Pollen morphology of *Silene* taxa (*Caryophyllaceae*) in four sections from Turkey

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Abstract. Pollen morphology of 23 taxa belonging to the genus *Silene*, from sections *Sclerocalycinae*, *Chloranthae*, *Tataricae,* and *Otites* was investigated by both light (LM) and scanning electron microscopy (SEM). The pollen grains were measured and their aperture characteristics and surface ornamentation determined. Significant differences in pollen size and pore number were also found in all species. Pollen types among all taxa examined were spheroid; ornamentations were generally microechinate-microperforate (punctate) and perforate in *S. caesarea*; structures were tectate and semitectate only in *S. caesarea*. The highest pore numbers were in *S. doganii*; the lowest pore numbers were in *S. frivadszkyana*. The widest perforate was observed in *S. caesarea,* whereas the lowest value was registered in *S. caramanica* var. *ilarslanii*. The species with the most different pollen morphology, according to its general characters, was *S. caesarea* as well as it is the most advanced, according to pore numbers and perforation. The most primitive species was observed to be *S. frivadszkyana*.

Key words: *Caryophyllaceae*, pollen, *Silene,* Turkey

Introduction

The genus *Silene,* which has about 750 species in 44 sections worldwide, is represented by 164 taxa and 31 sections in Turkey (Coode & Cullen 1967; Davis & al. 1988; Güner & al. 2000). Palynological examination of 23 taxa in the *Sclerocalycinae*, *Chloranthae*, *Tataricae,* and *Otites* sections belonging to genus *Silene* was carried out in this study.

There are significant palynological studies on some genera in the *Caryophyllaceae* family and on *Silene*. Pollen morphology revealed in these studies is significant, although not as significant as morphological and seed micromorphological characters for the clarification of systematic states of the *Silene* taxa. Melzheimer (1977) revised biosystematically the *Silene* taxa distributed in the Balkans in a study supporting this view. The author has compared the seed and pollen specifications, calyx and petal characters, and has stated that pollen characters are significant, but not as an adequate parameter to other parameters for the systematics of *Silene*. The pollen grains were pantoporate to *S. italica* (L.) Pers. and *S. viscosa*. The pollen grains of *S. italica* were punctitegillate–spinulose, whenever *S. viscosa* pollen was reticulate. Ghazanfar (1984) in her palynogical investigation of 44 taxa in the sections *Siphonomorpha* Otth. and *Auriculatae* Boiss. demonstrated that the ectexine sculpture of *Silene italica, S. viridiflora* L. and *S. rhynchocarpa* Boiss. was punctate. The sculpture of sexine of *S. caryophylloides* subsp. *subulata* (Boiss.) Coode & Cullen is recognized as semireticulate. Prentice (1987) determined the varia-

tions and significant specifications of *S. latifolia* Poir. pollen grains in his palynological study. Skvarla & Nowicke (1976) conducted a palynological study of species belonging to 11 families in *Centrospermae*. Pollen morphologies of some species belonging to *Silene* were also determined in this study. Nowicke & Skvarla (1977) too carried out palynological studies of 12 families, including the *Caryophyllaceae* from the order *Centrospermae*. The taxonomic positions of families and genera were discussed according to the results obtained from this study. Yıldız (1996, 2001a, b, 2005, 2006) examined the taxa of *S. chlorifolia, S. bupleuroides* subsp. *bupleroides* from the *Sclerocalycinae* section, *S. paphlagonica* from the *Chloranthae* section, and *S. otites* from the *Otites* section. The characters of *Silene* were determined as tectate, semitectate, spinulate, spinulate-microperforate, and semireticulate in these studies. Perveen (2000) discussed the pollen morphology and evolutionary positions of some taxa in the Karachi (Pakistan) flora. Some *Silene* taxa were used in this study to determine the systematic positions. Perveen & Qaiser (2006) worked on the pollen morphology of *Caryophyllaceae* taxa distributed in Pakistan and determined the specifications of 10 species belonging to genus *Silene*. Sahreen & al. (2008) studied pollen morphology of 16 species belonging to genus *Silene* from Pakistan. Pollen grains in their paper were observed as polypantoporate or periporate regarding the polar view.

This study was aimed at conducting a palynological study of 23 taxa belonging to genus *Silene*, as a significant genus for the floristic biodiversity in Turkey, and at using the palynological data from these studies in taxa evaluating.

Material and methods

We have examined 23 taxa of the genus *Silene* from Turkey. Palynological observations were based on the material collected between 2005 and 2007 from natural populations in various localities. They were then deposited as herbarium (MUFE) specimens. Pollen grains were sampled in the field, as well as from specimens at the Faculty of Science, the University of Istanbul (ISTF) and the Herbarium of Gazi University (GAZI) (Table 1). For scanning electron microscopy, the pollen grains were mounted on stubs with double-sided adhesive tape and were then coated with gold with a Polaron SC7620 sputter coater. These coated pollen grains were examined and then photographed with LEO 440 scanning electron microscope in the Erciyes University Technology Research and Developing Centre (Figs 1–4). Pollen measurements were implemented by examining 30 pollen grains for each taxon, with preparations set according to Wodehouse's (1935) method. Examination was made with triocular Olympus brand light microscope (LM), with ×100 oil immersion objective and ×10 ocular. The terminology follows Moore & al. (1997) and Punt & al. (2007) Characters of the pollen grains belonging to each taxon were given in Tables 2 and 3.

Results

When the general specifications of pollen grains of the examined taxa were evaluated, it was observed that the pollen types of all taxa were spheroid and apertures were polyporate. Ornamentation was perforate in *S. caesarea* (Fig. 2) and microechinate-microperforate (punctate) in all other taxa. Structures were generally tectate and semitectate only in *S. caesarea* (Fig. 2). The biggest pollen grains belonged to *S. swertiifolia* (Table 2), while the smallest pollen grains were observed in *S. confertiflora* (Table 2). The highest pore numbers were counted in *S. doganii* (Table 2) and the lowest in *S. frivadszkyana* (Table 1). Interporal distance was the greatest in *S. frivadszkyana* and the smallest in *S. paphlagonica* (Tables 2, 3), whereas the taxon that had the longest and the shortest microechinates was *S. caesarea* (Table 2). The widest perforate was recorded in *S. caesarea* and the lowest in *S. caramanica* var. *ilarslanii* (Table 2). *Silene caesarea* provided taxa with the most different pollen morphology, according to the above-mentioned specifications. The pollen of genus *Silene* was determined as pollen with medium diameter (30.67–43.34 µm) on the basis of the tables below. The findings from the study are presented in Tables 2 and 3.

Evaluation of the examined pollen grains according to the pollen diameter, pore diameter, interporal distance and number of pores
(Tables 2, 3; Figs 1–4)

Pollen grain diameters of the examined taxa varied between 30.67–43.34 µm. The taxa were grouped as

follows: five taxa between 30–35 µm, 11 taxa between 35–40 µm and seven taxa between 40–44 µm. Almost half of taxa were in the 35–40 µm group and most of them contained medium-sized pollen grains. Pore diameters varied between 3.54–7.7 µm. The taxa contained two taxa between 3–4 µm, two taxa between 4–5 µm, six taxa between 5–6 µm, 12 taxa between 6–7 µm, and one taxon between 7–8 µm. The pore diameters of most taxa varied between 6–7 µm. According to the interporal distance, there were three taxa between 3–5 µm, 11 taxa between 5–7 µm, 7 taxa between 7–9 µm, and two taxa between 9–11 µm. The interporal distances of nearly half of the taxa were between 5–7 µm. Pore numbers of the examined taxa were minimum 16 and maximum 38. Pore numbers were between 16–21 for six taxa, 22–27 for 11 taxa, 28–33 for five taxa, and 34–38 for one taxon. The pore numbers for nearly half of taxa varied between 22 and 27.

Evaluation of some pollen characters of section *Sclerocalycinae*

- **Ornamentation:** perforates in *S. caesarea* were 0.60–1.70 µm wide and differed considerably from the other taxa. In terms of length, microechinates were the longest in *S. laxa,* with 0.58–0.63 µm and the shortest in *S. armena* var. *armena,* with 0.34–0.35 µm. Microechinate base width values were highest in *S. cartilaginea* – 0.74–0.87 µm and lowest in *S. armena* var. *armena* – 0.37–0.39 µm. Furthermore, *S. caramanica* var. *ilarslanii*, *S. armena* var. *armena* and *S. armena* var. *serrulata* showed ectopori costa specifications.
- **Pollen diameter:** the biggest pollen grains belonged to *S. swertiifolia,* with 43.34±0.92 µm*;* and the smallest pollen grains belonged to *S. caramanica* var. *caramanica,* with 35.66 ±2.55 µm.
- **Pore diameter:** *S. bupleuroides* subsp. *bupleroides* had the biggest pores with 6.96 ±1.65 µm, whereas *S. cartilaginea* had the smallest pores with 3.54 ±0.66 µm.
- **Interporal distance:** the greatest distances were determined in *S. frivaldszkyana* – 10.43 ±2.38 µm and the smallest in *S. caramanica* var. *caramanica* – 4.58± 0.84 µm.
- **Pore numbers:** *S. doganii* had the highest numbers of pores – 38 (34–40); and *S. frivaldszkyana* had the lowest numbers of pores – 16 (15–18).
- **Microechinate number on the operculum:** *S. bupleuroides* subsp. *solanocalyx* had the highest number of microechinates on the operculum – 13–27; and *S. cartilaginea* had the lowest numbers of microechinates – 7–10.

Discussion

Melzheimer (1977) stated that there were some differences in the pollen grain characters in his study, where the *Silene* taxa were biosystematically revised, but the author also emphasized that these differences were not sufficient for systematic evaluations. However, in some studies palynological data have been used to determine the systematics of *Caryophyllaceae* (Skvarla & Nowicke 1976; Nowicke & Skvarla 1977; Parent & Richard 1993; Perveen 2000; Yıldız 2001b; Perveen & Qaiser 2006). In a palynological investigation of a number of species distributed in Turkey (Yıldız 1996, 2001a, b), the pollen grain characters were related to the *Silene* species as tectate, semitectate, periporate, spinulate, spinulate-microperforate, and reticulate. Our examinations revealed that the *Silene* pollen grains were tectate, semitectate, polyporate, microechinate, and microperforate. The pollen grain characters obtained in the study, the number of pores and several ornamentation characteristics, were generally compatible with those determined earlier.

The major evolutionary trend in exine structure proceeds from tectate-imperforate to tectate-perforate, to semitectate, to intectate exine (Walker 1974). A lower number of pores (Van Campo 1966) and an absence of spinules on tectum (Takhtajan 1980) of the pollen grains are generally accepted as primitive. In the light of the foregoing systematic evaluations have been carried out, as well as determination of palynological characters. *Silene caesarea* was determined as the most advanced taxon in respect to perforate specifications and pore numbers, whereas *S. caramanica* var. *ilarslanii, S. eremitica* and *S. skorpilii* were determined as the most primitive taxa in a classification from primitive to advanced, according to the ornamentation and pore numbers (Tables 2 & 3, Figs 1–4). It was noted that the taxa had different levels of advancement regarding the different characters. Pore numbers in *S. bupleuroides* subsp. *bupleroides* were given as 16–22 (Yıldız 2001b), whereas they were 20–27 in our study (Table 2, Fig. 1A).

Table 1. List of the studied taxa and specimens of *Silene*.

Taxa	Specimens studied
Sect. *Sclerocalycinae* (Boiss.) Schischk.	
S. bupleuroides L. subsp. *bupleroides*	Antalya; Elmalı, Tekke village, Dökergöl road, 1450-1500 m, 37°08'938"N,32°15'348"E, 13 July 2005, *K. Yıldız* & *M.Y. Dadandı*, MUFE 12117
S. bupleuroides L. subsp. *solanocalyx* (Boiss. & Huet) Melzh.	Van: Özalp, beween Şehittepe and Altınboğa villages, rocky places, 2220 m, 38°41'728"N, 43°59'573"E, 30 July 2005, *K. Yıldız* & *M.Y. Dadandı*, MUFE 12152
S. caramanica Boiss. & Heldr. var. *caramanica*	Karaman: Karaman to Bucakkışla (Ermenek) 17. km, roadside, 1300 m, 37°04'539"N, 33°05'425"E, 05 June 2007, *K. Yıldız*, *A. Çırpıcı* & *M.Y. Dadandı*, MUFE 12395
S. caramanica var. *ilarslanii* Aytaç & Dural	Antalya: Akseki, Çukurköy plateau, Topbaş, 2050 m, *Duran* 2888 (GAZI)
S. doganii A. Duran & Y. Menemen	Osmaniye: Above Zorkun plateau, canyon, 1870-2000 m, 36°58'910"N, 36°24'125"E,09 July 2006, *K. Yıldız* & *M.Y. Dadandı*, MUFE 12307
S. peduncularis Boiss.	Bayburt: From Bayburt to Aşkale (Erzurum) 14. km, steppe, 1620 m, 40°10'761"N,40°21'505"E, 27 July 2005, *K. Yıldız* & *M.Y. Dadandı*, MUFE 12120
S. armena Boiss. var. *armena*	Nevşehir: West of Zelve, streamside, field, 1045 m, 38°40'288"N, 34°51'751"E, 04 July 2005, *K. Yıldız* & *M.Y. Dadandı*, MUFE 12015
S. armena var. *serrulata* (Boiss.) Coode & Cullen	Antalya: Elmalı, Tekke village, Dökergöl road, *Cedrus-Juniperus* forest border, 1450-1500 m, 37°08'938"N, 32°15'348"E, 13 July 2005, *K. Yıldız* & *M.Y. Dadandı*, MUFE 12081
S. laxa Boiss. & Kotschy	Konya: Hadim, around turning of Bozkır, rocky places, 36°59'199"N, 32°27'834"E, 10 July 2005, *K. Yıldız* & *M.Y. Dadandı*, MUFE 12067
S. chlorifolia Sm.	Karaman: Ermenek to Mut road 40-45. km, begining point of Gezende barrage, rockyplaces, 1050 m, 36°32'818"N, 33°12'472"E, 09 July 2005, *K. Yıldız* & *M.Y. Dadandı*,MUFE 12056
S. swertiifolia Boiss.	Antalya: Elmalı to Finike 24. km, between Avlan lake and Finike, south-east slopes, rocky places, 1050 m, 36°32'072"N, 29°59'156"E, 10 June 2006, *A. Çırpıcı* & *K. Yıldız*, MUFE 12260
S. caesarea Boiss. & Balansa	Antalya: Elmalı, Tekke village, Dökergöl road, 13 km to Dökergöl, *Cedrus libani* forest,1500-1600 m, 36°32'N, 29°52'E, 13 July 2005, *K. Yıldız* & *M.Y. Dadandı*, MUFE 12086
S. sclerophylla Chowdhuri	Van: Tatvan to Van 40 km, south-east slopes, rocky places, 1750 m, 38°26'136"N,42°34'387"E, 01 Aug. 2005, *K. Yıldız* & *M.Y. Dadandı*, MUFE 12171
S. cartilaginea Hub.-Mor.	Van: Van-Hoşap, Güzeldere, alpine meadow, 2800 m, 08. Aug. 1993, *Y. Altan*, ALTAN5474 (GAZI)
S. haradjianii Chowdhuri	Hatay: Dörtyol, Topaktaş plateau, 1730 m, 36°49'682´´N, 36°22'318"E, 10 July 2006,*K. Yıldız* & *M.Y. Dadandı*, MUFE 12309
S. frivaldszkyana Hampe	Edirne: Keşan, seashore of Mecidiye, sea level 40°36'072"N, 26°30'016"E, 19 July 2006, *K. Yıldız*, MUFE 12377
S. lycaonica Chowdhuri	Mersin: Arslanköy, Yedioluk place, stony slopes, rocky hills, 1500 m, 37°00'183"N,34°15'124"E,09 July 2005, *K. Yıldız* & *M.Y. Dadandı*, MUFE 12050
Sect. *Chloranthae* Rohrb.	
S. viscosa (L.) Pers.	Konya: Karapınar, Nasuhpınar village, 1020 m, 24 June 1997, *M. Vural* 7809(GAZI)
S. paphlagonica Bornm.	Çankırı: Ilgaz mountain, Çankırı-Kastamonu border, south slopes, 1850-1870 m, 41°03'925"N, 33°44'999"E, 15 July 2005, *K. Yıldız* & *M.Y. Dadandı*, MUFE 12093
Sect. *Tataricae* Chowdhuri	
S. eremitica Boiss.	Kars: Iğdır, Iran border, Subaşı, salty and sandy soil, 800 m, 19 July 1956, *H. Demiriz*, ISTF 16076
S. skorpilii Velen.	Edirne: Edirne-Lalapaşa road, 0.5-1. km, hills, 150 m, 41°40'584"N, 6°35'029"E, 25 July2006, K. *Yıldız*, MUFE 12387
Sect. *Otites* (Adans.) Otth	
S. otites (L.) Wibel	Kayseri: Gesibağı-Ildem, open places, stony steppe, 1200-1250 m, 38°46'929"N,35°37'504"E, 04 July 2005, *K. Yıldız* & *M.Y. Dadandı*, MUFE 12001
S. confertiflora Chowdhuri	Hatay: Dörtyol, Topaktaş plateau, Mığır summit, 1100-1150 m, 36°49'206"N, 36°21'317"E, 19 Aug. 2006, *K.Yıldız* & *M.Y. Dadandı*, MUFE 12381

Table 2. Variation in the pollen characters of *Silene, Sclerocalycinae* section.

	Pollen diameter (µm)		Pore diameter (µm)		Interporal distance (µm)		Size of microechinae height × base (µm)	Microperphorate diameter (µm)	Pore number	Number of operculum microechinae
Taxa	**M**	**(V)**	**M**	**(V)**	**M**	**(V)**	**V**	**V**	**M(V)**	**V**
Sect. *Sclerocalycinae*										
S. bupleuroides subsp. *bupleroides*	38.86±2.21	(34.21–41.17)	6.96±1.65	(4.21–8.35)	6.34±1.29	(5.29–8.54)	0.45–0.49 × 0.53–0.58	0.2–0.39	23 (20–27)	9–17
S. bupleuroides subsp. *solanocalyx*	42.88±3.53	(37.32–48.18)	6.74±1.45	(5.26–8.66)	6.25±1.77	(4.73–8.79)	0.42–0.54 × 0.56–0.72	0.2–0.46	29 (26–32)	13–27
S. caramanica var. *caramanica*	35.66±2.55	(32.75–39.78)	4.61±0.73	(3.87–6.21)	4.58±0.84	(3.93–6.25)	0.34–0.54 × 0.44–0.83	0.2–0.4	33 (28–37)	7–14
S. caramanica var. *ilarslanii*	41.78±2.56	(39.92–44.18)	6.92±0.73	(5.88–7.35)	7.89±1.56	(5.06–10.18)	0.42–0.46 × 0.60–0.65	0.12–0.16	25 (23–28)	7–15
S. doganii	39.44±2.15	(37.12–43.47)	5.93±1.27	(4.76–7.20)	8.87±2.19	(6.15–11.78)	0.39–0.46 × 0.54–0.58	0.2–0.34	38 (34–40)	8–13
S. peduncularis	37.30±2.25	(33.30–40.11)	5.54±1.33	(3.73–7.36)	5.95±0.94	(4.73–7.11)	0.45–0.59 × 0.61–0.69	0.26–0.6	32 (27–36)	10–15
S. armena var. *armena*	35.77±1.45	(32.15–38.86)	6.61±1.05	(5.24–7.70)	7.67±0.90	(5.52–8.94)	0.34–0.35 × 0.37–0.39	0.2–0.3	22 (19–25)	10–18
S. armena var. *serrulata*	36.15±2.11	(32.24–39.44)	5.89±0.58	(4.21–6.44)	6.45±0.86	(5.44–8.38)	0.36–0.39 × 0.47–0.48	0.2–0.3	25 (21–29)	13–20
S. laxa	42.72±1.78	(40.36–45.53)	6.09±0.95	(5.65–7.20)	6.73±0.45	(6.06–7.87)	0.58–0.63 × 0.77–0.83	0.2–0.46	25 (22–30)	813
S. chlorifolia	41.07±2.19	(38.89–47.98)	6.97±1.04	(5.79–8.06)	7.98±0.87	(6.45–9.03)	0.41–0.49 × 0.54–0.67	0.2–0.4	27 (23–31)	7–13
S. swertiifolia	43.34±0.92	(40.85–45.52)	6.95±0.44	(5.63–7.73)	6.58±1.29	(4.87–8.78)	0.29–0.39 × 0.42–0.58	0.27–0.37	27 (20–32)	5–18
S. caesarea	39.55±2.54	(35.10–43.42)	6.35±0.77	(5.56–7.50)	7.85±1.34	(6.00–10.43)	0.43–0.49 × 0.47–0.54	0.6–1.7	24 (20–27)	12–20
S. sclerophylla	40.26±1.55	(35.25–42.23)	7.70±0.52	(7.11–8.77)	5.64±0.37	(5.20–6.96)	0.39–0.51 × 0.76–0.80	0.1–0.22	23(20–26)	11–13
S. cartilaginea	37.20±2.25	(33.84–39.56)	3.54±0.66	(2.63–4.17)	10.23±1.72	(9.21–12.36)	0.36–0.47 × 0.74–0.87	0.2–0.4	23 (20–26)	7–10
S. haradjianii	33.29±2.32	(27.75–35.44)	3.95±0.65	(3.36–4.87)	4.74±0.85	(3.80–6.32)	0.37–0.41 × 0.46–0.48	0.2–0.27	21 (19–24)	10–17
S. frivaldszkyana	42.67±2.71	(40.76–46.83)	6.15±0.76	(5.34–7.17)	10.43±2.38	(7.5–13.63)	0.49–0.55 × 0.62–0.71	0.4–0.8	16 (15–18)	12–22
S. lycaonica	37.77±1.78	(34.03–40.27)	6.35±0.68	(4.8–7.49)	5.78±1.94	(3.35–9.88)	0.49–0.36 × 0.55–0.45	0.25–0.33	27 (25–31)	8–20

Table 3. Variation in the pollen characters of *Silene, Chlorantha*, *Tataricae* and *Otites* sections.

	Pollen diameter (µm)		Pore diameter (µm)		Interporaldistance (µm)		Size of microechinae height × base (µm)	Microperphorate diameter (µm)	Pore number	Number of operculum microechinae
Taxa	**M**	**(V)**	**M**	**(V)**	**M**	**(V)**	**V**	**V**	**M (V)**	**V**
Sect. *Chloranthae*										
S. viscosa	38.34±3.26	(35.50–42.88)	6.25±0.57	(5.55–7.54)	8.71±1.60	(7.33–11.18)	0.39–0.44 × 0.60–067	0.2–0.33	18(15–20)	7–20
S. paphlagonica	31.14±2.87	(26.47–34.93)	4.74±1.03	(3.61–5.78)	3.76±0.51	(3.20–4.40)	0.20–0.31 × 0.30–0.36	0.2–0.32	31(28–35)	25–29
Sect. *Tataricae*										
S. eremitica	32.55±1.73	(29.11–35.50)	5.24±0.65	(4.44–6.15)	7.54±1.58	(6.25–10.31)	0.41–0.43 × 0.47–0.63	0.2– 0.3	19(17–23)	12–18
S. skorpilii	38.25±1.71	(34.56–40.78)	6.34±0.56	(4.97–7.15)	6.83±1.45	(4.21–8.87)	0.48–0.53 × 0.44–0.61	0.43–0.65	17(15–20)	9–17
Sect. *Otites*										
S. otites	32.97±1.92	(28.88–36.50)	5.61±0.87	(4.76–7.80)	5.69±0.55	(4.75–7.78)	0.36–0.55 × 0.40–0.60	0.1–0.26	21(17–25)	12–17
S. confertiflora	30.67±2.08	(28.40–34.50)	5.14±0.33	(4.09–6.34)	5.33±0.52	(4.44–6.35)	0.31–0.56 × 0.42–0.61	0.1– 0.3	24(22–28)	15–23

Abbreviations: **M** – mean value; **SD** – standard deviation; **V** – variation, minimum–maximum values in parenthesis.

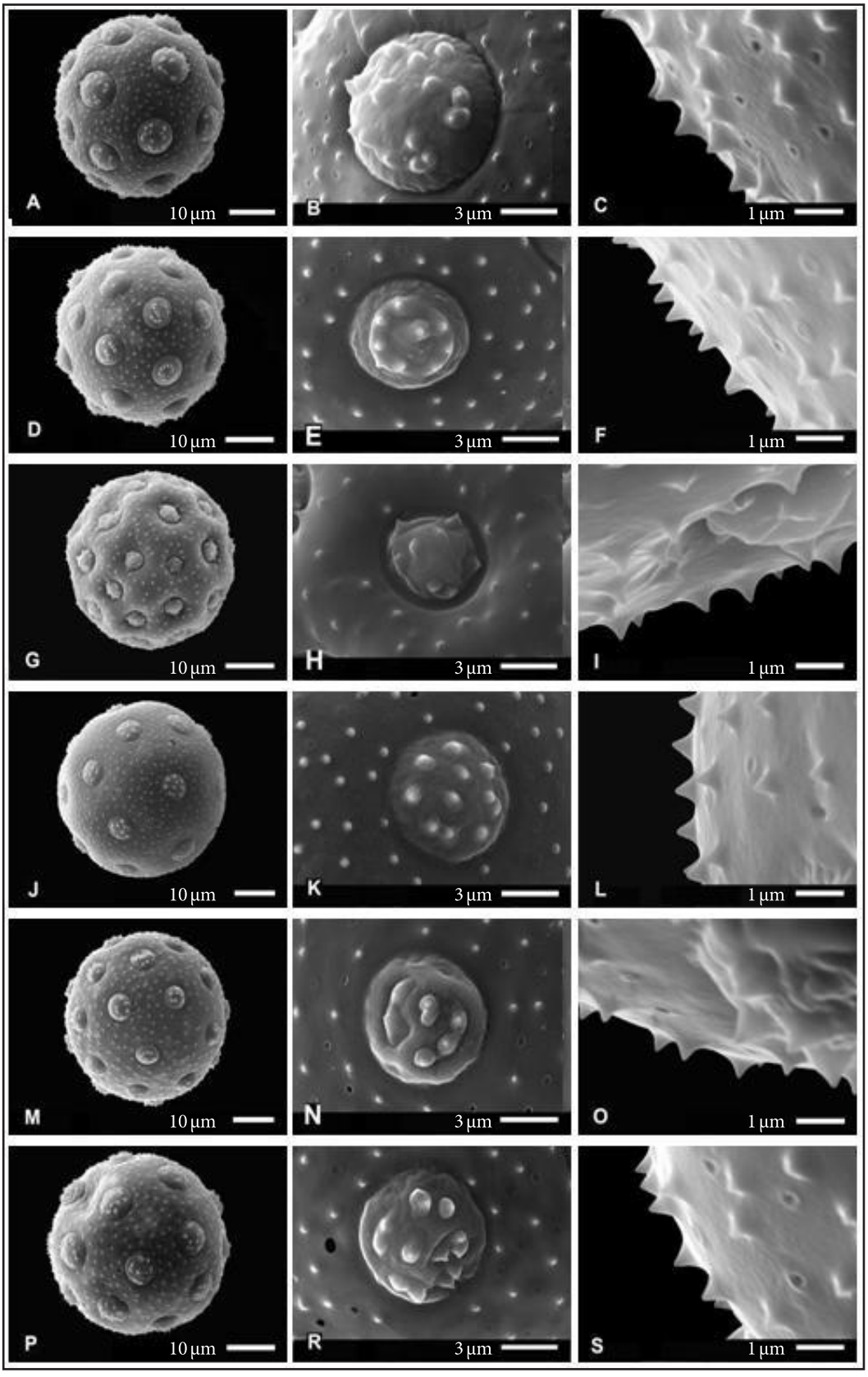

Fig. 1. **A-C**: *S. bupleuroides* subsp. *bupleroides* (MUFE 12117); **D-F**: *S. bupleuroides* subsp. *solanocalyx* MUFE 12152); **G-I**: *S. caramanica* var. *caramanica* (MUFE 12395); **J-L**: *S. caramanica* var. *ilarslanii* (Duran 2888, GAZI); **M-O**: *S. doganii* (MUFE 12307); **P-S**: *S. pedunculari*s (MUFE 12120).

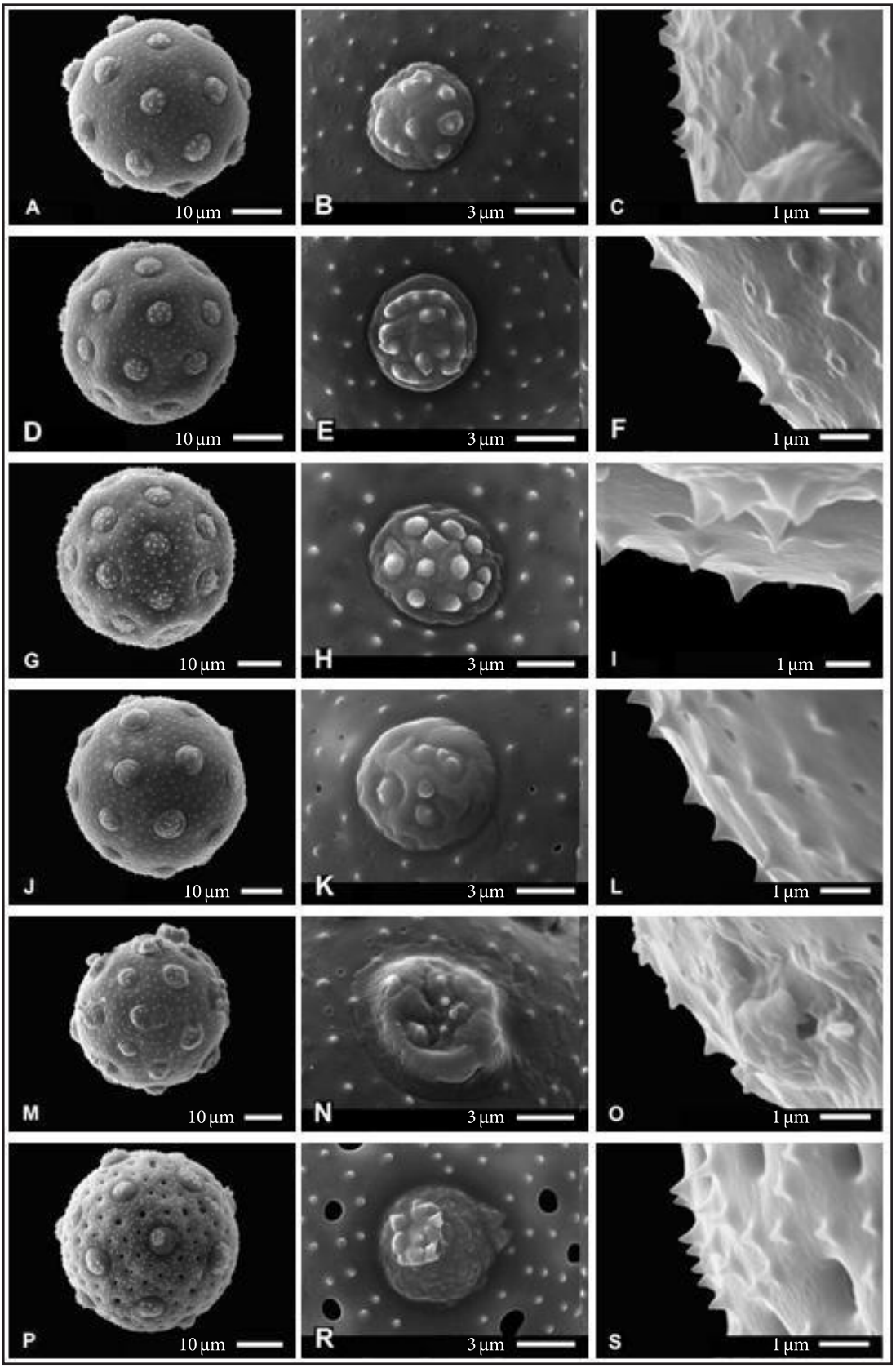

Fig. 2. **A-C**: *S. armena* var. *armena* (MUFE 12015); **D-F**: *S. armena* var. *serrulata* (MUFE 12081); **G-I**: *S. laxa* (MUFE 12067); **J-L**: *S. chlorifolia* (MUFE 12056); **M-O**: *S. swertiifolia* (MUFE 12260); **P-S**: *S. caesarea* (MUFE 12086).

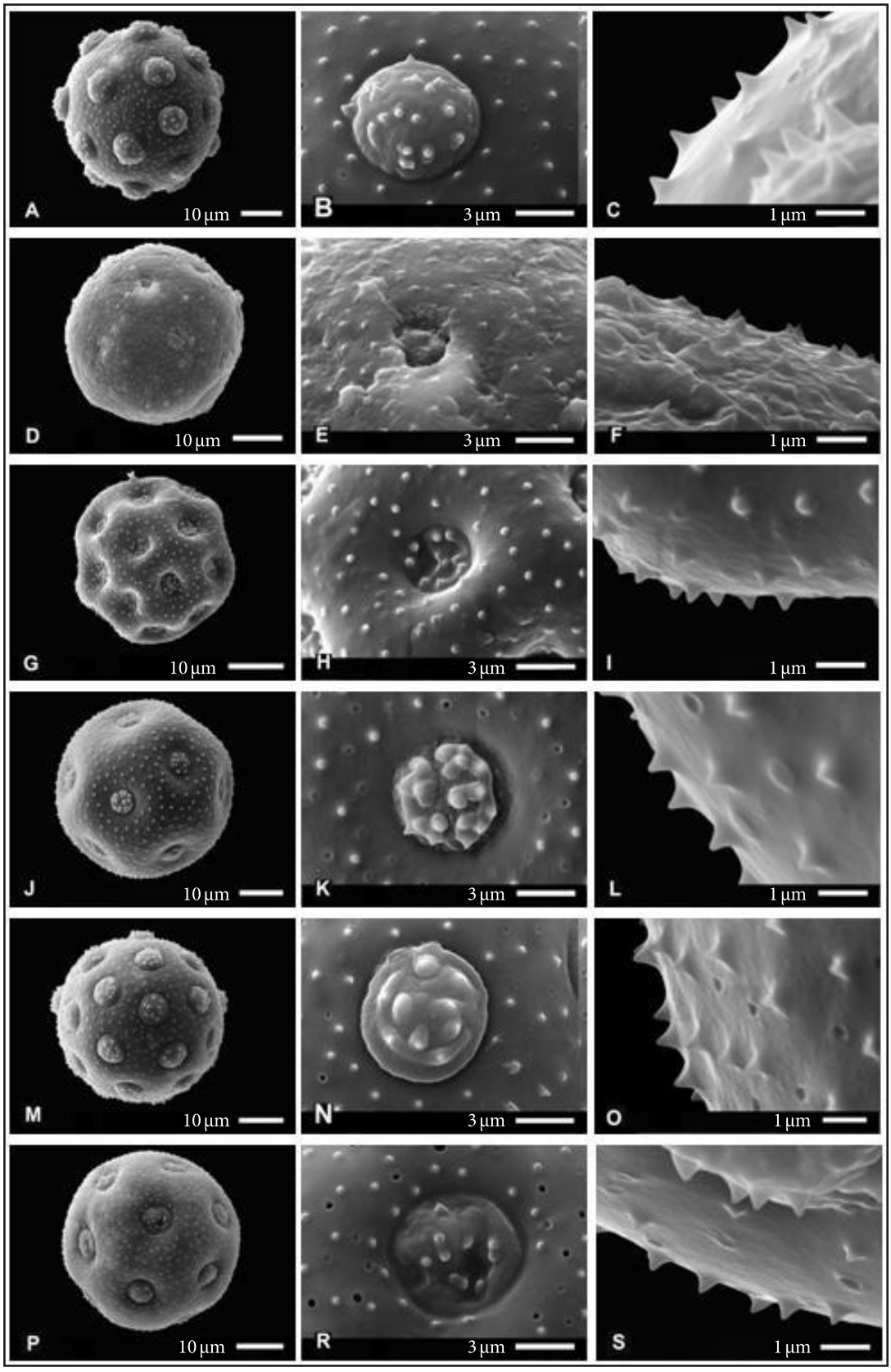

Fig. 3. **A-C**: *S. sclerophylla* (MUFE 12171); **D-F**: *S. cartilaginea* (Altan 5474, GAZI); **G-I**: *S. haradjianii* (MUFE 12309); **J-L**: *S. frivaldszkyana* (MUFE 12377); **M-O**: *S. lycaonica* (MUFE 12050); **P-S**: *S. viscosa* (M.Vural 7809 GAZI).

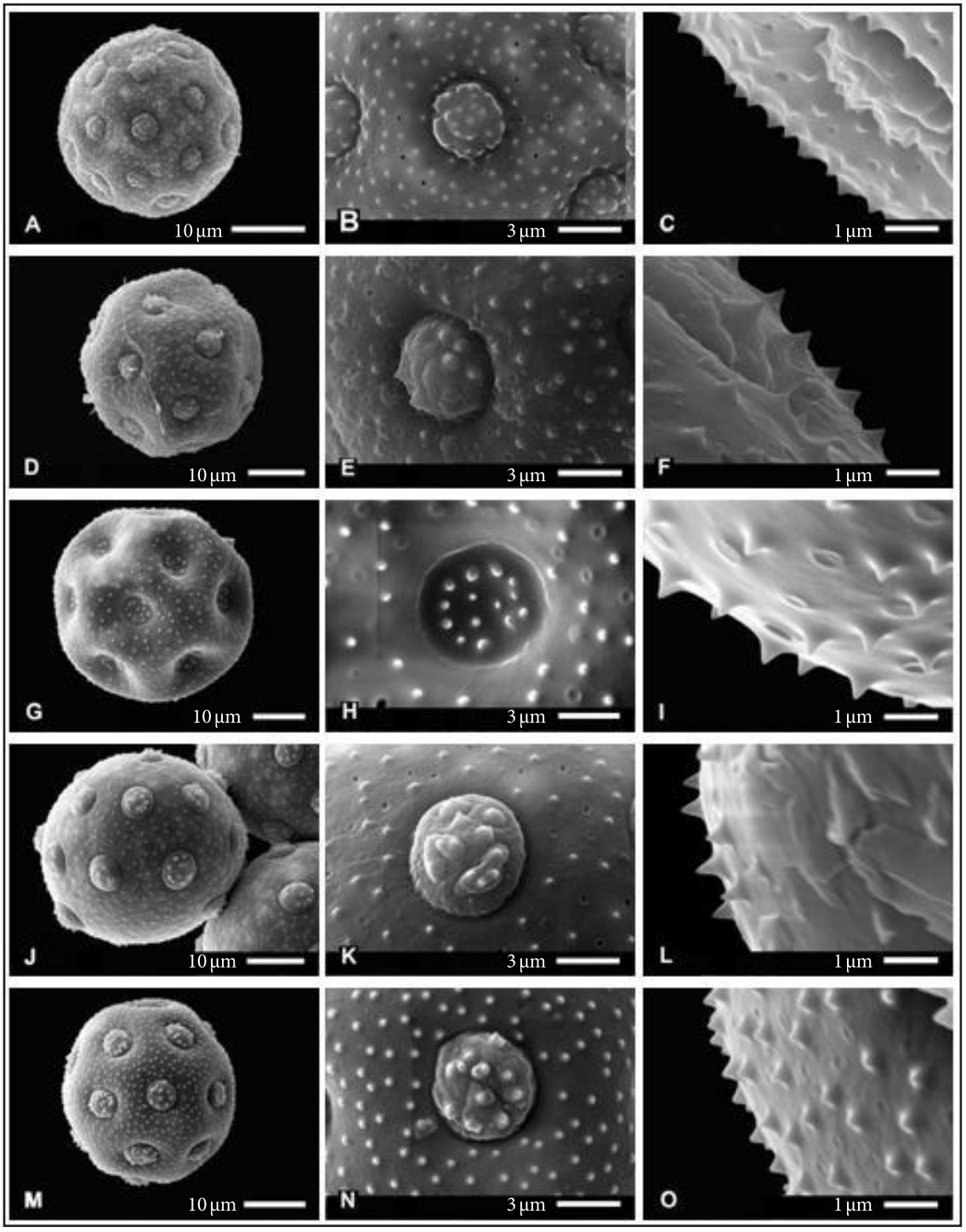

Fig. 4. **A-C**: *S. paphlagonica* (MUFE 12093); **D-F**: *S. eremitica* (ISTF 16076); **G-I**: *S. skorpilii* (MUFE 12387); **J-L**: *S. otites* (MUFE 12001); **M-O**: *S. confertiflora* (MUFE 12381).

Taxonomic evaluations

Section *Sclerocalycinae*
(Table 2, Figs 8D-O, 9A-O, 10A-I)

Similarities were recorded in *S. bupleuroides* subsp. *bupleuroides* with subsp. *solanocalyx*; *S. caramanica* var. *caramanica,* var. *ilarslanii*, and *S. doganii*; *S. armena* var. *armena* with var. *serrulata*; *S. laxa* with *S. caesarea*; and *S. chlorifolia* with *S. swertiifolia* from the *Sclerocalycinae* section. *Silene bupleuroides,* which is not differentiated into a subspecies in the Turkish flora (Coode & Cullen 1967), was given as a subspecies in the *Flora Europaea* (Chater & al. 1993), for Iran (Melzheimer 1988), and Greece (Greuter & Pirker 1997). The most significant difference regarding the pollen characters was that the pollen grain diameter of *S. bupleuroides* subsp. *solanocalyx* was greater than in subsp. *bupleroides* (Table 2, Figs 1A-F). There were also some differences between *S. caramanica* var. *caramanica* and *S. caramanica* var. *ilarslanii. Silene caramanica* var. *ilarslanii* had bigger pollen grains, bigger pore diameters, longer interporal distances, and shorter microechinates than the other varieties (Table 2, Fig. 1G-L). Ectopori costa was observed in var. *caramanica* (Fig. 1H). *Silene caramanica* var. *caramanica* differed distinctly from *S. doganii* with its greater pollen diameter and lower pore numbers in our evaluations (Table 2, Figs 1J-O). In terms of palynological differences between the two varieties, var. *armena* differed from var. *serrulata* with its smaller pore size and lower pore numbers (Table 2, Figs 2A-F). *Silene laxa* and *S. caeserea* showed morphological similarities and this was corroborated in *Flora Iranica* (Melzheimer 1988). *Silene laxa* was noted to differ from *S. caeserea* by its shorter interporal distances, greater number of pores, and narrower perforate diameters in our evaluations (Table 2, Figs 2G-I, 2P-S). *Silene chlorifolia* and *S. swertiifolia* showed close morphological similarities. The two taxa were differentiated from each other by the fact that the base of cauline leaves of *S. chlorifolia* were amplexicaul, while the leaves of *S. swertiifolia* were cuneate. *Silene chlorifolia* differed from *S. swertiifolia* in terms of palynological specifications by its smaller pollen grains and longer interporal distances (Table 2, Figs 10J-O).

Regarding the above-mentioned evaluations, evolutionary setups of sections and taxa within the sections can be examined, according to the perforate specifications and pore numbers. Here is the evolutionary setup of taxa in the *Sclerocalycinae* section from primitive to advanced, according to perforate wideness: *S. caramanica* var. *ilarslanii*, *S. sclerophylla*, *S. haradjianii*, *S. armena* var. *armena*, *S. armena* var. *serrulata*, *S. lycaonica*, *S. doganii*, *S. swertiifolia*, *S. bupleuroides* subsp. *bupleroides*, *S. cartilaginea*, *S. chlorifolia*, *S. caramanica* var. *caramanica*, *S. laxa*, *S. bupleuroides* subsp. *solanocalyx*, *S. peduncularis*, *S. frivaldszkyana* and *S. caesarea*. And here is the evolutionary setup of taxa in *Sclerocalycinae* section from primitive to advanced, according to the pore numbers: *S. frivaldszkyana*, *S. haradjianii*, *S. armena* var. *armena*, *S. cartilaginea*, *S. sclerophylla*, *S. caesarea*, *S. caramanica* var. *ilarslanii*, *S. armena* var. *serrulata*, *S. laxa*, *S. chlorifolia*, *S. lycaonica*, *S. swertiifolia*, *S. bupleuroides* subsp. *solanocalyx*, *S. bupleuroides* subsp. *bupleroides*, *S. peduncularis*, *S. caramanica* var. *caramanica* and *S. doganii*.

S. caesarea and *S. doganii* were determined as the most advanced taxa, whereas the most primitive taxon was *S. haradjianii,* according to both characters. There has been a discrepancy in *S. frivaldszkyana* – one of the advanced taxa according to the perforate diameter, although the taxon is considered primitive according to the pore numbers. The taxa *S. bupleuroides* subsp. *solanocalyx* and *S. bupleuroides* subsp. *bupleroides*, *S. armena* var. *armena* and *S. armena* var. *serrulata*, *S. swertiifolia, S. chlorifolia,* and *S. laxa* were close to each other in terms of advancement, according to both characters.

Sections *Chloranthae*, *Tataricae* and *Otites*
(Table 3, Figs 3P-S, 4)

It was difficult to make a salutary and detailed systematic and palynological evaluation of the general structures of sections, since only two taxa were examined in each of the three sections. Thus, these sections were evaluated only by pore and perforate specifications.

Silene paphlagonica in *Chloranthae* section, *S. eremitica* in *Tataricae* section, and *S. confertiflora* in *Otites* section had higher pore numbers. *Silene viscosa* differed from *S. paphlagonica,* both in *Chloranthae* section and with most similar specifications: bigger pollen and pore diameters, longer interporal distances, higher numbers of columella granules, longer microechinates, and lower pore numbers (Table 3; Figs 3P-S, 4A-F, M-O). Perforate specifications were determinant only in *S. skorpilii* (Table 3, Figs 4G-I), the other values were unconvincing in the evaluations of the evolutionary aspect.

In conclusion, the pollen types of all taxa were spheroid and poliporate; ornamentations were generally microechinate-microperforate (punctate) and perforate only in *S. caesarea;* structures were tectate and semitectate only in *S. caesarea*. The most advanced species, according to the pore numbers and perforation, was *S. caesarea,* while the most primitive were *S. frivadszkyana* and *S. caramanica* var. *ilarslanii.*

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