

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

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## Abstract

Morphological features of seeds of 9 species of *Campanula* L., section *Quinqueloculares* (Boiss.) Photos (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. sorgereia* 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 & Hugely (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 Lobelioïd 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. sorgerae* 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).

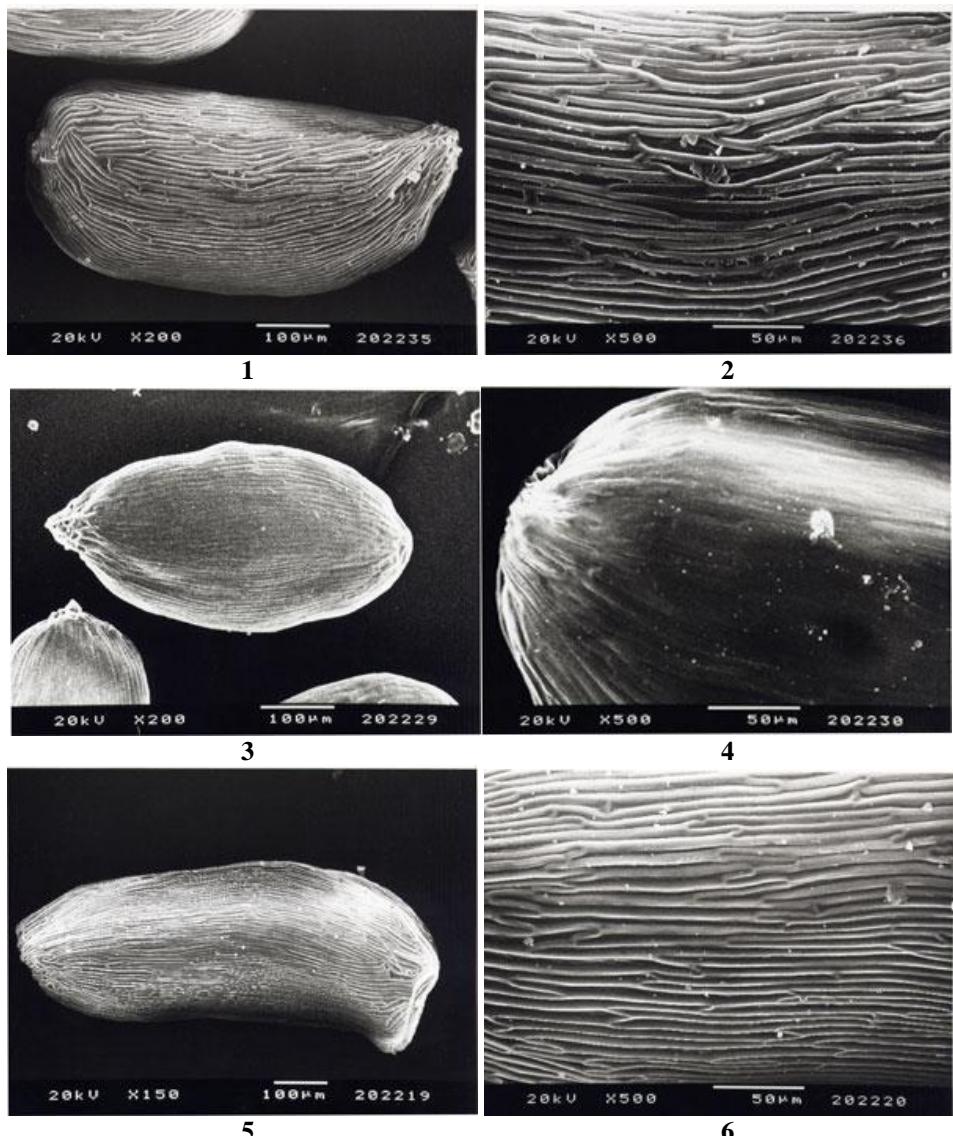
The morphology of seeds of sect. *Quinqueloculares* are not reported in Flora of Turkey (Damboldt, 1978). Seed characters, colour, size, shape are of limited taxonomic value according to our observations. However, the sculpturing of the seed surface patterns as seen by SEM shows a wide range of variation 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-striped 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. sorgerae*, *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.

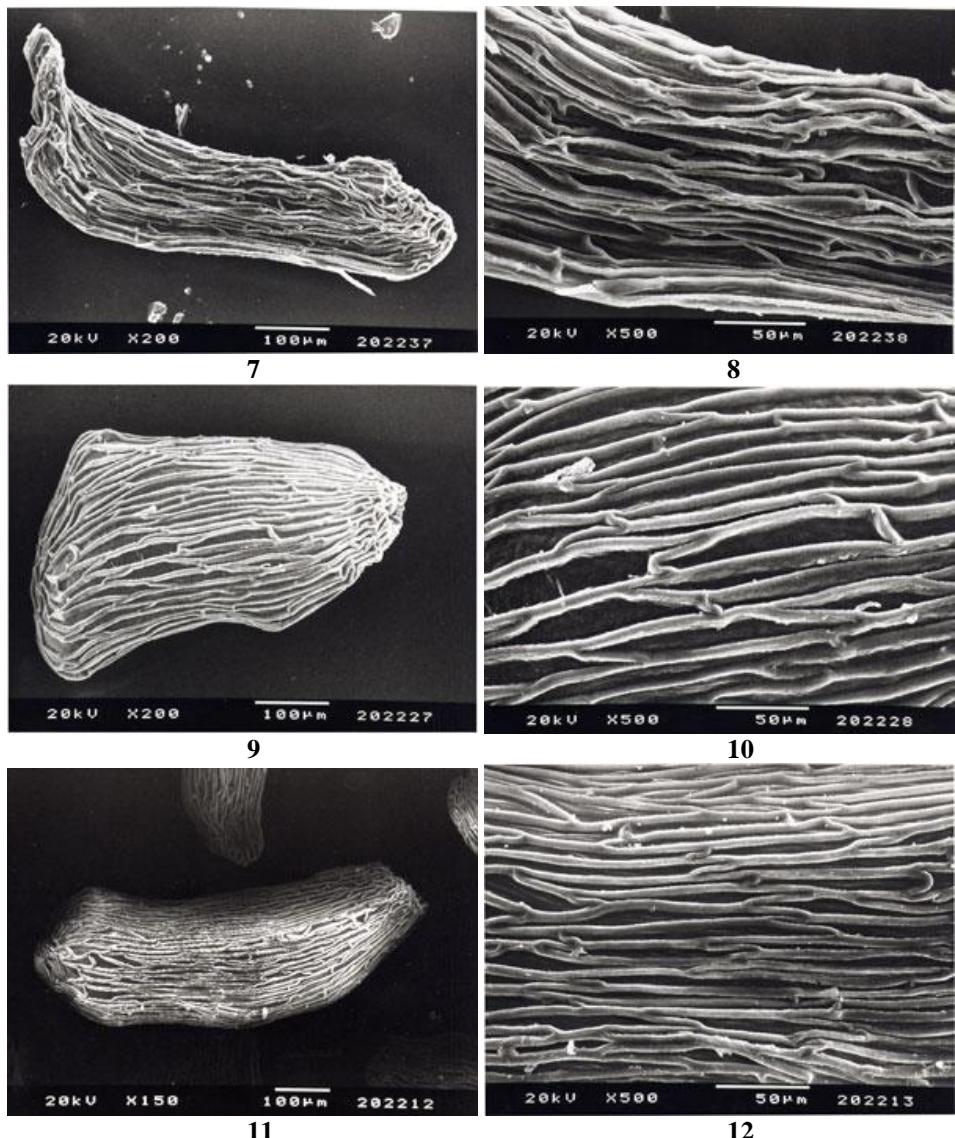




Figs. 1-6. Section *Quinqueloculares* seeds and their coat surfaces in SEM. Figs. 1,2 *C. crispa* Figs. 3,4. *C. tomentosa*. Figs. 5,6 *C. iconia*.

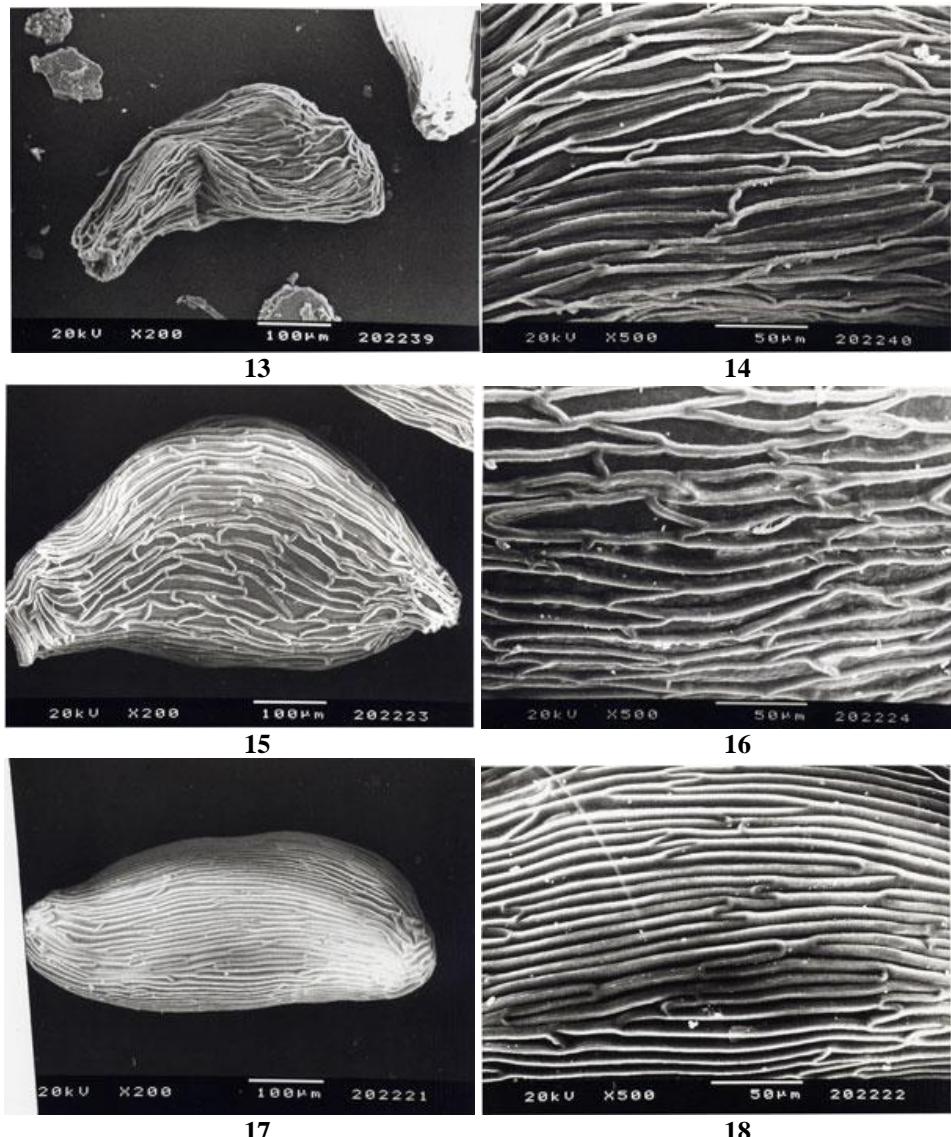
**Subtype-IIb:** The nearness of striations are very small in this subtype in comparasion to upper type. Taxa included this subtype of seeds are *C. davisii*, *C. crispa* and *C. iconia* (Figs. 17, 18 - 3, 4 -5, 6).

Barthlott (1981) stated that SEM of the seed-coat can be a good taxonomic and phylogenetic marker at the subgeneric to subfamilia 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 characters. Murata



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

(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



Figs. 13-18. Section *Quinquelocularis* 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-striped. 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. *Quinquelocularis* (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-striped 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. sorgereia* are very few, such as corolla length and the presence of a denser indumentum. Based on the morphological data the taxonomic rank of *C. sorgereia* 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 Oganesian (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 Oganesian (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.

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