

# STUDIES ON SEED MORPHOLOGY OF *CAMPANULA* L. SECTION *QUINQUELOCULARES* (BOISS.) PHITOS (CAMPANULACEAE) IN TURKEY

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## Abstract

Morphological features of seeds of 9 species of *Campanula* L., section *Quinqueloculares* (Boiss.) Phitos (Campanulaceae) which are distributed in Turkey were investigated by scanning electron microscopy (SEM). Characteristics of the seeds and their surface are described and compared. Two main types and two subtypes of surface ornamentation patterns are observed. These can be considered as diagnostic characters.

## Introduction

The genus *Campanula* L., (Campanulaceae) contains about 300 species and is distributed in most of Mediterranean Region (about 150 species) in the World (Cronquist, 1988; Heywood, 1998). This genus is important because of its large number of species and high ratio of endemics in Turkey. The genus *Campanula* is divided into 9 informal groups (designated A, B, C, D, E, F, G, H and I) in the Flora of Turkey (Damboldt, 1978). These are morphologically different from each other and have important lineaments. Group A [Sect. *Quinqueloculares*] is characterized by large and reflexed calyx appendages. Ovary is 5-locular. Stigma is 5. Capsule is opening by five basal pores. The species of the section are biannual or perennial herbs, usually monocarpic. Its stems are usually tall. The Sect. *Quinqueloculares* is represented by 11 species and subspecies as of which 10 are endemic to Turkey and Greece. Two species are distributed in Aegean Islands (Greece) but not Turkey (Damboldt, 1978; Davis *et al.*, 1988; Güner *et al.*, 2000). In appearance some species showed close similarity with each other. The taxonomy of some species, such as *C. lyrata* subsp. *lyrata*, *C. hagielia*, *C. sorgerea* and *C. betonicifolia* is problematic. Because the vegetative characters are very variable, rendering species identification difficult. However, the surface morphological features of seeds and their taxonomical significance have not been investigated.

Studies of the seeds of Campanulaceae have been few and limited because the features of the seeds have not been employed as an important taxonomic feature within the family. However, the potential taxonomic value of seed coat microsculpture has been demonstrated by Krochmal & Huguely (1971); Geslot (1980); Belyayev (1984a, 1984b, 1985). Shetler & Morin (1986) and Haridasan & Mukherjee (1988) recognized seed testa cells as diagnostic characters from North American and Indian Campanulaceae. Murata (1992, 1995) has made extensive studies and examined a diversity of Lobelioideae seeds *via* SEM. Buss *et al.*, (2001) made also detailed observations of Lobelioideae. Similarly, they have examined ultrastructure of the seeds of the genera *Goodenia* (Carolin, 1980), *Cyananthus* (Shrestka & Kravtsova, 1992) and *Cyclodon* (De-Yuan & Kai-Yu, 1998) have also been made relatively *via* SEM.

The present research studies the previously poorly and unknown seed morphology of section *Quinqueloculares* from Turkey investigates its potential as a complement to the morphological characters already available.

## Materials and Methods

The plants were collected from several localities in Turkey between 2001 and 2005. Examined species belonging to the sect. *Quinqueloculares*: *C. crispa* Lam., *C. tomentosa* Lam., *C. iconia* Phitos, *C. lyrata* Lam. subsp. *lyrata*, *C. hagielia* Boiss., *C. sorgerea* Phitos, *C. betonicifolia* Sm., *C. telmessi* Hub.-Mor. & Phitos, *C. davisii* Turrill., are listed in Table 1. All the species that were used were endemic except from *C. crispa* Lam. For SEM observations, dried mature seeds were mounted on brass stubs and coated with a thin layer of gold. A JEOL JMS 5200 instrument at the Ege University, Dentistry Faculty Laboratory, İzmir were used for examination and for taking the micrographs (Figs. 1-18). The terminology of Stearn (1978) and Barthlott (1981) was adopted to describe the SEM aspects of the seed-coat. Width and length were measured under a light microscopy (LM) with micrometer at the longest and widest axis of the seed. In order to determine the lengths and widths of seed sizes, 10 seeds from each species were measured (Table 2).

## Results and Discussion

A summary of the distribution of the seed characters (seed size, shape, colour, surface pattern) are given in the Table 2. The seeds of all species are glabrous, elliptic to oblong or lanceolate in outline. Generally, they show low variation in colour from yellowish brown, dark brown to, light-brown. It appears that the size of seeds are variable within the species of sect. *Quinqueloculares* in Turkey. The largest seeds occur in *C. iconia* (average 7.2 mm long, 0.42 mm in wide) and *C. crispa* (average 0.71 mm long, 0.41 mm wide). The seeds are smallest and narrowest in *C. davisii* (average 0.43 mm long, 0.29 mm wide) and *C. tomentosa* (average 0.44 mm in long, 0.30 mm in wide).

The morphology of seeds of sect. *Quinqueloculares* are not reported in Flora of Turkey (Damboldt, 1978). Seed characters, colour, size, shape are of limited taxonomic value according to our observations. However, the sculpturing of the seed surface patterns as seen by SEM shows a wide range of variation at section level. As a result of this study, the seed-coat cells of this section in Turkey can be divided into the two main and two subtypes described below (Figs. 1-18).

**Type-I:** Type I is characterised by surface cells with weakly striate or a wavy-striated radial walls. This type is indicated by only endemic *C. tomentosa* (Figs. 3-4).

**Type-II:** Type II is characterised by areoles laterally compressed to such a degree that the lumen is essentially linear, giving the seed-coat a faintly striate appearance. The striations are regular and prominent radial walls. The following subtypes are recognized

**Subtype-IIa:** The areole walls are formed by the excavated striations, which are scabrate within (*C. telmessi*, *C. hagielia*) (Figs. 15, 16 - 9, 10) or striate within (*C. lyrata* subsp. *lyrata*, *C. sorgerea*, *C. betonicifolia*) (Figs. 7, 8 - 11, 12 - 13, 14). The lumen is very large in this subtype. This subtype is observed in most of the species of the section.

Table 1. Specimens examined for Turkey.

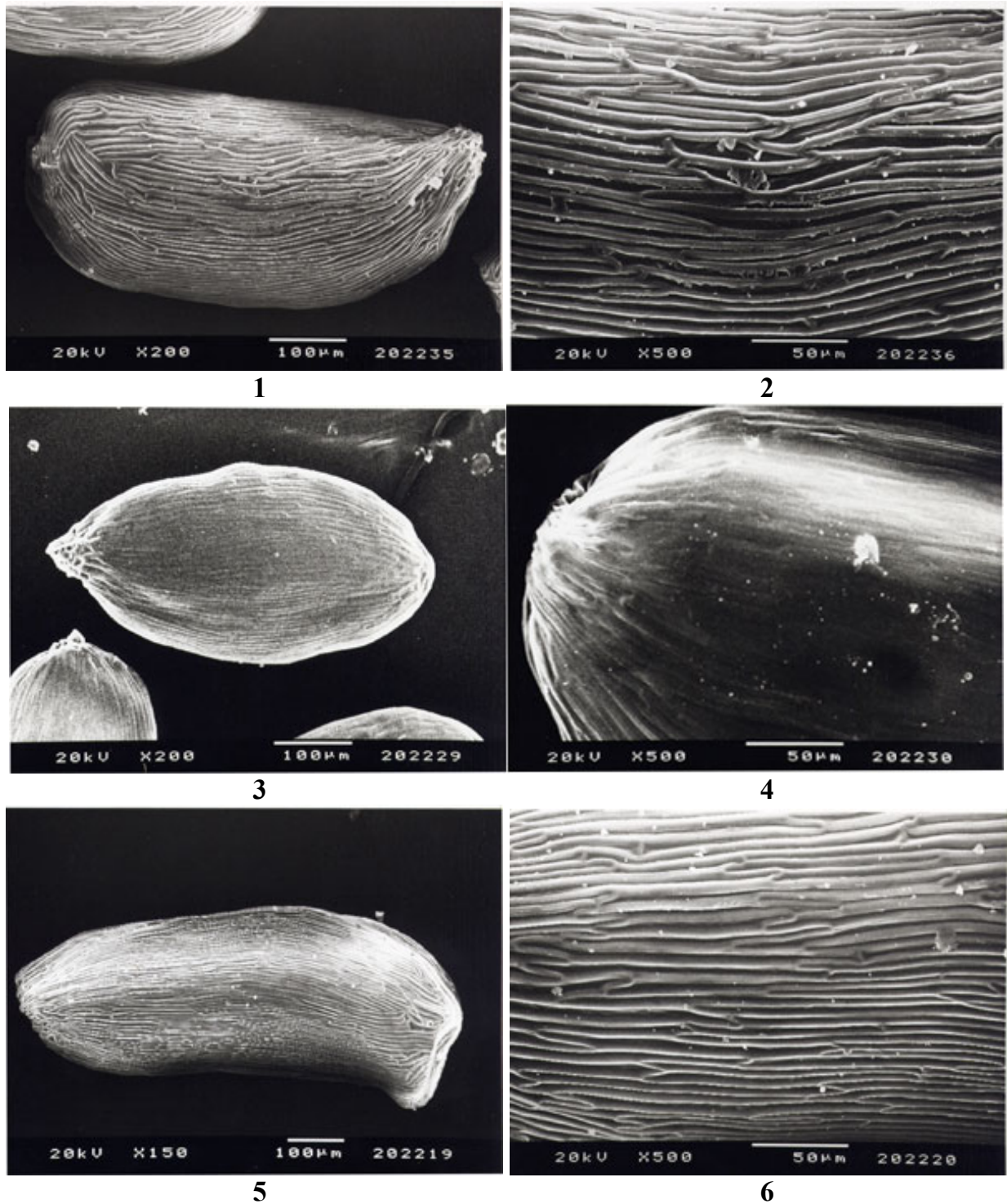
Species	Number	Locality and Collector
<i>Campanula crispa</i> Lam.	AE 2129	A8 Erzurum, 50 Km from Tortum, calcareous rocks, 1900 m, AE
<i>C. tomentosa</i> Lam. (E)	AE 2138	C1 İzmir, Efes, in ruins, 50-60 m, AE
<i>C. iconia</i> Phitos (E)	AE 2247	B3 Konya, Akşehir, Tekke village, Çiçekli Pasture, under <i>Quercus</i> , c. 1784 m, AE
<i>C. lyrata</i> Lam. subsp. <i>lyrata</i> (E)	AE 2149	B1 Manisa, Spil Mountain, on road, c.1000 m, AE
<i>C. hagielia</i> Boiss. (E)	AE 2252	C2 Muğla, Kaunos ruins, calcareous rocks, c. 50 m, AE
<i>C. sorgereae</i> Phitos (E)	AE 2268	C4 Konya, c. 50 km of Uşak, 900 m, AE
<i>C. betonicifolia</i> Sm. (E)	AE 2276	B1 İzmir, Bozdağ, Küçük Çavdar Pasture, c. 1400 m, AE
<i>C. telmessi</i> Hub.-Mor.& Phitos (E)	AE 2115	C2 Muğla, Fethiye, Kayaköy, calcareous rocks, AE
<i>C. davisii</i> Turrill (E)	AE 2150	C4 Antalya, Kazancı, Koçaş location, on rocks, 1500 m, AE

E: Endemic for Turkey; A, B, C: Grid system of Flora of Turkey; AE: Alçtepe, Emine

Table 2. A comparison between seed size, shape and seed-coat sculpturing in section *Quinqueloculares* growing in Turkey.

Taxa/Characters	Length (mm) min. max.	Width (mm) min. max.	Shape	Colour	Ornamentation	Lumen
<i>C. crispa</i>	0.6-0.7 ± 0.07	0.3-0.5 ± 0.07	Oblong	Light-brown	Type-IIb	Narrow
<i>C. tomentosa</i>	0.4-0.5 ± 0.04	0.25-0.35 ± 0.03	to	Light-brown	Type-I	Cell structure not visible
<i>C. iconia</i>	0.55-0.9 ± 0.11	0.3-0.5 ± 0.35		Light-brown	Type-IIIb	Narrow
<i>C. lyrata</i> subsp. <i>lyrata</i>	0.5-0.7 ± 0.07	0.3-0.4 ± 0.05		Light-brown to yellowish-brown	Type-IIa	Medium
<i>C. hagielia</i>	0.5-0.6 ± 0.04	0.3-0.4 ± 0.04	Elliptic	Light-brown	Type-IIa	Broad
<i>C. sorgereae</i>	0.5-0.7 ± 0.06	0.2-0.4 ± 0.07		Light-brown	Type-IIa	Medium
<i>C. betonicifolia</i>	0.5-0.7 ± 0.06	0.2-0.4 ± 0.07	or	yellowish-brown	Type-IIa	Broad
<i>C. telmessi</i>	0.6-0.8 ± 0.05	0.3-0.45 ± 0.04	Lanceolate	Dark-brown	Type-IIa	Broad
<i>C. davisii</i>	0.35-0.43 ± 0.06	0.25-0.4 ± 0.29		Light-brown	Type-IIIb	Narrow

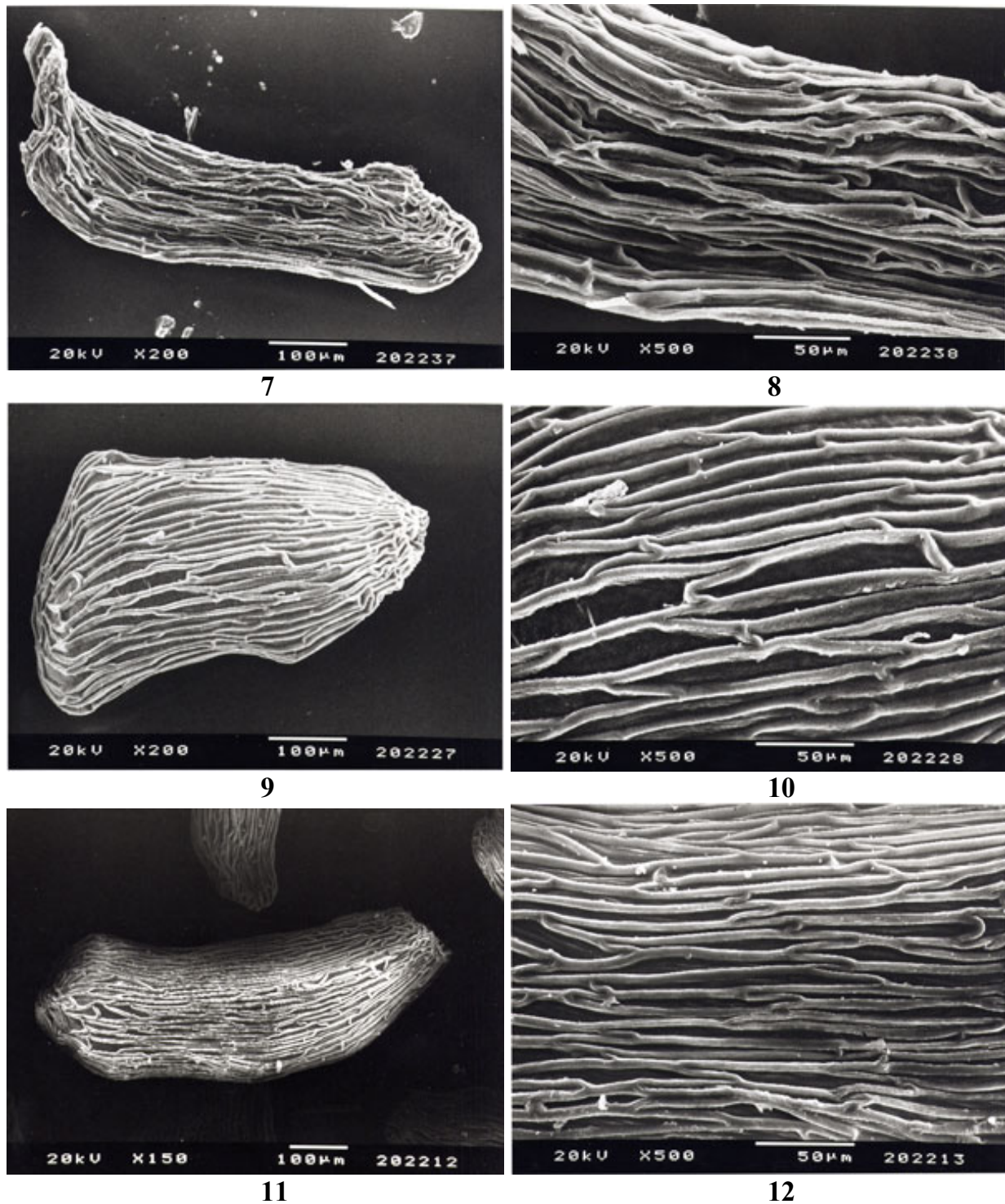
\*, Sizes are given as minimum, Maximum and standard deviation



Figs. 1-6. Section *Quinqueloculares* seeds and their coat surfaces in SEM. Figs. 1,2 *C. crispera* Figs. 3,4. *C. tomentosa*. Figs. 5,6 *C. iconia*.

**Subtype-IIb:** The nearness of striations are very small in this subtype in comparison to upper type. Taxa included this subtype of seeds are *C. davisii*, *C. crispera* and *C. iconia* (Figs. 17, 18 - 3, 4 -5, 6).

Barthlott (1981) stated that SEM of the seed-coat can be a good taxonomic and phylogenetic marker at the subgeneric to subfamilial level. But in systematic revisions of any genus of Campanulaceae the micromorphological character of seeds were either totally ignored or seldom mentioned in spite of their stability as a character. Murata

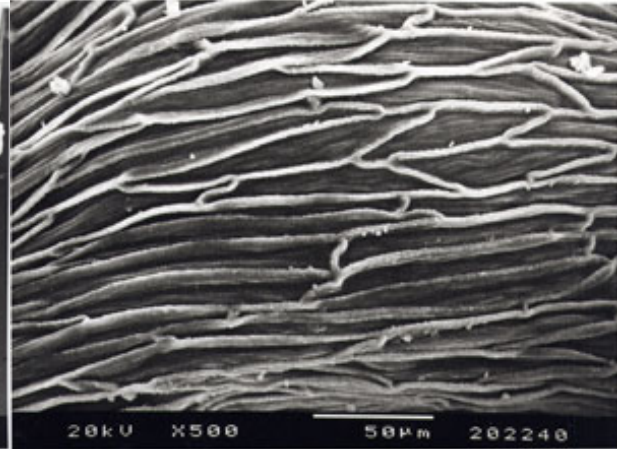


Figs. 7-12. Section *Quinqueloculares* seeds and their coat surfaces in SEM. Figs. 7, 8 *C. lyrata* subsp. *lyrata* Figs. 9, 10. *C. hagielia*. Figs. 11, 12 *C. sorgerea*.

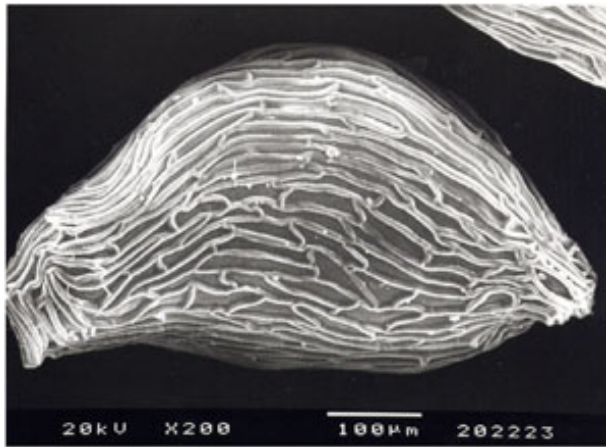
(1992, 1995) described five seed coat patterns (type-A, B, C, D, E) for subfamily Lobelioideae (Campanulaceae). In addition, two new testal patterns (type-F, G) were also identified among the 41 species of Lobelioideae by Buss *et al.*, (2001). According to these authors, the sculpturing of the seed in this subfamily is useful for ascertaining relationships among species. The general results of the present study are in conformity with those of Murata (1992, 1995), who described the characters of the seeds belonging



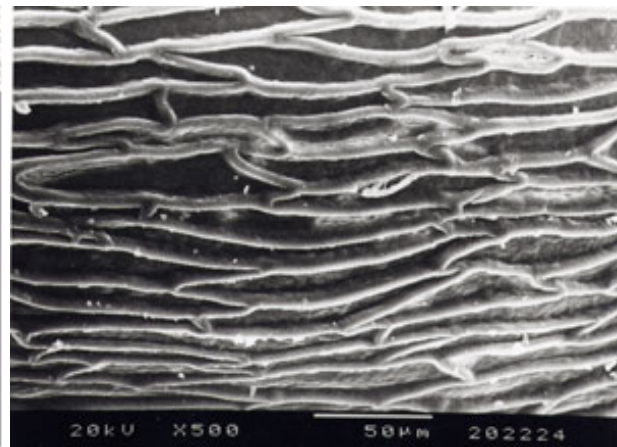
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14



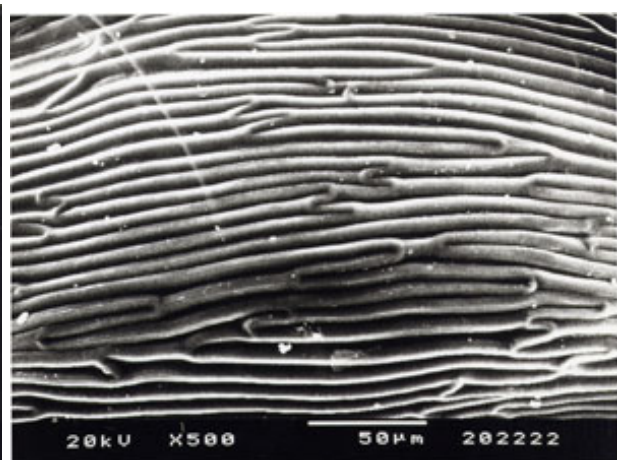
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17



18

Figs. 13-18. Section *Quinqueloculares* seeds and their coat surfaces in SEM. Figs. 13, 14 *C. betonicifolia* Figs. 15, 16. *C. telmessi*. Figs. 17, 18. *C. davisii*.

to Lobelioideae. The seeds of *C. tomentosa* resembles type-D seeds (Murata, 1992, 1995), characterised by surface cells with a wavy-striated. SubtypeII-b resembles Type-C (Murata, 1992, 1995) in having the areoles of the cells laterally compressed to such a degree that the lumen essentially linear giving the seed coat a faintly striate appearance. Shetler & Morin (1986) who revised Campanulaceae in North America and studied the structure of the seed surface used these characters in the taxonomy of the family. Seed-coat sculpturing in sect. *Quinqueloculares* (type-II) was similar to that illustrated for

some *Githopsis* sp., *Triodanis* sp. and *Campanula* sp., by Shetler & Morin (1996). There are some surveys on seed structure of genera such as *Goodenia* (Carolin, 1980) and *Pentaphragma* (Belyayev, 1985). This study on seed morphology of *Goodenia* and *Pentaphragma* showed that structure of the seed morphology is suitable for classification of genera which is reported herein. The detailed microsculpturing of sect. *Quinqueloculares* seeds are distinct from those as *Goodenia* and *Pentaphragma*. Geslot (1980) examined the seed surface of some species of Campanulaceae. *Campanula rotundifolia* is one of them and its surface is also the same as that of our samples. In general, it was composed of elongated cells that is rather deep in sect. *Quinqueloculares* of species but is weakly striate or wavy-striated in *C. tomentosa*. Morphologically, these taxon is easily distinguished from the other taxa because it is also very distinct species with length of corolla and shape of corolla in Flora of Turkey (Damboldt, 1978). Furthermore, it is completely different from other species in terms of seed-coat surface. Morphological characters that differentiate *C. lyrata* subsp. *lyrata* from *C. sorgerea* are very few, such as corolla length and the presence of a denser indumentum. Based on the morphological data the taxonomic rank of *C. sorgerea* is closely relatives *C. lyrata* subsp. *lyrata*. Seed-coat characteristics among this two species are similar (subtype-IIa, striate within) (Table 2, Figs. 11, 12-7, 8). Some taxa can not be separated by seed characteristics. Thus, further taxonomic investigation between the two species is needed. Seeds of *C. hagielia* and *C. lyrata* subsp. *lyrata* show superficial resemblance, especially in size, shape, colour but they can be distinguished by differences in striations within scabrate (*C. hagielia*) and within striate (*C. lyrata* subsp. *lyrata*). while Oganessian (1985) observed on the seed of *C. crispa* (only not endemic) in LM examination but not SEM. The result of the present study were in conformity with those of Oganessian (1985) who described the general characters of the seeds belonging to *C. crispa*. It is also morphologically and geographically isolated species within the section according to Flora of Turkey (Damboldt, 1978).

Seed morphology in *Campanula* sect. *Quinqueloculares* can be used as a taxonomic trait but should be combined with other traits for the diagnostic determination of species.

## References

- Barthlott, W. 1981. Epidermal and seed surface characters of plant: Systematic applicability and some evolutionary aspects. *Nord. J. Bot.*, 1: 345-355.
- Belyayev, A.A. 1984a. Seed anatomy in some representatives of the family *Campanulaceae*. *Bot. Zurn.*, 69(5): 585-594.
- Belyayev, A.A. 1984b. Surface Ultrastructure and some morphological characteristics of seeds representatives of the family *Campanulaceae*. *Bot. Zurn.*, 69(7): 890-898.
- Belyayev, A.A. 1985. The new data on the anatomical structure of the testa and ultrastructure of seed surface in the representatives of the genus *Pentaphragma* (*Campanulaceae*). *Bot. Zurn.*, 70(7): 955-957.
- Buss, C.C., T.G. Lammers and R.R. Wise. 2001. Seed-coat morphology and its systematic implications in cyanea and other genera of *Lobelioidea* (*Campanulaceae*). *Am. J. Bot.*, 88(7): 1301-1308.
- Carolin, R.D.1980. Pattern of seed surface of *Goodenia* and related genera. *Austral. J. Bot.*, 28:123-137.
- Cronquist, A. 1988. *The Evolution and classification of flowering plants*. The New York Bot Gard, New York.
- Damboldt, J. 1978. *Campanulaceae* In: *Flora of Turkey and the East Aegean Islands*. (Ed.): P.H. Davis. Edinburgh Univ Press, 6: 2-89, Edinburgh.

- Davis, P.H., R.R. Milli and T. Kit. 1988. *Flora of Turkey and the East Aegean Islands* (Suppl.1). Edinburgh Univ Press, vol. 10, Edinburgh.
- De-Yuan, H. and P. Kai-Yu. 1998. The restoration of the genus *Cyclocodon* (*Campanulaceae*) and its evidence from pollen and seed-coat. *Acta Phytotaxonomica Sinica*, 36(2): 267-278.
- Geslot, A. 1980. Le Tequment seminal de Quelques *Campanulacees*: Etude Au Microscope Electronique A Balayage. *Adansonia*, 2(19): 307-318.
- Güner, A., N. Özhatay, T. Ekim and K.H.C. Başer. 2000. *Flora of Turkey and the East Aegean Islands* (Suppl.2). Edinburgh Univ Press, vol. 11, Edinburgh.
- Heywood V.H. 1998. Flowering Plants of the World. *BT Batsford ltd. London*.
- Krocmal, A. and J. Huguely. 1971. Seed Descriptions of four common *Lobelias*. *Castenea*, 36: 257-259.
- Murata, J. 1992. Systematic implications of seed coat morphology in *Lobelia* (*Campanulaceae-Lobelioideae*). *Journal of the Faculty of Science, University of Tokyo (section 3)*, 15: 155-172.
- Murata, J. 1995. A revision of infrageneric classification of systematic *Lobelia* (*Campanulaceae-Lobelioideae*) with special reference to seed coat morphology. *Journal of the Faculty of Science, University of Tokyo (Section 3)*, 15: 349-371.
- Oganesian, M.E. 1985. Structural features of seeds In: The *Campanula* and *Symphyandra* (*Campanulaceae*). *Bot. Zurn.*, 70(7): 947-955.
- Shetler, S.G. and N.R. Morin. 1986. Seed morphology in North American *Campanulaceae*. *Ann. Missouri Bot. Gard.*, 73(4): 653-688.
- Shrestkha K.K and T.I. Kravtsova. 1992. Seed-coat anatomy and ultrasculpture in the genus *Cyananthus* (*Campanulaceae*) in relation to its systematics. *Bot. Zhurn.*, 77(6):18-29.
- Stearn, W.T. 1978. *Botanical Latin*. 2nd edition. Newton Abbot : David & Charles, 506-507.

(Received for publication 3 March 2009)