flat, granulate or flat, smooth. In

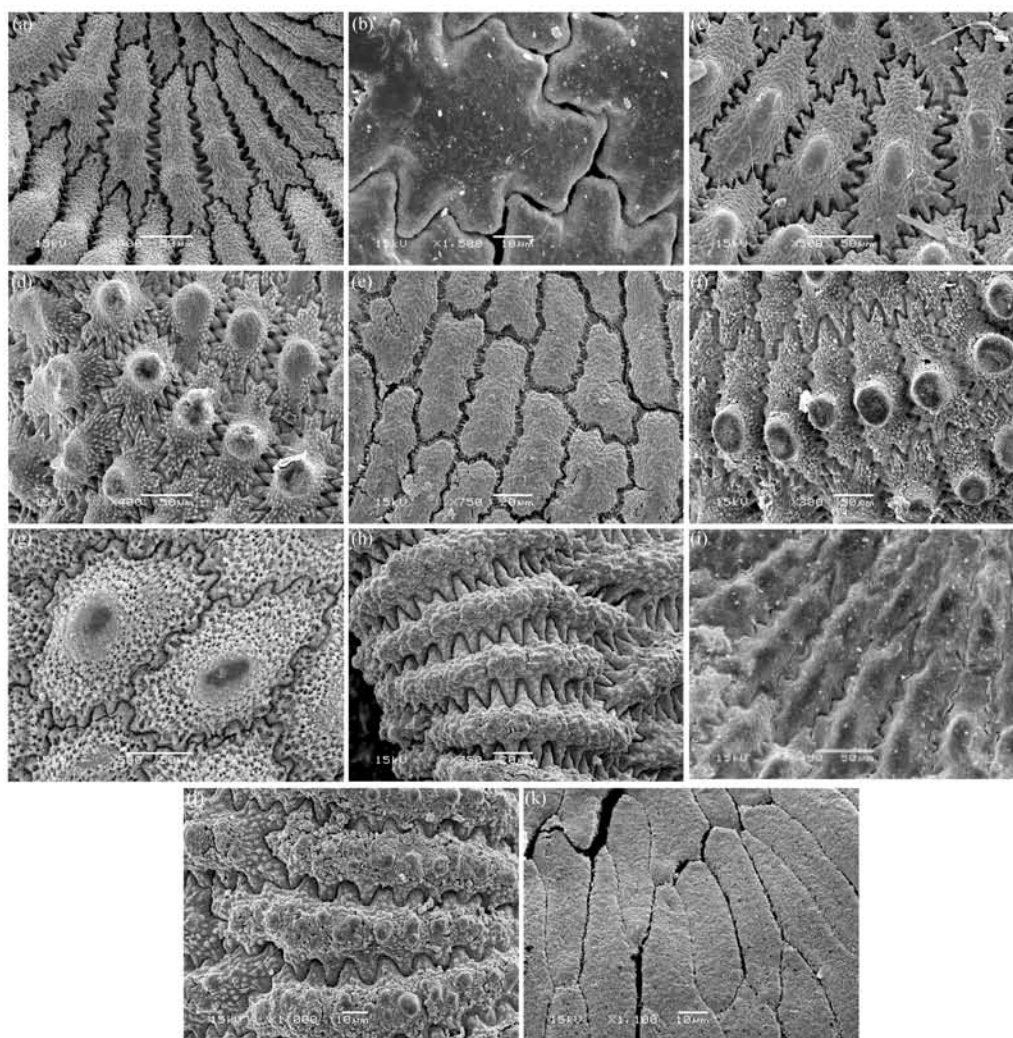


Fig. 2: SEM photographs of seed coat surface: (a) *S. behen*, (b) *S. conica*, (c) *S. conoidea*, (d) *S. cserei*, (e) *S. cucubalus*, (f) *S. dichotoma*, (g) *S. longiflora*, (h) *S. nocturna*, (i) *S. otites*, (j) *S. rubella* and (k) *S. villosa*

Table 2: Comparison of characteristics of seeds of taxa studied of *Silene*

Taxa	Seed shape	Seed colour	Seed Length-width (mm)	Lateral surface	Dorsal surface	Testa cell max. length (mm)	Testa cell outline	Anticlinal walls	Periclinal walls
<i>S. behen</i>	Reniform-circular	Brown	1.2 X 1.0	Concave	Concave-grooved	0.18	Elongated polygonal	V-undulated	Convex, granulate, with tubercle in the central area
<i>S. conica</i>	Reniform-circular	Greenish	0.7 X 0.7	Flat	Concave-grooved	0.11	Elongated polygonal	V-undulated	Flat, smooth
<i>S. conoidea</i>	Reniform-Circular	Greenish	1.1 X 1.1	Concave	Concave-grooved	0.16	Elongated polygonal	V-undulated	Convex, granulate, with tubercle in the central area
<i>S. cserei</i>	Reniform-circular	Brown	0.9 X 0.9	Concave	Concave-grooved	0.14	Elongated polygonal	V-undulated	Convex, granulate, with tubercle in the central area
<i>S. cucubalus</i>	Reniform-Circular	Brown	0.8 X 0.8	Flat	Concave-grooved	0.10	Elongated polygonal	U-undulated	Flat, granulate
<i>S. dichotoma</i>	Reniform-circular	Greenish	1.1 X 1.1	Concave	Concave-grooved	0.20	Elongated polygonal	V-undulated	Convex, granulate, with tubercle in the central area
<i>S. longiflora</i>	Reniform-circular	Greenish	1.2 X 1.3	Flat	Convex	0.18	Polygonal	S-undulated	Convex, granulate-reticulate, with tubercle in the central area
<i>S. nocturna</i>	Reniform	Brown	0.5 X 0.7	Concave-grooved	Concave-grooved	0.14	Elongated polygonal	V-undulated	Convex, granulate
<i>S. otites</i>	Reniform	Greenish	0.7 X 0.9	Concave	Concave-grooved	0.16	Elongated polygonal	V-undulated	Convex, granulate, with tubercle in the central area
<i>S. rubella</i>	Reniform	Brown	0.8 X 0.9	Concave-grooved	Concave-grooved	0.14	Elongated polygonal	V-undulated	Convex, granulate
<i>S. villosa</i>	Reniform-circular	Brown	0.9 X 0.9	Flat	Concave-grooved	0.11	Elongated polygonal	Straight	Flat, smooth

Table 3: Seed criteria of the studied taxa

Taxa seed character	<i>S. behen</i>	<i>S. conica</i>	<i>S. conoidea</i>	<i>S. cserei</i>	<i>S. cucubalus</i>	<i>S. dichotoma</i>	<i>S. longiflora</i>	<i>S. nocturna</i>	<i>S. otites</i>	<i>S. rubella</i>	<i>S. villosa</i>
Seed shape:											
Reniform (0)											
Reniform-circular (1)	1	1	1	1	1	1	1	0	0	0	1
Seed colour:											
Greenish (0)											
Brown (1)	1	0	0	1	1	0	0	1	0	1	1
Seed length:											
Less than 1 mm (0)											
More than 1 mm (1)	1	0	1	0	0	1	1	0	0	0	0
Lateral surface:											
Flat (0)											
Concave-grooved (1)	1	0	1	1	0	1	0	1	1	1	0
Dorsal surface:											
Convex (0)											
Concave-grooved (1)	1	1	1	1	1	1	0	1	1	1	1
Testa cell max. Length:											
Less than 0.15 mm (0)											
More than 0.15 mm (1)	1	0	1	0	0	1	1	0	1	0	0
Testa cell outline:											
Polygonal (0)											
Elongated polygonal (1)	1	1	1	1	1	1	0	1	1	1	1
Anticlinal walls:											
Straight (0)											
Undulated (1)	1	1	1	1	1	1	1	1	1	1	0
Periclinal walls:											
Flat (0)											
Convex (1)	1	0	1	1	0	1	1	1	1	1	0
Periclinal walls:											
Smooth (0)											
Granulate (1)	1	0	1	1	1	1	1	1	1	1	0
Periclinal walls:											
Central tubercle absent (0)											
Central tubercle present (1)	1	0	1	1	0	1	1	0	1	0	0

Table 4: Similarity indices of seed criteria among the studied taxa

Proximity matrix (Jaccard measure)						
Taxa	1- <i>S. behen</i>	2- <i>S. conica</i>	3- <i>S. conoidea</i>	4- <i>S. cserei</i>	5- <i>S. cucubalus</i>	6- <i>S. dichotoma</i>
1- <i>S. behen</i>	100					
2- <i>S. conica</i>	36.4	100				
3- <i>S. conoidea</i>	90.9	40	100			
4- <i>S. cserei</i>	81.8	44.4	72.7	100		
5- <i>S. cucubalus</i>	54.5	66.7	45.5	66.7	100	
6- <i>S. dichotoma</i>	90.9	40	100	72.7	45.5	100
7- <i>S. longiflora</i>	63.6	22.2	70	45.5	30	70
8- <i>S. nocturna</i>	63.6	37.5	54.5	77.8	62.5	54.5
9- <i>S. otites</i>	72.7	33.3	80	70	40	80
10- <i>S. rubella</i>	63.6	37.5	54.5	77.8	62.5	54.5
11- <i>S. villosa</i>	36.4	60	27.3	44.4	66.7	27.3

Proximity matrix (Jaccard measure)					
Taxa	7- <i>S. longiflora</i>	8- <i>S. nocturna</i>	9- <i>S. otites</i>	10- <i>S. rubella</i>	11- <i>S. villosa</i>
1- <i>S. behen</i>					
2- <i>S. conica</i>					
3- <i>S. conoidea</i>					
4- <i>S. cserei</i>					
5- <i>S. cucubalus</i>					
6- <i>S. dichotoma</i>					
7- <i>S. longiflora</i>	100				
8- <i>S. nocturna</i>	27.3	100			
9- <i>S. otites</i>	50	66.7	100		
10- <i>S. rubella</i>	27.3	100	66.7	100	
11- <i>S. villosa</i>	100	37.5	20	37.5	100

This is a similarity matrix

all taxa studied the cells in the lateral and dorsal surfaces are usually similar in pattern and anticlinal wall boundaries but the cells in the lateral surface somewhat smaller in size. The previous results showed that seeds of *Silene* have characters might be of high taxonomic value. Duke (1961) reported that seed characters were of critical value in the classification of genus *Drymaria* (Caryophyllaceae). Hong *et al.* (1999) provided key, depending on the seed morphology, to differentiate between the *Silene* species or groups of species in Korea.

The dendrogram (Fig. 3), resulted from the hierarchical cluster analysis of the applied seed characters, divided the studied species into two groups. The similarity between the species of the first group and the species of the second group ranged between 22.2 and 62.5%. The first group formed of three species (*S. conica*, *S. cucubalus* and *S. villosa*). These three species can easily distinguish from the species of the second group by its flat periclinal cell wall. The similarity between these species ranged between 60 to 66.7%. The second group includes the remaining eight taxa. The species in this group characterized by its convex-granulate periclinal cell walls. Within the second group, *S. longiflora* is delimited from the remaining 7 species. *S. longiflora* can easily distinguish by its S-undulated anticlinal walls. Whereas the remaining 7 species divided into two subgroups. The first subgroup composed of *S. cserei*, *S. rubella* and *S. nocturna*. *S. cserei* can easily distinguish from *S. rubella* and *S. nocturna* by the

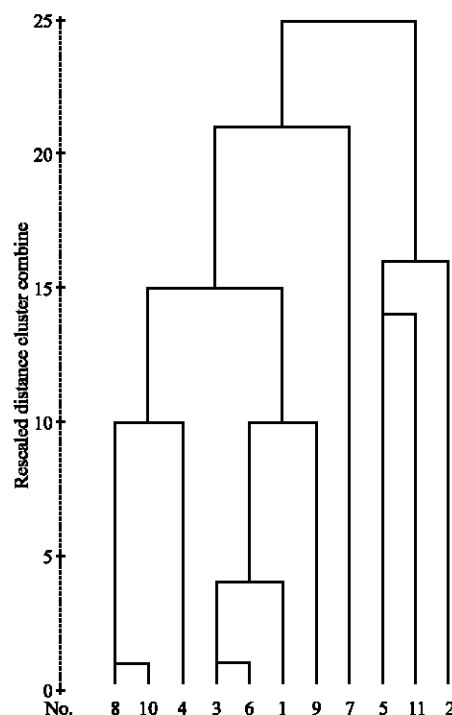


Fig. 3: Dendrogram based on the variation in data of seed criteria illustrating average taxonomic distance (dissimilarity) between the taxa studied. (1) *S. behen*, (2) *S. conica*, (3) *S. conoidea*, (4) *S. cserei*, (5) *S. cucubalus*, (6) *S. dichotoma*, (7) *S. longiflora*, (8) *S. nocturna*, (9) *S. otites*, (10) *S. rubella* and (11) *S. villosa*

presence of a tubercle in the central area of the periclinal cell walls. The second subgroup composed of *S. behen*, *S. conoidea*, *S. otites* and *S. dichotoma*.

El-Oqlah and Karim (1990) showed that the characters of seed testa cells are significant in classification but not enough in delimiting the genus *Silene* into different sections because some of the species from two different sections show the same seed characters. Hong *et al.* (1999) recorded that, on the basis of the seed characters, the Korean taxa of *Silene* can be distinguished to some extent. They found some taxa have the same seed characters such as *S. fasciculata* and *S. koreana*. In this study we agree with them because both of *S. conoidea* and *S. dichotoma* as well as *S. nocturna* and *S. rubella* show the same seed characters. Zareh (2005) showed that the numerical analysis of macromorphological data and seed characters as a combined data is more significant than the analysis of seed characters alone. New (1959) and Taia (1994) indicated that the ultramorphological characters of seeds were important in the identification of some species of Caryophyllaceae.

In conclusion, microornamentation of the seeds was important in the identification and classification of some species of *Silene*.

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