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SEED MORPHOLOGY OF *CARYOPHYLLACEAE* SPECIES FROM TURKEY (NORTH ANATOLIA)

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Abstract

Scanning electron microscopy (SEM) techniques were used to investigate the macro and micromorphology of seed of 17 species (12 genera) of *Caryophyllaceae.* All material studied was collected from North Anatolia (Square A3-A8 of Flora of Turkey). Three of the species are endemic for Turkey. Some important character states identified were: **Seed type**: Reniform, ovoid, reniform to orbicular, orbicular, peltate, scaled-winged, winged, cylinderical, ovoid to reniform; **seed surface type**: Flat-concave, flat, convex, wringed crugosus aculeate, concavo-convex, rounded; **tubercle shape:** Tall/short conical, obtuse, rounded, flat and aculeate-verrucate, digitate; **surface granulation:** Medium, fine and coarse or not; **suture outline:** Digitate/serrate/ stellate/ sharply-sinuous, fine digitate and sharply serrate; **hylar zone:** Recessed, prominent, facial and flat.

Introduction

The *Caryophyllaceae* family consists of 80 genera and more than 2000 species world-wide (Heywood 1998); of which 32 of the genera, including over 470 species occur as native species in Turkey (Davis, 1967, 1988). Five genera are the largest with *Silene* L. (129 species), *Dianthus* L. (69 species), *Gypsophila* L. (51 species), *Arenaria* L. (47 species) *Minuartia* L. (45 species) (Davis, 1967; 1988; Baytop, 1992).

Seed characters are consistent at generic or species level and therefore useful as systematic tools. It is interesting to note that inspite of the importance of and stability of seed characters in systematic, very little work seems to have been published on seed morphology as compared to other fields.

The seed morphology of 12 *Gypsophila* species was investigated by Fedatova & Artzhanova (1992). Kovtonyuk (1994) carried out studies with seeds of 10 Siberian *Gypsophila* L., species by scanning electron microscopy. The supplementary diagnostic characters were found in the shape and structure of testa cells. Yıldız & Çırpıcı (1998) studied seed morphology of 19 *Silene* species from Turkey (Northwest Anatolia). The other studies known in the seed morphology of the *Caryopyllaceae* family include those of Chowdhuri (1957), Melzheimer (1977), Yıldız & Çırpıcı (1992) and Volponi (1993). Chowdhuri (1957) made a revision of *Silene* taxa in the world, and Melzheimer (1977) conducted biosystematical studies of *Silene* taxa available in the Balkans. They studied seed testa cells as diagnostic characters. The morphology of *Silene* species was studied by Yıldız & Çırpıcı (1992). *Stellaria cuspidata* Schlechtend and some related species were studied micromorphologically by Volponi (1993).

This study on the seed macro and micromorphology of *Caryophyllaceae* species from North Anatolia showed that structure of the seed morphology is suitable for classification of species which is reported herein. The present study has been conducted on the collective species of *Caryophyllaceae* in order to find out additional micromorphological characters for its delimination.

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Materials and Methods

The specimens were collected from various fields in the Northern Anatolia as shown in Fig 1. A list of material used is given in Table 1. The specimens are stored in the Biology Department of Celal Bayar University.

Table 1. Data for the collection of *Caryophyllaceae* species seed. (E): Endemic for Turkey, A: A Square of Flora of Turkey, Y: Yıldız, Kemal

Species	Locality and collector	Number
Minuartia anatolica var. *anatolica* **(E)**	A6 Tokat, 1 km from Başçiftlik to Niksar, slopes, 1200 m., Kemal Yıldız.	Y 45
Minuartia erythrosephala var. *cappadocica* **(E)**	A4 Çankırı, Ilgaz TV station, screes, 2100 m., K.Yıldız.	Y 78
Stellaria holostea	A6 Tokat, near Güzelce village, shrub, 1100 m., K.Yıldız.	Y 3
Cerastium chlorifolium	A6 Tokat, Tekneli village, field, 1200 m., K.Yıldız.	Y 23
Moenchia mantica var. *mantica*	A6 Tokat, 13 km from Gökdere to Erbaa, banks, 900 m., K.Yıldız.	Y 30
Dianthus crinitus var. *crinitus*	A5 Çorum, 25 km from Sungurlu to Çorum, slopes, banks, 1000m., K.Yıldız.	Y 69
Dianthus carmelitarum **(E)**	A7 Giresun, 37 km from Ş.karahisar to Giresun, near Tamdere, 1600 m., K.Yıldız.	Y 60
Dianthus celocephalus	A6 Tokat, 1 km from Başçiftlik to Niksar, slopes, 1200 m., K.Yıldız.	Y 44
Petrorhagia saxifraga	A5 Amasya, 7 km from Ladik to Akdağ, near Dam, 900 m., K.Yıldız.	Y 46
Velezia rigida	A6 Ordu, 14 km from Akkuş to Niksar, near. Quercus forest, 1100 m., K.Yıldız.	Y 132
Gypsophila elegans	A8 Rize, Kaçkar mountain, near Ayder hot spring, 2500 m., K.Yıldız.	Y 128
Vaccaria pyramidata var. *grandiflora*	A6 Tokat, near Oğulcuk village, field, 700 m., K.Yıldız.	Y 11
Silene montbretiana	A6 Tokat, Çamlıbel radar station, rocky places, 1900 m., K.Yıldız.	Y 17
Silene caryophylloides subsp. *subulata*	A6 Tokat, Akdağ, rocky places, 1700m., K.Yıldız.	Y 36
Silene conica	A5 Amasya, near Akdağ, 900 m., K.Yıldız.	Y 87
Lychnis coronaria	A3 Bolu, Abant lake, 1300 m., K.Yıldız.	Y 152
Agrostemma githago	A6 Tokat, Yeşilırmak banks, 550 m., K.Yıldız.	Y 29

Macro and microphotographs which showed general view of seed surface were taken by Jeol JSM 5400 SEM at Gazi Osman Paşa University Electron Microscopy Unit. The seeds were coated with gold for the SEM. The number of seeds varied from taxon to taxon. Only healthy and mature seeds were studied. The following morphological

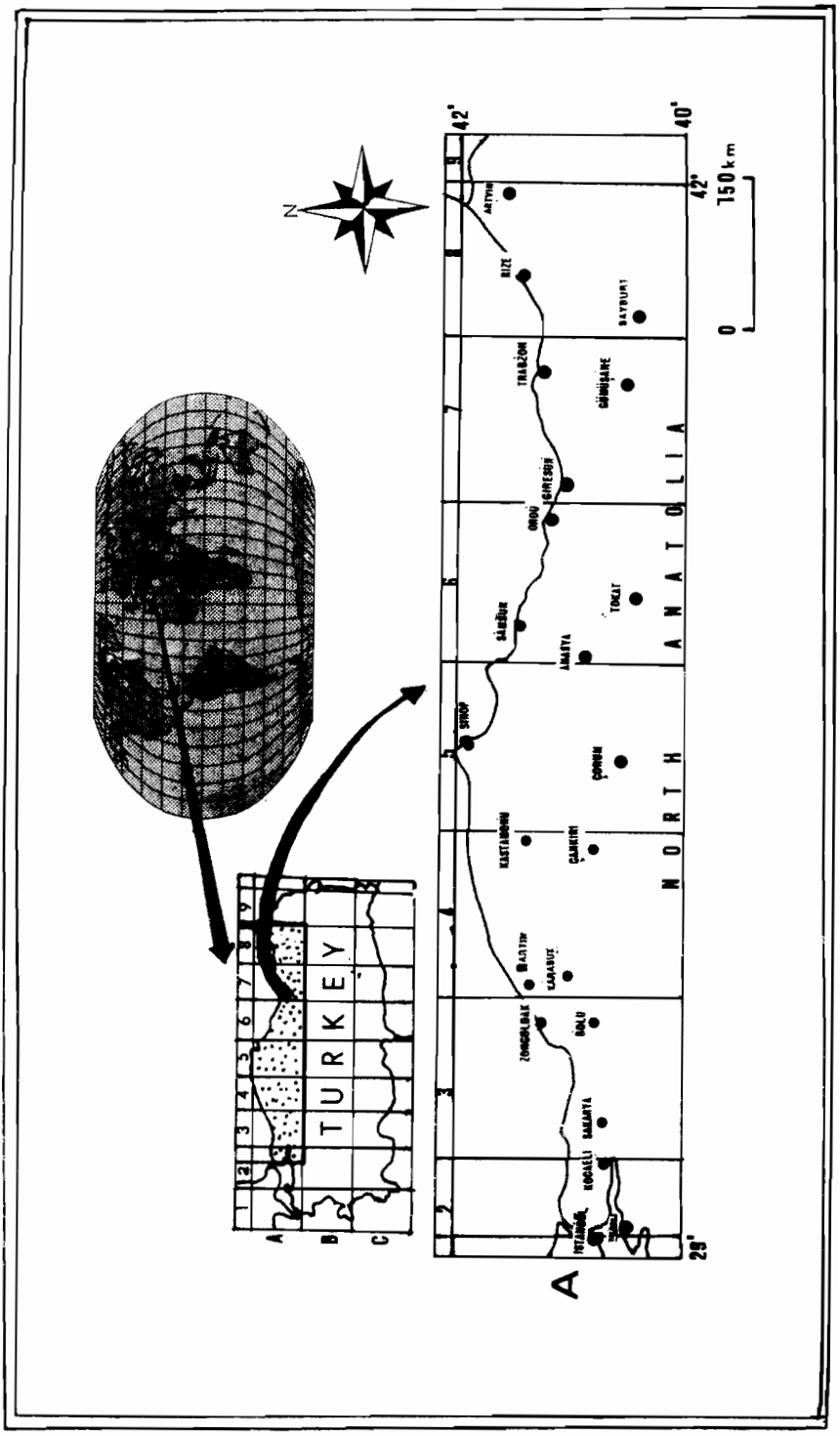

Fig. 1. The investigation area.

characteristics of seeds were studied according to Stearn (1996) and Prentice (1978): Seed type, seed back shape, seed tubercle shape, seed surface type, granulation, number of suture point per plate, suture outline, hylar zone.

Results and Discussion

The seeds bear numerous morphological characters which can be used for taxonomic purposes. The ornamentation features of the seed surface and its relief are different from one species to another, even at higher magnifications (X500). Davis & Heywood (1963) emphasized the use of seed characters as these are reliable fairly and constant within a taxon. The advanced families usually have complex seed types.

The seed morphology of *Minuartia* L., *Stellaria* L., *Cerastium* L., *Moenchia* Ehrh. and *Vaccaria* Medik., *Silene* L., *Lychnis*, *Agrostemma* L., is similar. The seed type of *Minuartia erythrosephala* (Bieb.) Hand var. *cappadocica* (Fig. 2c, d), *Silene montbretiana* Boiss. (Fig. 4g, h), *Silene conica* L. (Fig. 5c, d) is reniform; *Stellaria holostea* L. (Fig. 2e, f) reniform to orbicular, *Silene caryophylloides* (Poiret) Otth. subsp. *subulata* (Boiss.) Coode & Cullen (Fig. 5a, b), *Lychnis coronaria* (L.) Desr., (Fig. 5e, f), and *Agrostemma githago* L., (Fig. 5g, h) ovoid to reniform. The seed type of *Dianthus crinitus* Sm. var. *crinitus* (Fig. 3a, b) is peltate. *Dianthus carmelitarum* Reut., (Fig. 3c, d) and *Dianthus celocephalus* Boiss., (Fig. 3e, f) are scaled-winged. *Velezia rigida* L., (Fig. 4a, b) is cylinderical. *Minuartia anatolica* (Boiss.) Woron var. *anatolica* (Fig. 2a, b) and *Vaccaria pyramidata* Medik. var.*grandiflora* (Fig. 4e, f) are ovoid. The seed type of *Cerastium chlorifolium* (Fig. 2g, h), *Moenchia mantica* (L.) Bartl.var. *mantica* (Fig. 2i, k) and *Gypsophila elegans* (Fig. 4c, d) is ovoid - orbicular. Also *Dianthus* species (Fig. 3a-f), *Petrorhagia saxifraga* (figs. 3g, h) and *Velezia rigida* (Fig. 4a, b) are the clearest in the other studied species according to scaled-winged, winged and cylinderical seeds.

Hylar zone of *Minuartia anatolica* (Boiss.) Woron var. *anatolica* (Fig. 2a, b), *Minuartia erythrosephala* (Bieb.) Hand var. *cappadocica* (Fig. 2c, d), *Cerastium chlorifolium* Fish. & Mey., (Fig. 2g, h), *Moenchia mantica* (L.) Bartl.var. *mantica* (Fig. 2i, k), *Gypsophila elegans* Bieb., (Fig. 4c, d), *Vaccaria pyramidata* Medik. var.*grandiflora* (Fig. 4e, f), *Silene montbretiana*. (Fig. 4g, h), *Silene caryophylloides* subsp. *subulata* (Fig. 5a, b), *Silene conica* L., (Fig. 5c, d), *Lychnis coronaria* (L.) Desr., (Fig. 5e, f), *Agrostemma githago* (Fig. 5g, h) is recessed.

The suture outline of *Velezia rigida* (Fig. 4a, b) is fine digitate. Testa cells of *Cerastium chlorifolium* (Fig. 2g, h) and *Moenchia mantica* var., *mantica* (Fig. 2i, k) are stellate. In *Gypsophila elegans* (Fig. 4c, d) and *Vaccaria pyramidata* var. *grandiflora* (Fig. 4e, f) seeds are similar to *Silene* seeds in its morphology (Table 2).

The granulation of *Gypsophila elegans* (Fig. 4c, d), *Silene caryophylloides* subsp. *subulata* (Fig. 5a, b), *Silene conica* (Fig. 5c, d), *Lychnis coronaria* (L.) Desr., (Fig. 5e, f) and *Agrostemma githago* (Fig. 5g, h) is clearer than the other studied species.

Hylar zone of *Minuartia anatolica* var. *anatolica* (Fig. 2a, b) and *Minuartia erythrosephala* var. *cappadocica* (Fig. 2c, d) is quite similar to each other. The suture outline of *Minuartia eryhtrosephala* var. *cappadocica* is sharper than *Minuartia anatolica* var. *anatolica*. *Stellaria holostea* L. (Fig. 2e, f) and *Lychnis coronaria* (Fig. 5e, f) tubercles are more visible in the studied species. The suture outline of *Stellaria holostea* (Fig. 2e, f) is only irregular (Table 2).

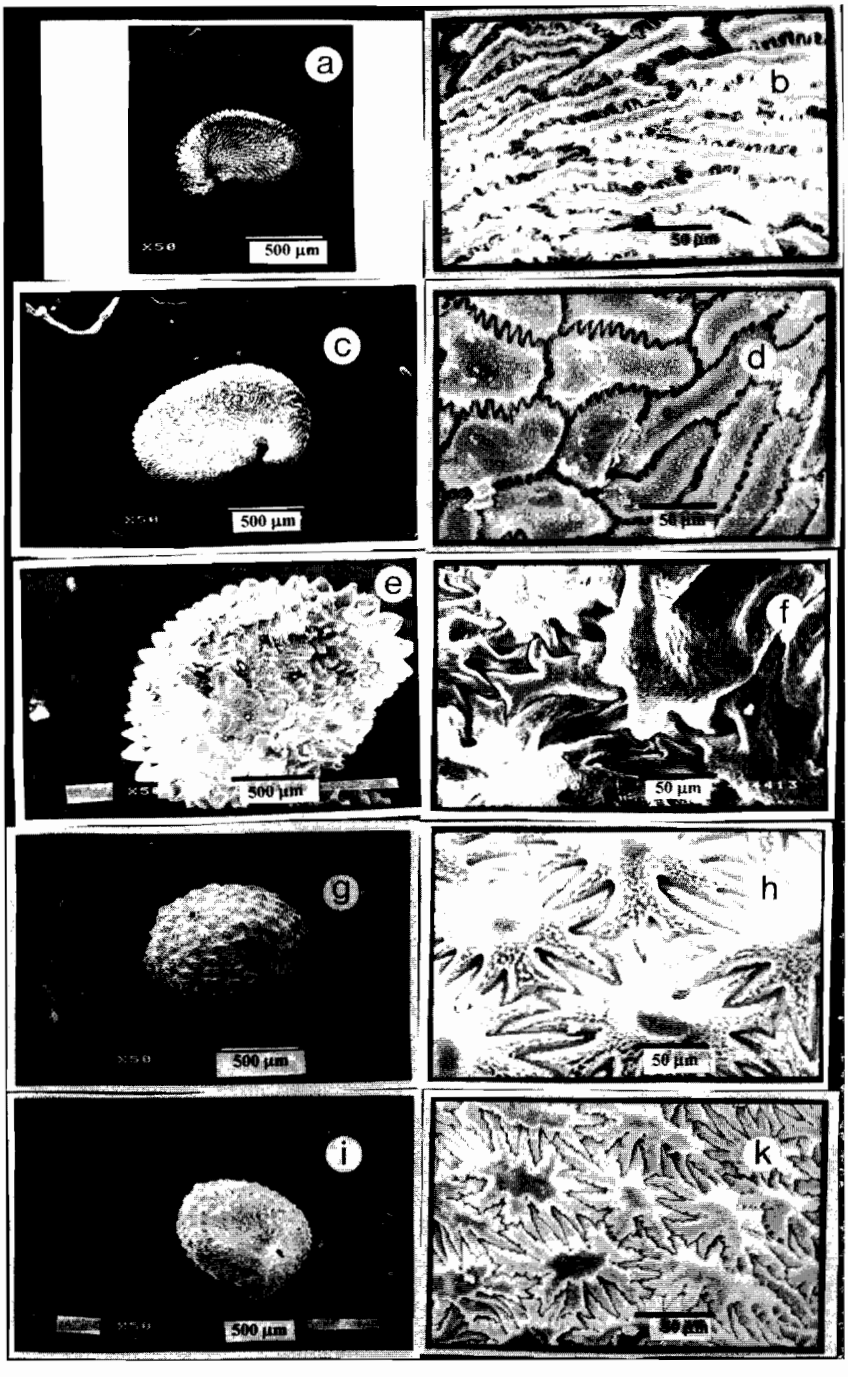

Fig. 2. SEM of seed morphology of *Caryophyllaceae* species.
a. b. *Minuartia anatolica* var. *anatolica*, c. d. *Minuartia erythrosepala* var. *cappadocica*,
e. f. *Stellaria holostea*, g. h. *Cerastium chlorifolium*, i. k. *Moenchia mantica* var. *mantica*

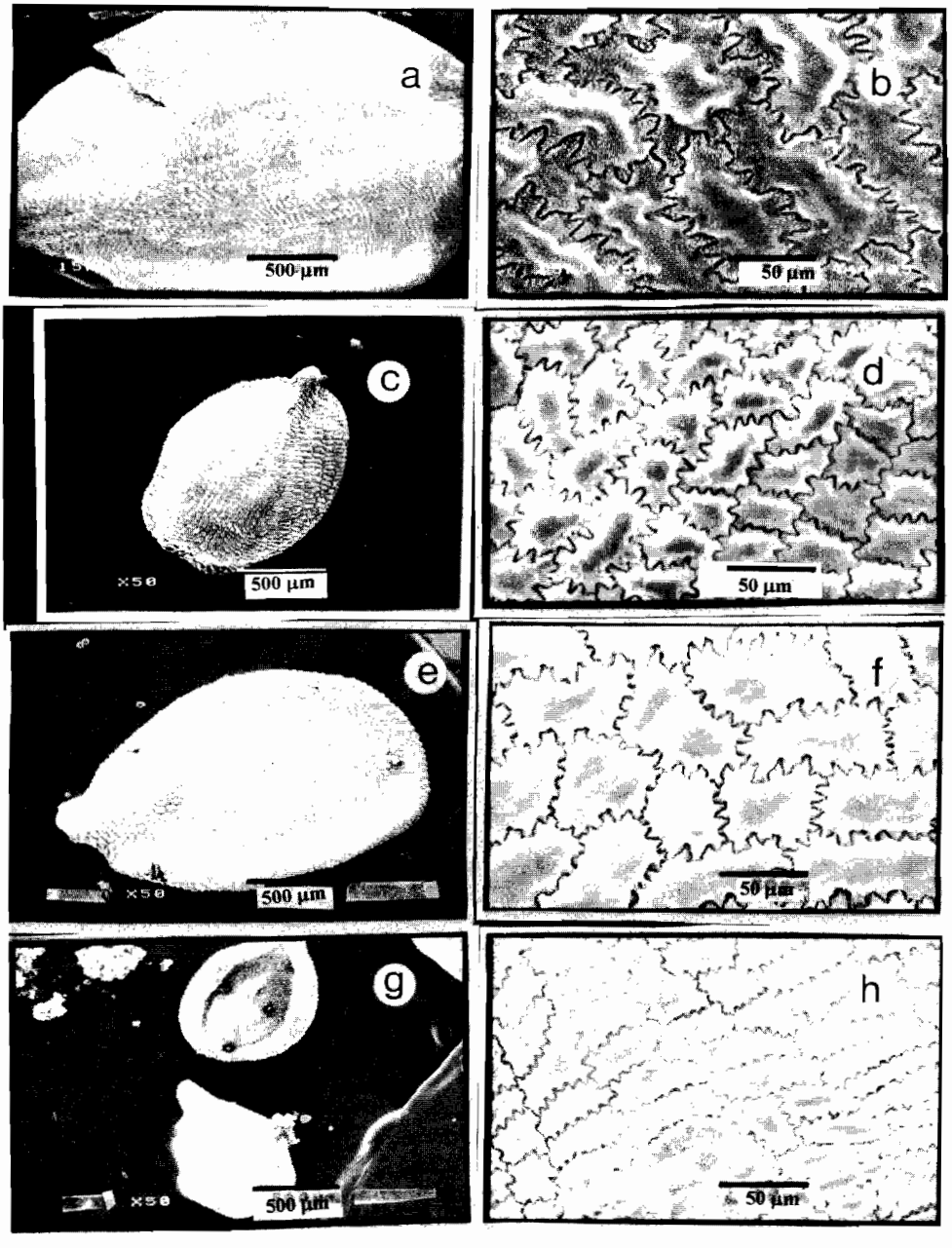

Fig. 3. SEM of seed morphology of *Caryophyllaceae* species.
a. b. *Dianthus crinitus* var. *crinitus*, c. d. *Dianthus carmelitarum*, e. f. *Dianthus celocephalus*, g. h. *Petrorhagia saxifraga*

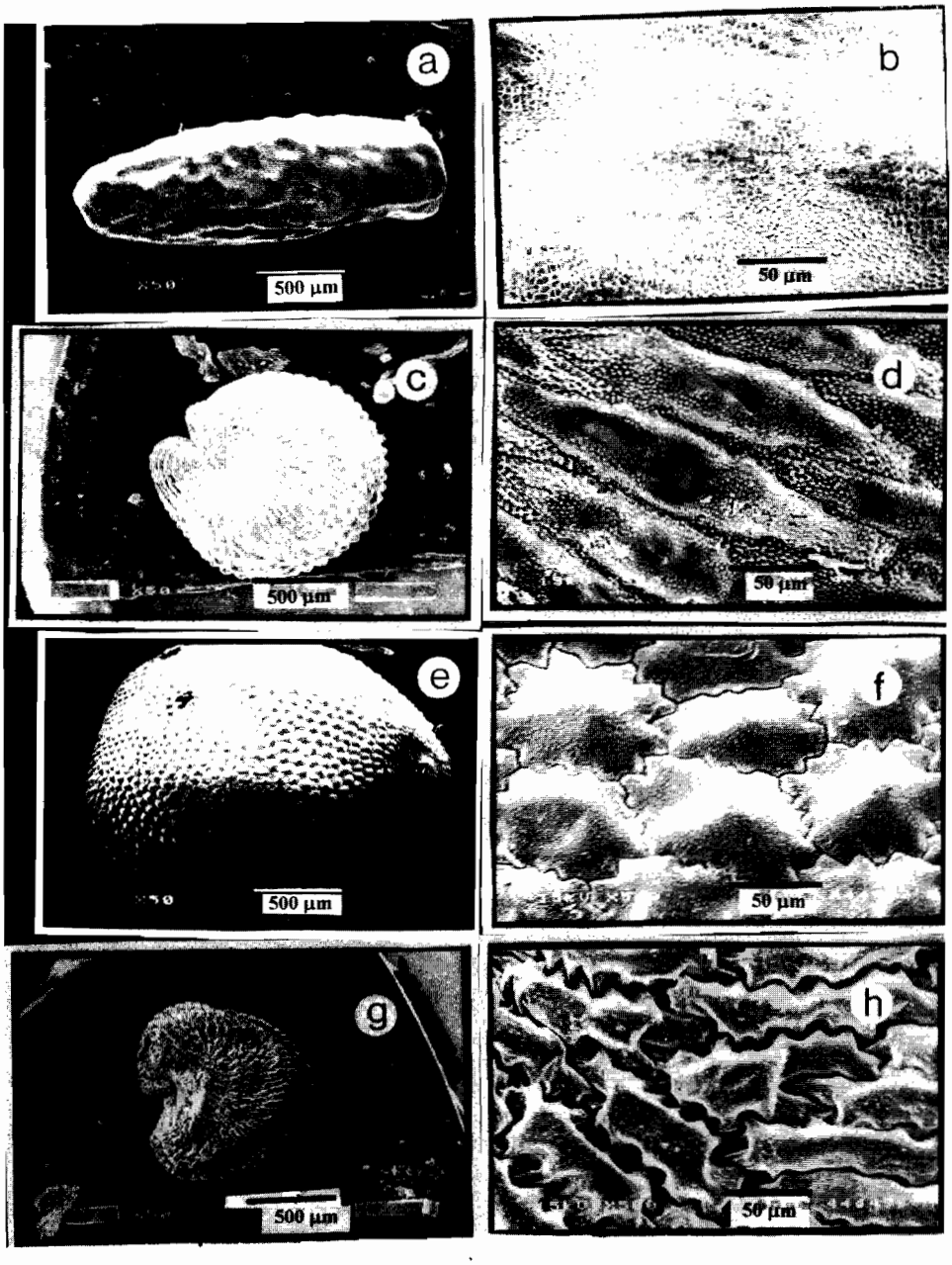

Fig. 4. SEM of seed morphology of *Caryophyllaceae* species.
a. b. *Velezia rigida*, c. d. *Gypsophila elegans*, e. f. *Vaccaria pyramidata* var. *grandiflora*,
g. h. *Silene montbretiana*.

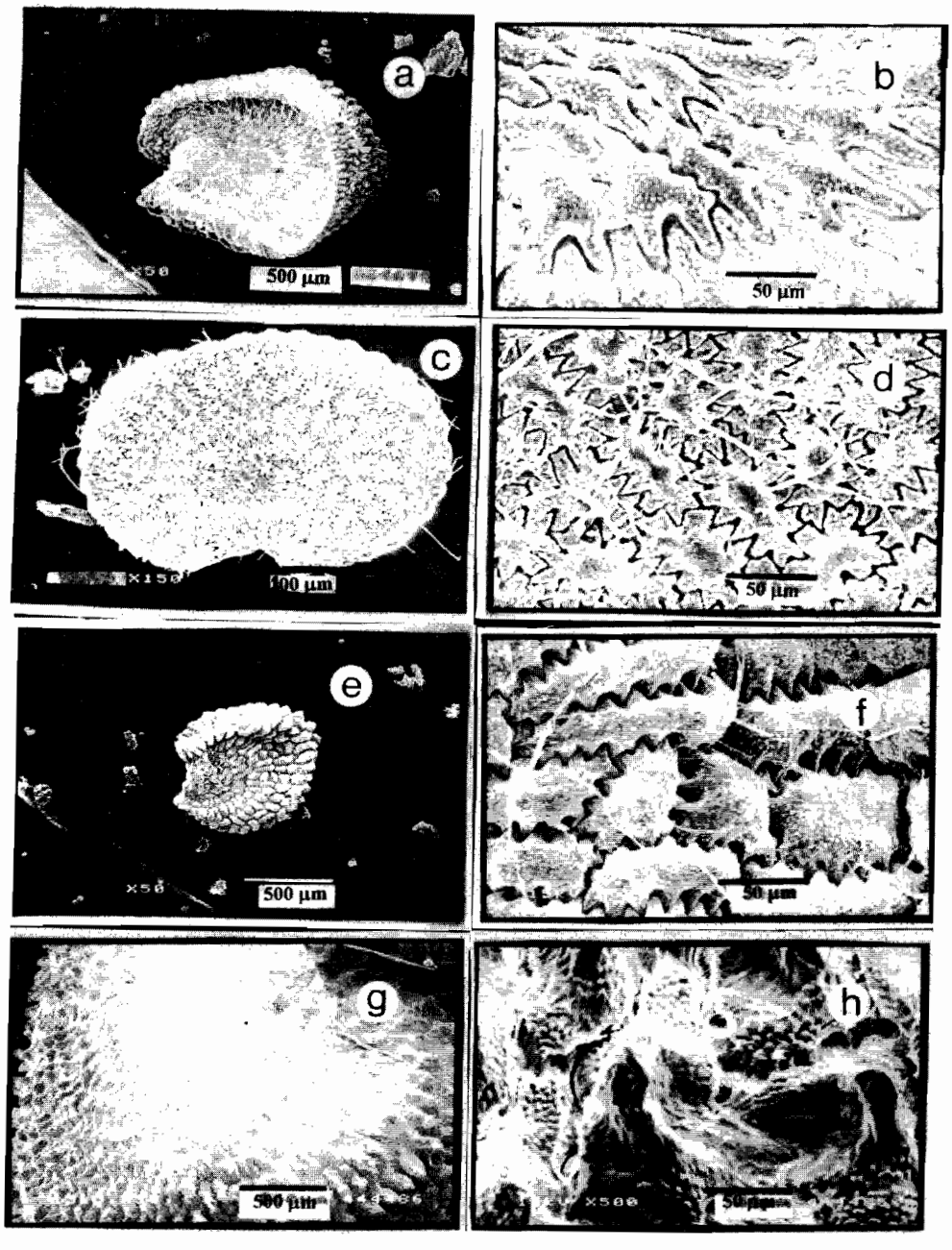

Fig. 5. SEM of seed morphology of *Caryophyllaceae* species.
a. b. *Silene caryophylloides* subsp. *subulata*, c. d. *Silene conica*, e. f. *Lychnis coronaria*, g. h. *Agrostemma githago*

Table 2. Seed morphology of *Caryophyllaceae* species, (E): Endemic for Turkey.

Species	Seed type	Seed back	Seed tubercle shape	Seed surface type
Minuartia anatolica var. *anatolica* **(E)**	Ovoid	Flat-convex Flat-rounded	Tall-conical	Flat-concave
Minuartia erythrosephala var. *cappadocica* **(E)**	Reniform	Rounded Convex	Obtuse Rounded	Flat Convex
Stellaria holostea	Reniform to orbicular	Rounded Convex	Obtuse-tall conical Aculeate-verrucate	Wringled crugosus aculeate
Cerastium chlorifolium	Ovoid-Orbicular	Rounded Convex	Obtuse/ Short-conical	Convex
Moenchia mantica var. *mantica*	Ovoid-Orbicular	Rounded	Obtuse	Flat/convex
Dianthus crinitus var. *crinitus*	Peltate	Flat Concavo-convex	Fine-obtuse	Concavo-convex
Dianthus carmelitarum **(E)**	Scaled-winged	Flat-convex	Obtuse	Concavo-convex
Dianthus celocephalus	Scaled-winged	Flat-convex	Obtuse	Concavo-convex
Petrorhagia saxifraga	Winged	Rounded Concave or flat	Obtuse	Concavo-convex
Velezia rigida	Cylinderical	Rounded convex	Not tubercle	Rounded
Gypsophila elegans	Ovoid-orbicular	Rounded convex	Obtuse conical	Convex
Vaccaria pyramidata var. *grandiflora*	Ovoid	Rounded convex	Obtuse	Rounded convex
Silene montbretiana	Reniform	Winged concave	Obtuse or Flat	Flat-Concavo
Silene caryophylloides subsp. *subulata*	Ovoid to reniform	Winged flat	Obtuse	Concavo-concave
Silene conica	Reniform	Rounded convex	Obtuse (Large)	Flat convex
Lychnis coronaria	Ovoid to reniform	Rounded flat	Obtuse conical	Flat concavo
Agrostemma githago	Ovoid to reniform	Rounded	Digitate	Flat-convex

Fedatova & Artzhanova (1992) investigated seed anatomy and ultra structure in 12 *Gypsophila* species by light and scanning electron microscopy. According to the results of this study (Fedatova & Artzhanova, 1992) the campylotropous seed with a testal seed-coat was characteristic for the genus. The ultrastructure of the seed surface could be used as a taxonomic aid. The association between the structure of the testa and its seed protitive function exists in several contemporary genera of the *Caryophyllaceae*. Kovtonyuk (1994) studied with seeds of 10 Siberian *Gypsophila* species using SEM. The supplementary diagnostic characters were found in the shape and structure of testa cells. According to the present observations, *Gypsophila elegans* (Fig. 4c, d; Table 2), seed types are ovoid or orbicular, seed backs are rounded convex, seed tubercle shapes are obtuse conical, seed surface convex, granulation medium, number of suture point per plate

Table 2 (Cont'd.)

Species	Seed granulation	Number of suture point per plate	Suture outline	Hylar zone type
Minuartia anatolica var. *anatolica* **(E)**	Medium	23-30	Digitate-sinuous	Recessed near apical
M.erythrosephala var. *cappadocica* **(E)**	Medium	25-35	Sharply-sinuous	Recessed near apical
Stellaria holostea	Not	Variable	Variable	Invisible
Cerastium chlorifolium	Medium or coarse	10-15	Stellate	Recessed
Moenchia mantica var. *mantica*	Fine	9-17	Stellate	Recessed
Dianthus crinitus var. *crinitus*	Medium	15-20	Serrate-sinuous	Prominent facial
Dianthus carmelitarum **(E)**	Fine	10-17	Stellate-sinuous	Prominent
Dianthus celocephalus	Fine	15-20	Sharply or digitate sinuous	Prominent
Petrorhagia saxifraga	Medium	10-17	Sinuous	Prominent
Velezia rigida	Not	-	Fine digitate	Flat
Gypsophila elegans	Medium	20-30	Sinuous	Recessed
Vaccaria pyramidata var. *grandiflora*	Fine or Medium	12-15	Sinuous	Recessed
Silene montbretiana	Fine	10-14	Sinuous	Recessed
Silene caryophylloides subsp. *subulata*	Coarse or Medium	6-10	Sinuous	Recessed
Silene conica	Coarse	10-14	Sharply serrate	Recessed
Lychnis coronaria	Medium	11-18	Sharply serrate	Recessed
Agrostemma githago	Generally coarse	Invisible	Invisible	Recessed

20-30, suture outline sinuous, hylar zone recessed. Yıldız & Çırpıcı (1998) studied 19 *Silene* species morphology from Northwest Anatolia. Seed type of *Silene* species generally reniform; suture outline of testa cells is generally serrate, serrate-sinuous, sharply sinuous; hylar zone recessed, prominent and level. In this study, *Silene* species seeds were reniform, suture outline sinuous, sharply serrate and hylar zone recessed. Volponi (1993) studied the *Stellaria cuspidata* complex from the Andes. *Stellaria* seeds are reniform to orbicular, its surface ornamented with papillae or in addition sometimes with glochids at apex, dorsally more prominent than on the lateral surface. According to the results of the present study, *Stellaria* seeds are reniform to orbicular, seed tubercles obtuse tall conical, aculeate-verrucate (Table 2).

The seed morphological studies clearly support the taxonomic decisions to divide the *Caryophyllaceae* genera and species. This study is in conformity with the studies carried out by Fedatova & Artzhanova (1992), Kovtonyuk (1994), Yıldız & Çırpıcı (1992, 1998), Melzheimer (1977) and Volponi (1993).

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