

## POLLEN MORPHOLOGY OF *SILENE* L. (*CARYOPHYLLACEAE*) FROM TURKEY

KEMAL YILDIZ

Department of Biology, Science and Arts Faculty,  
Celal Bayar University, 45040 Muradiye-Manisa, Turkey.

### Abstract

Morphology of pollen grains of 13 species (3 of which are endemics in Turkey) belonging to nine sections of the genus *Silene* L., (*Caryophyllaceae*), collected from Northwest Anatolia in Turkey, was investigated using light, scanning electron (SEM) and projectina screen scale microscopy. The pollen grains were pantoporate, spheroidal and semitectate with perforations, spinulose exine. *S. rhynchocharpa* Boiss., with highest number and *S. otites* (L.) Wibel with lowest number of pores have the right taxonomical positions. The taxonomical position of *S. compacta* Fischer and *S. dichotoma* Ehrh. subsp. *sibthorpiana* (Reichb) Reich., which have flowers forming heads and are monochasial is disputed because they have lower pore number in relation to the other taxa, although they have other phylogenetically advanced characteristics.

### Introduction

The family *Caryophyllaceae* which has about 80 genera and more than 2000 species distributed in the world (Heywood, 1978) is represented by 35 genera and more than 470 species in Turkey (Coode & Cullen 1967; Davis, 1988). One of the important genus of this family in Turkey is *Silene* L. Out of 44 sections (Chowdhuri, 1957) and about 500 species (Willis, 1965) of the genus *Silene* L., which have a global distribution, it is represented by 31 sections and 129 species in Turkey, 40% of which are endemic (Coode & Cullen 1967; Davis, 1988; Baytop, 1992).

A number of workers have examined palynology of the genus *Silene* L., (Aytug, 1971; Skvarla & Nowicke, 1976; Melzheimer, 1977; Ghazanfar, 1984; Prentice *et al.*, 1984; Mastenbroek *et al.*, 1984). Besides the palynological features, the taxonomical position of *Silene* L. species is also discussed.

Aytug (1971) defined the pollen sculpture of *S. compacta* as made of bacule in "The pollen atlas of Istanbul region plants". Skvarla & Nowicke (1976), in their palynological study of eleven families of *Centrospermae*, compared the species of 8 genera belonging to *Caryophyllaceae* with the species of other families and tried to find phylogenetical links. The most important common feature was that the exine sculpture was spinulose-tubuliferous/punctate. Pollen type of *S. noctiflora* was termed pantoporate, reticulate. Melzheimer (1977) made a biosystematical revision of *Silene* taxa available in the Balkans. The pollen grains were pantoporate [*S. italica* (L.) Pers., *S. viscosa* (L.) Pers]. The pollen grains of *S. italica* were punctitegillate - spinulose whereas *S. viscosa* pollen were reticulate. Ghazanfar (1984), in his palynological investigation of 44 taxa represented in the sections *Siphonomorpha* Oth., and *Auriculatae* Boiss., demonstrated that the sexine sculpture of *S. italica*, *S. viridiflora* and *S. rhynchocharpa* was punctate. Prentice *et al.*, (1984) studied 32 samples of *S. latifolia* Poiret collected from several regions of Europe and differentiated the geographic variations of the pollen grains. Prentice (1987) underlined the reticulate and microechinate characteristics of 130 specimens of *Silene* species which were distributed in Europe and Asia. Morphological and biochemical data were analysed from 30 greenhouse grown populations of European *Silene latifolia* by Mastenbroek *et al.*, (1984).

Yildiz (1996) in his palynological study of 6 taxa represented in the sect. *Siphonomorpha* Otth., sect. *Elisanthe* (Fenzl) Fenzl, sect. *Silene* described the exine sculpture of *S. italica* (L.) Pers., *S. viridiflora* L., *S. kalba* (Miller) Krause subsp. *ericalycina* (Boiss.) Walters, *S. noctiflora* L., *S. gallica* L., *S. bellidifolia* Jacq., as spinulose, spinulose - microperforate. The present report gives the palynological data on *Silene* species found in Turkey, where average diameter of pollen grains and of pores, thickness of exine, distance between two pores, the number of pores and diameter of spinule base and sexine sculpture have been made to understand the taxonomical positions.

### Materials and Methods

The pollen samples were collected during the field trips around the region of Northwest Anatolia (A3-A6) from Turkey and deposited in the Marmara University Atatürk Education Faculty Herbarium (MARA) (Table 1). The pollen grains were acetolysed according to the method of Erdtman (1960). Slides of the fresh pollen grains and acetolysed pollen grains were prepared in glycerine-jelly-fuchsin mixture for light microscopic investigations. The fresh pollen grains were prepared according to the Wodehouse's Method (Wodehouse, 1935). Fresh pollen grains and acetolysed pollen grains were examined with light microscope. Olympus triocular BH-2 microscope with D plan 100-1.25 160/0.17 oil immersion objective and NFK x 3.3 LD 125 lens were used and photomicrographs were taken by an Olympus camera. Screen scale Projectina light microscope was used for pollen measurements. An average of 100 counts were made for the diameter of the pollen grains, 20 for exine thickness, diameter of pores and distance between two pores. In addition, arithmetic mean and standard deviations were calculated. Monoszon's Method (Monoszon, 1952) was used to determine pore numbers.

**Table 1. Source of *Silene* L. pollen. (MARA: Marmara University Atatürk Education Faculty Herbarium., A: A Square of Flora of Turkey).**

Taxa	Locality	Herbarium (MARA)
<i>Silene marschallii</i>	A4 Cankiri, Cerkes near slopes 800 m.	2789
<i>S. olympica</i> (E)	A3 Bolu, Kartalkaya rocky slopes 1900 m	2983
<i>S. chlorifolia</i>	A6 Tokat, Gijgij hill, scress, 750-800 m	2444
<i>S. paphlagonica</i> (E)	A4 Cankiri, Ilgaz, under abies forest, 1700 m	2953
<i>S. otites</i>	A6 Tokat, Gijgij hill, slopes, 900 m	2800
<i>S. cappadocica</i>	A5 Corum, Iskilip near, slope places, 700 m	3801
<i>S. spergulifolia</i>	A6 Tokat, Camhbel hill, screes, slopes, 1500-1700 m	1620
<i>S. supina</i> subsp <i>pruinosa</i>	A3 Bolu, Yenicaga near, slopes, 1400 m	2961
<i>S. sangaria</i> (E)	A3 Sakarya, Karasu seaside, sandysea shoes, dunes	3916
<i>S. vulgaris</i> var. <i>vulgaris</i>	A4 Kastamonu, Ballidag, scrubs, slopes places 1200 m	2951
<i>S. rhynchocarpa</i>	A3 Bolu, Kartalkaya, screes, rocky slopes, 2050 m	3745
<i>compacta</i>	S. A3 Bolu, Kartalkaya, under open forest, 1420 m	3742
<i>S. dichotoma</i> subsp <i>sibthorpiana</i>	A3 Bolu, Kartalkaya near, banks, rocky places, 1500 m	2900

Acetolysed pollen grains were preformed for SEM study following conventional method for scanning electron microscopy (Jeol JSM 5200). Average number of pores, diameter of spinule base were observed and a comparative study of light and scanning electron microscopy was made. Slides were deposited at Celal Bayar University, Science and Arts Faculty Biology Department for future reference.

The diameter of the perforations less than 0.5  $\mu\text{m}$  of the ectexine is termed punctate. Where the perforations are larger than the distance between them, the ectexine is termed reticulate (Birks, 1973). Where the perforations range from 1 to 2  $\mu\text{m}$ , not in uniform shape and irregularly scattered, the ectexine is termed semireticulate. It is termed perforate where the diameter of the pits of the sculpture is less than 1  $\mu\text{m}$  (Moore & Webb, 1978).

## Results and Discussion

Morphological characteristics showed that all the pollen grains have "common feature" of being pantoporate, spheroidal with perforated exine (Tables 2 & 3). Sexine sculpture of *Silene* L., taxa are termed punctate (microperforate, perforate) and spinulose. The spinules, perforates and pores are usually arranged rarely regularly.

The number of pores varies considerably (Table 3) with 9 as lowest pore number (*S. otites*) and 36 highest (*S. rhynchoarpa*). Average diameter of the unacetolysed pollen grains is between 29.11  $\mu\text{m}$  (*S. otites*) and 45.31  $\mu\text{m}$  [*S. vulgaris* (Moench.) Garcke var. *vulgaris*] and of the acetolysed grains is between 24.46 (*S. otites*) and 49.59  $\mu\text{m}$  (*S. vulgaris* var. *vulgaris*). Borders of the pores are generally evident and smooth. The average pore diameter of unacetolysed is between 4.59 [*S. supina* Bieb. subsp. *pruinosa* (Boiss.) Chowd.] and 9.20  $\mu\text{m}$  (*S. marschallii* C.A. Meyer). The pore opercula were granulate ranging from 4 to 32. The distance between two pores of unacetolysed pollen ranged from 2.40 (*S. supina* subsp. *pruinosa*) to 11.40  $\mu\text{m}$  (*S. vulgaris* var. *vulgaris*), and of the acetolysed pollen from 2.40 (*S. vulgaris* var. *vulgaris*) to 8.00  $\mu\text{m}$  (*S. vulgaris* var. *vulgaris*). The thickness of the exine in unacetolysed pollen values ranged between 1.35 and 3.43  $\mu\text{m}$ , and between 2.00 and 4.17  $\mu\text{m}$  in acetolysed pollens. The base of spinule diameter ranges from 0.2 to 1.0  $\mu\text{m}$ . The shortest diameter is seen in *S. paphlagonica* Bornm. (0.2  $\mu\text{m}$ ) and the longest one in *S. supina* subsp. *pruinosa*, *S. olympica* and *S. vulgaris* var. *vulgaris* (c. 0.1  $\mu\text{m}$ ).

Aytug (1971) found that the pollen of *S. compacta* have prominent bacules. The present electron microscopy study, however reveals that those were spinules and not bacules. Skvarla & Nowicke (1976) reported that pollen of the family *Caryophyllaceae* were mostly spinulose and tubuliferous/punctate. Melzheimer (1977), during his biosystematical revision of *Silene* of Balkan, noticed that the pollen grains were pantoporate, punctitiegillate-spinulose and reticulate. Ghazanfar (1984) defined the sexine of the pollen of *Silene* as punctate, reticulate and semireticulate-tubuliferous and spinulose. Prentice *et al.*, (1984), Prentice (1987), Mastenbroek *et al.*, (1984) described the pollen of *S. alba* (Miller) Krause as microechinate-reticulate.

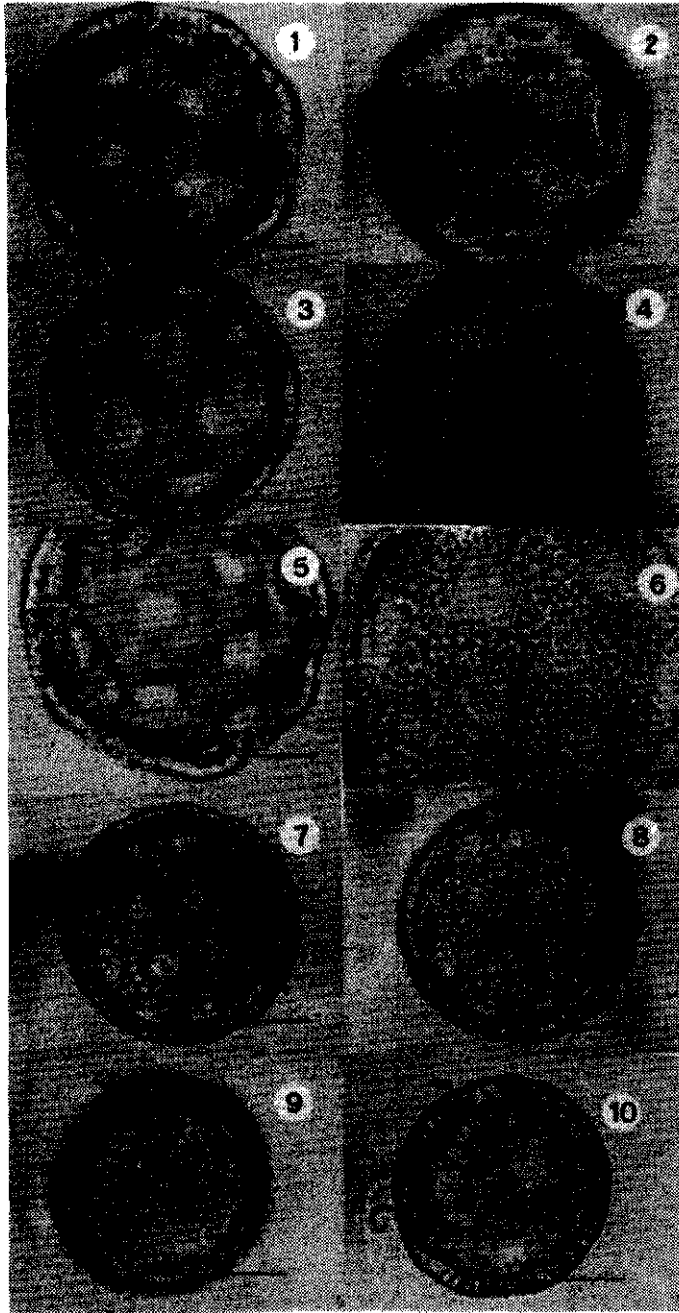
Thirteen taxa of *Silene* distributed in Northwest Anatolia were semitectate and characterized with their punctate (microperforate, perforate) and tubuliferous/spinulose sexine. The results that were obtained from our study show conformity with the previous studies.

Table 2. The morphological data of *Silene L.* pollen grains. (M: Average diameter of pollen, S: Standard deviation, E: Endemic for Turkey).

Taxa	Diameter of pollen ( $\mu\text{m}$ )				Diameter of exine thickness ( $\mu\text{m}$ )			
	Unacetolyzed M	Pollen S ( $\pm$ )	Acetolyzed M	Pollen S ( $\pm$ )	Unacetolyzed M	Pollen S ( $\pm$ )	Acetolyzed M	Pollen S ( $\pm$ )
<i>Silene marschallii</i>	40.79	3.72	35.14	2.15	2.00	0.59	2.00	0.28
<i>S. olympica</i> (E)	34.62	3.03	30.16	1.82	1.35	0.37	2.30	0.19
<i>S. chlorifolia</i>	39.28	2.01	36.38	2.38	2.00	0.58	2.52	0.38
<i>S. paphlagomica</i> (E)	33.76	1.49	35.90	2.13	2.00	0.28	2.13	0.45
<i>S. otites</i>	30.92	1.81	24.46	2.17	2.06	0.46	2.32	0.40
<i>S. cappadocica</i>	31.79	2.39	28.42	2.06	1.90	0.28	2.10	0.41
<i>S. spergulifolia</i>	32.10	3.89	31.57	1.94	1.80	0.34	2.50	0.44
<i>S. supina</i> subsp. <i>pruinosa</i>	30.92	1.24	33.98	2.48	1.60	0.30	2.80	0.30
<i>S. sangaria</i> (E)	39.90	2.04	33.56	2.21	1.49	0.48	2.00	0.43
<i>S. vulgaris</i> var. <i>vulgaris</i>	45.31	2.47	49.29	3.97	3.43	0.54	4.17	0.45
<i>S. rhynchocharpa</i>	43.57	3.61	38.23	2.62	1.47	0.52	2.32	0.18
<i>S. compacta</i>	29.11	1.79	26.62	1.86	1.52	0.54	2.00	0.28
<i>S. dichotoma</i> subsp. <i>sibthorpiana</i>	41.46	4.19	39.97	2.24	2.40	0.40	2.73	0.28

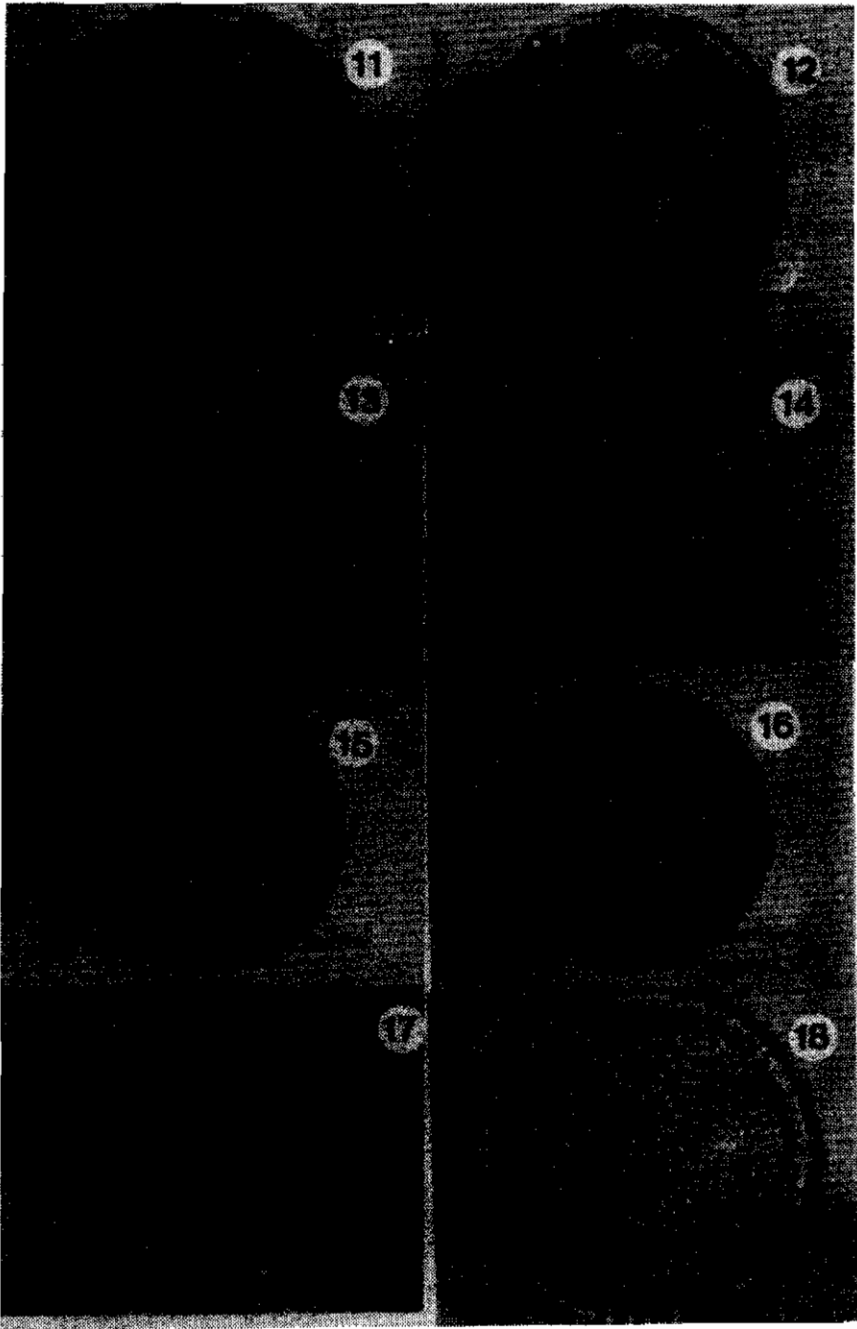
Table 3. The morphological data of *Silene* L. pollen grains. M: Average diameter of pollen, S: Standard deviation.

Taxa	Diameter of pore (µm)						Distance between two pores (µm)						Number of granules	Number of spinule base (µm)	Diameter	
	Unacetylyzed		Acetylyzed		Pollen S (±)		Unacetylyzed		Acetylyzed		Pollen S (±)					Number of pores
	M	S (±)	M	S (±)	M	S (±)	M	S (±)	M	S (±)	M	S (±)				
<i>Silene marschallii</i>	9.20	1.87	5.90	0.81	7.36	1.08	5.46	0.22	18-16	8-15	0.5-0.7					
<i>S. olympica</i> (E)	5.40	0.39	5.56	0.58	5.12	0.80	3.60	0.62	22-31	4-8	~1.0					
<i>S. chlorifolia</i>	6.31	1.43	5.83	1.23	7.57	1.25	8.60	1.47	20-26	8-15	0.6-0.9					
<i>S. paphlagonica</i> (E)	5.00	0.84	5.25	0.89	3.33	0.28	4.10	0.99	25-32	15-22	0.2-0.3					
<i>S. otites</i>	5.44	0.58	4.40	0.30	5.26	1.31	5.86	1.47	9-14	10-15	0.4-0.6					
<i>S. cappadocica</i>	5.26	0.94	4.80	0.49	4.51	0.48	4.15	0.71	24-30	5-8	0.5-0.6					
<i>S. spergulfolia</i>	5.48	0.46	5.45	0.86	3.20	1.13	2.40	0.80	25-34	5-8	~0.6					
<i>S. supina</i> subsp. <i>pruinosa</i>	4.53	0.37	5.37	0.92	3.40	0.28	5.60	0.56	17-23	8-13	~1.0					
<i>S. sangaria</i> (E)	5.27	0.81	4.47	0.74	4.80	1.03	3.20	0.57	22-29	8-14	~0.5					
<i>S. vulgaris</i> var. <i>vulgaris</i>	8.25	1.75	7.70	1.51	11.40	0.89	8.00	1.13	15-31	5-9	~1.0					
<i>S. rhynchocharpa</i>	5.26	0.40	5.77	0.54	4.27	0.87	4.40	0.84	29-36	24-32	~0.5					
<i>S. compacta</i>	4.80	0.89	4.00	0.52	5.00	0.89	3.87	1.19	12-20	-	0.6-0.9					
<i>S. dichotoma</i> subsp. <i>sibiripiana</i>	5.55	1.10	5.30	0.42	6.13	0.44	6.00	2.29	17-23	5-10	0.5-0.8					

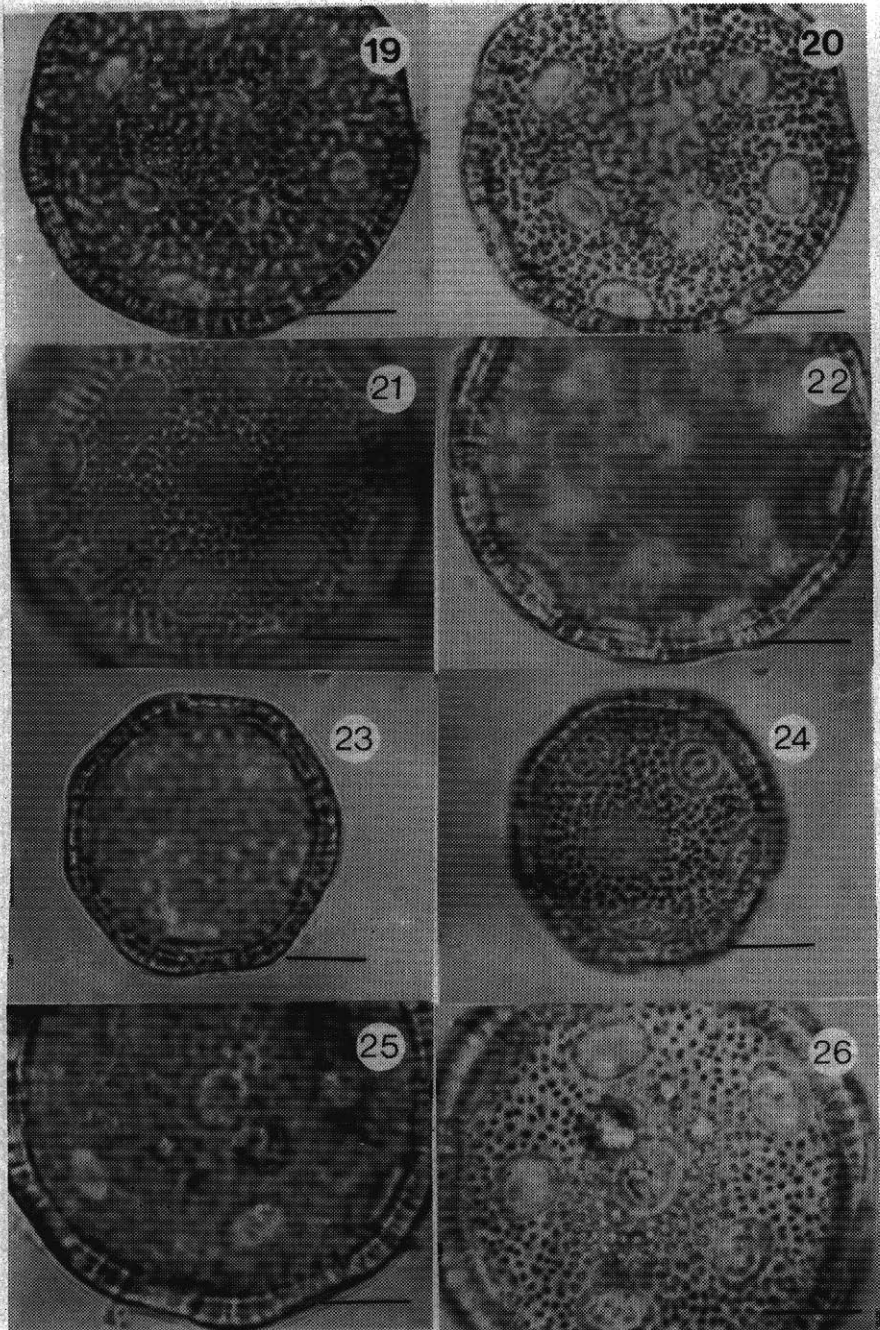


Figs. 1-26. Light micrographs of *Silene* (The scale equals  $10\ \mu\text{m}$ ).

Figs. 1-2. *S. marschallii* pollen. Fig. 1. Optical section. Fig. 2. Surface view. Figs. 3-4. *S. olympica* pollen. Fig. 3. Optical section. Fig. 4. Surface view. Figs. 5-6. *S. chlorifolia* pollen. Fig. 5. Optical section. Fig. 6. Surface view. Figs. 7-8. *S. paphlagonica* pollen. Fig. 7. Optical section. Fig. 8. Surface view. Figs. 9-10. *S. otites* pollen. Fig. 9. Optical section. Fig. 10. Surface view.

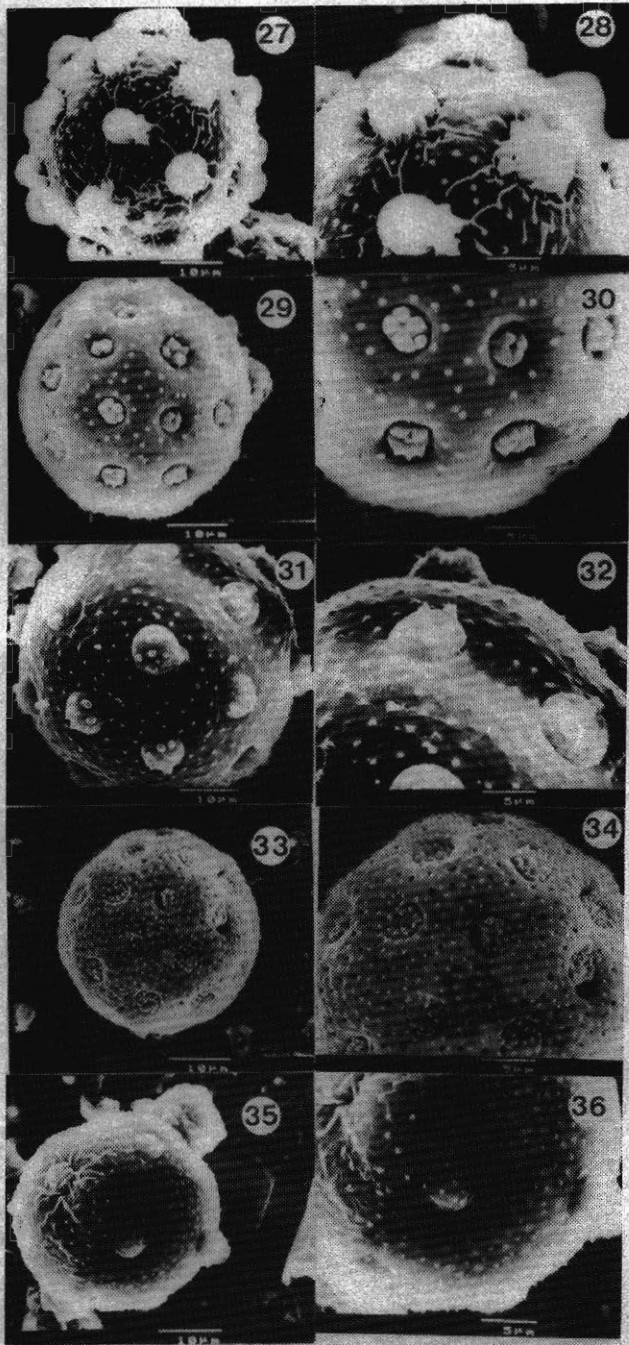


Figs. 11-12. *S. cappadocica* pollen. Fig. 11. Optical section. Fig. 12. Surface view. Figs. 13-14. *S. spergulifolia* pollen. Fig. 13. Optical section. Fig. 14. Surface view. Figs. 15-16. *S. supina* subsp. *pruinosa* pollen. Fig. 15. Optical section. Fig. 16. Surface view. Figs. 17-18. *S. sangaria* pollen. Fig. 17. Optical section. Fig. 18. Surface view.

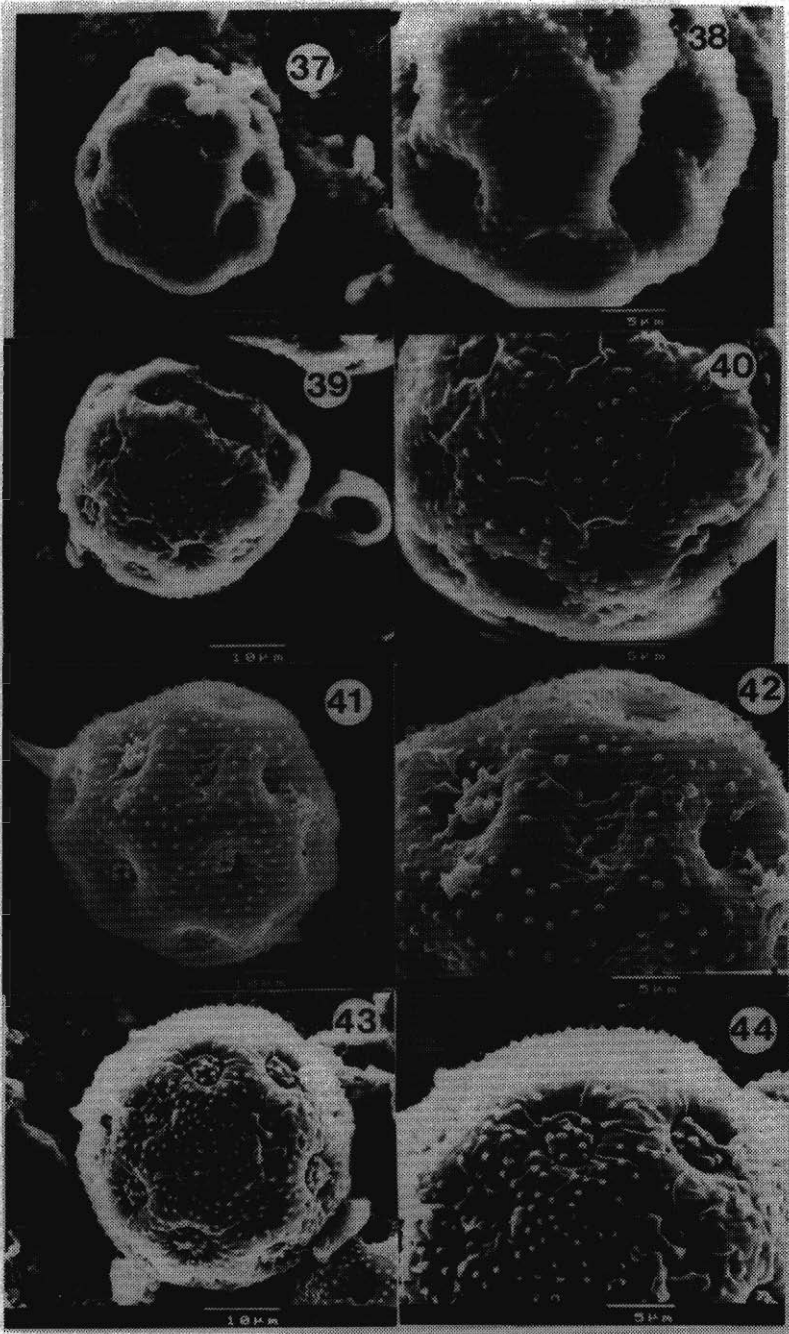


Figs. 19-20. *S. vulgaris* var. *vulgaris* pollen. Fig. 19. Optical section. Fig. 20. Surface view. Figs. 21-22. *S. rhynchocharpa* pollen. Fig. 21. Optical section. Fig. 22. Surface view. Figs. 23-24. *S. compacta* pollen. Fig. 23. Optical section. Fig. 24. Surface view. Figs. 25-26. *S. dichotoma* subsp. *sibthorpiana* pollen. Fig. 25. Optical section. Fig. 26. Surface view.

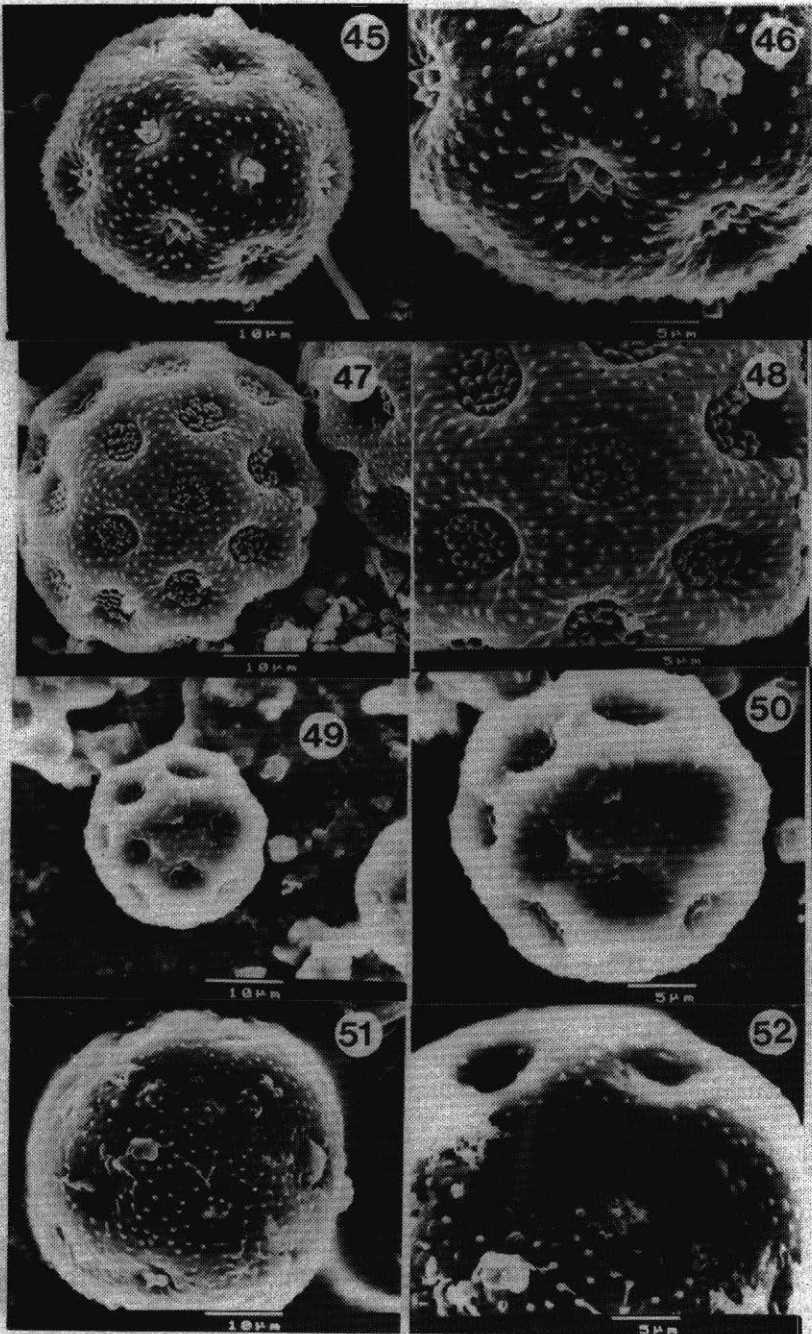




Figs. 27-52. SEM micrographs of *Silene*.  
 Figs. 27-28. *S. marschallii* pollen. Fig. 27. General view. Fig. 28. Surface view. Figs. 29-30. *S. olympica* pollen. Fig. 29. General view. Fig. 30. Surface view. Figs. 31-32. *S. chlorifolia* pollen: Fig. 31. General view. Fig. 32. Surface view. Figs. 33-34. *S. paphlagonica* pollen. Fig. 33. General view. Fig. 34. Surface view. Figs. 35-36. *S. otites* pollen. Fig. 35. General view. Fig. 36. Surface view.



Figs. 37-38. *S. cappadocica* pollen. Fig. 37. General view. Fig. 38. Surface view. Figs. 39-40. *S. spergulifolia* pollen. Fig. 39. General view. Fig. 40. Surface view. Figs. 41-42. *S. supina* subsp. *pruinosa* pollen. Fig. 41. General view. Fig. 42. Surface view. Figs. 43-44. *S. sangaria* pollen. Fig. 43. General view. Fig. 44. Surface view.



Figs. 45-46. *S. vulgaris* var. *vulgaris* pollen. Fig. 45. General view. Fig. 46. Surface view. Figs. 47-48. *S. rhynchocharpa* pollen. Fig. 47. General view. Fig. 48. Surface view. Figs. 49-50. *S. compacta* pollen. Fig. 49. General view. Fig. 50. Surface view. Figs. 51-52. *S. dichotoma* subsp. *sibirorptiana* pollen. Fig. 51. General view. Fig. 52. Surface view.

Ghazanfar (1984) observed that the pollen diameter of *S. rhynhocarpa* was between 36-40  $\mu\text{m}$ . Pore diameter was between 5 and 6  $\mu\text{m}$ . The distance between two pores ranged from 6.5 to 8.0  $\mu\text{m}$ . The number of the pores ranged from 32 to 38. Sexine was termed punctate. The present study showed that average diameter of the unacetolysed pollens was 43.57 and of the acetolysed pollens 38.23  $\mu\text{m}$ . Average diameter of pores of the unacetolysed pollens was 5.26  $\mu\text{m}$ , and of the acetolysed pollens 5.77  $\mu\text{m}$ . Average distance between two pores of the unacetolysed pollens was 4.27  $\mu\text{m}$  and of the acetolysed pollens 4.40  $\mu\text{m}$ . Number of pores range from 29 to 36. Pollen structure is semitectate, and sculpture of sexine is punctate and tubuliferous/ spinulose which is similar to the reports of Ghazanfar (1984) (Figs. 21-22, 47-48; Tables 2-3).

Imperforate exine (Walker, 1974a; 1974b), less number of pores (Van Campo, 1966) and absence of spinules on tectum of the pollen (Takhtajan, 1980); hermaphrodite and solitary flowers and perennial habits (Smith, 1974) are generally accepted as primitive examples of pollen of *Saponaria* L., (*Caryophyllaceae*) in Turkey (Arkan & Inceoglu, 1992), which had same characteristics as *Silene* i.e., absence of spinules in *Saponaria pumilio* Boiss., pollen, less pore number, which suggested that the relevant taxon was placed in the right taxonomical position (Arkan & Inceoglu, 1992).

Pollen of *S. otites* in having lowest pore number (Figs. 9-10, 35-36; Tables 2-3) has a right taxonomical position and so *S. rhynhocarpa* with highest pore number (Figs. 21-22, 47-48; Tables 2-3). However, the taxonomical position of *S. compacta* (Table 3) and *S. dichotoma* subsp. *sibthorpiana* (Table 3) with low pore numbers is open to discussion. *S. compacta* flowers formed in heads and had smaller seeds than the other taxa; *S. dichotoma* subsp. *sibthorpiana* having monochasial upper flowers show advanced characteristics, confirming correct taxonomical position, inspite of conflicting palynological result.

From the same section i.e., *Lasiostemones* Boiss., *S. marschallii* (Figs. 1-2, 27-28; Tables 2-3) and *S. olympica* Boiss., (Figs. 3-4, 29-30; Tables 2-3) are distinct with regard to pollen morphology. Pollen and pore diameters and the distance between two pores in case of *S. marschallii* is larger than those of *S. olympica*. On the other hand, *S. olympica* (22 to 31) has a higher number of pores than *S. marschallii* (18 to 26).

*S. cappadocica* Boiss. & Held., and *S. spergulifolia* (Desf.) Bieb., of the section of *Spergulifoliae* Boiss., have only a few difference in external morphology, similar pollen morphology (Figs. 11-14, 37-40; Tables 2-3). On the contrary, some members of the same section viz., *S. supina* subsp. *pruinosa* and *S. sangaria* Coode & Cullen do differ in both external morphology and pollen morphology (Figs. 15-18, 41-44; Tables 2-3).

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