



Notes on the taxonomical, morphological and mucilage features of *Capsella bursa-pastoris* Medik. and *Capsella rubella* Reuter taxa (Brassicaceae)

Capsella bursa-pastoris Medik. ve *Capsella rubella* Reuter taksonlarının (Brassicaceae) taksonomik, morfolojik ve musilaj özellikleri üzerine notlar

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Abstract

In this study, examinations on the taxonomical, morphological and mucilage characters of the *Capsella bursa-pastoris* and *Capsella rubella* taxa growing in Turkey were performed. The properties were acquired at the flowering and fruiting periods of inhabitants. The samplings were made of 13 locations. In morphological revisions, descriptions reported in Flora of Turkey of the studied taxa were reviewed in view of the comprehensive assessments over 200 samples. In addition, surfaces of the seeds were studied micromorphologically with scanning electron microscope. Also, seed mucilage structures were examined in detail. The mucilage in the studied taxa was in the pectin or cellulose structure. The columellae figures were prominent or flattened. Furthermore, soil adhesion capacities of the examined taxa varied between 248 mg and 344 mg. The occurrence of the mucilage in seeds may provide an important adaptive feature in dispersal and colonization of *Capsella* taxa.

Özet

Bu çalışmada, Türkiye'de yetişen *Capsella bursa-pastoris* ve *Capsella rubella* taksonlarının taksonomik, morfolojik ve müsilağ karakterleri üzerine incelemeler yapılmıştır. Özellikler bireylerin çiçekli ve meyveli dönemlerinde elde edilmiştir. Örneklemeler 13 lokasyonda yapılmıştır. Morfolojik incelemelerde, çalışılan taksonların Türkiye Florasında bildirilen deskripsiyonları, 200'den fazla örneğin kapsamlı değerlendirilmeleri ışığında yeniden gözden geçirilmiştir. Buna ilaveten, tohumların yüzeyleri taramalı elektron mikroskobu ile mikromorfolojik olarak incelenmiştir. Ayrıca, tohum müsilağ yapıları detaylı olarak incelenmiştir. Çalışılan taksonlardaki müsilağ, pektin veya selüloz yapısındaydı. Kolumella şekli belirgin veya düzleşmişti. Dahası, incelenen taksonların toprak yapıştırma kapasiteleri 248 mg ile 344 mg arasında değişmiştir. Tohumlardaki müsilağın oluşumu, *Capsella* taksonlarının dağılıma ve kolonizasyonunda önemli bir adaptif özelliği sağlayabilir.

INTRODUCTION

Brassicaceae (Cruciferae) family contains 365 genera and 3250 species in worldwide and include many important taxa in terms of economic (Tekin et al. 2013; Karaismailoğlu 2016). Turkey, where are in circa 61 genera, 653 species, 39 subspecies, 18 varieties, and 226 endemics, is very variety with regard to the presence of Brassicaceae (Al Shehbaz et al. 2007; Al-Shehbaz 2010; Mutlu and Karakus 2015; Karaismailoğlu 2018).

Capsella Medik. genus has been positioned in subordo Capsellinae in the subclassis Lepidieae by Hayek (1911), Janchen (1942) and Hedge (1976). The many taxonomic

applications on the *Capsella* has showed high polymorphism in morphological features, in particularly silicula and leaves (Hurka and Neuffer 1997). This situation has caused to disagreement in terms of phylogenetic relations, speciation approach, biogeographic origin of the genus.

Numerous works to clarify the evolutionary past and biology of *Capsella* genus have performed (Hurka and Neuffer 1997; Aksoy et al. 1998; Ceplitis et al. 2005; Slotte et al. 2006; Neuffer et al. 2014). Also, the biogeographic and phylogenetic outlines of the genus

have been disclosed by Tutin (1993) and Neuffer et al. (2014).

Capsella bursa-pastoris (L.) Medik. and *Capsella rubella* Reuter are 2 out of 4 taxa distributed in Turkey. In this study, taxonomical, morphological (macro and micro) and mucilage structures of these taxa in Turkey have been examined for the first time in detailed.

MATERIAL AND METHOD

The specimens taken from different phytogeographical areas in 2013-2017 and their locations were presented in Table 1 and Figure 1. They were recognized in accordance with the Flora of Turkey and deposited in Siirt University Flora and Fauna Center (SUFAF) or in the collection of M. C. Karaismailoğlu. Also, *Capsella* taxa in ISTF, ISTE, ISTO, KATO and KNYA herbaria in Turkey were examined.

Macromorphological examinations on vegetative and generative characters were performed with utilizing an Olympus ZS51 stereomicroscope and Kameram imaging software. In micromorphological examinations, seeds were arranged for JEOL Neoscope-5000 Scanning Electron Microscopy. Samples were fixed with silver

adhesive on stub, covered with gold, and analyzed (Karaismailoğlu 2015a and 2015b). The terminologies utilized are mainly that of Stearn (1985).

The changes on wetted seeds was detected, and assessments on the capacity to hydrate were made. The wetted tests with distilled water were made at room temperature for 12 minutes. Methylene blue and safranin stains were applied seeds to define the mucilage type (Kreitschitz and Vallès 2007; Inceer 2011). Pure sea sand was used for determining the soil adhesion capacity of the seeds of the examined taxa. Firstly, the 50 seeds were placed on the wetted sea sand in a petri dishes, mucilage shaped after 10 min at the interaction part between the seed and sand. Subsequently, the petri dishes with the seeds and sand were relocated to 50°C for 24 h. After, the seeds were sensibly detached from petri dishes and the weights (last weights) were recorded. The soil adhesion capacity of the seeds has planned by comparison of the initial and final weights of the seeds (Huang et al. 2000). Mucilage features were perceived with utilizing an Olympus CX21FS1 microscope and Kameram imaging software.

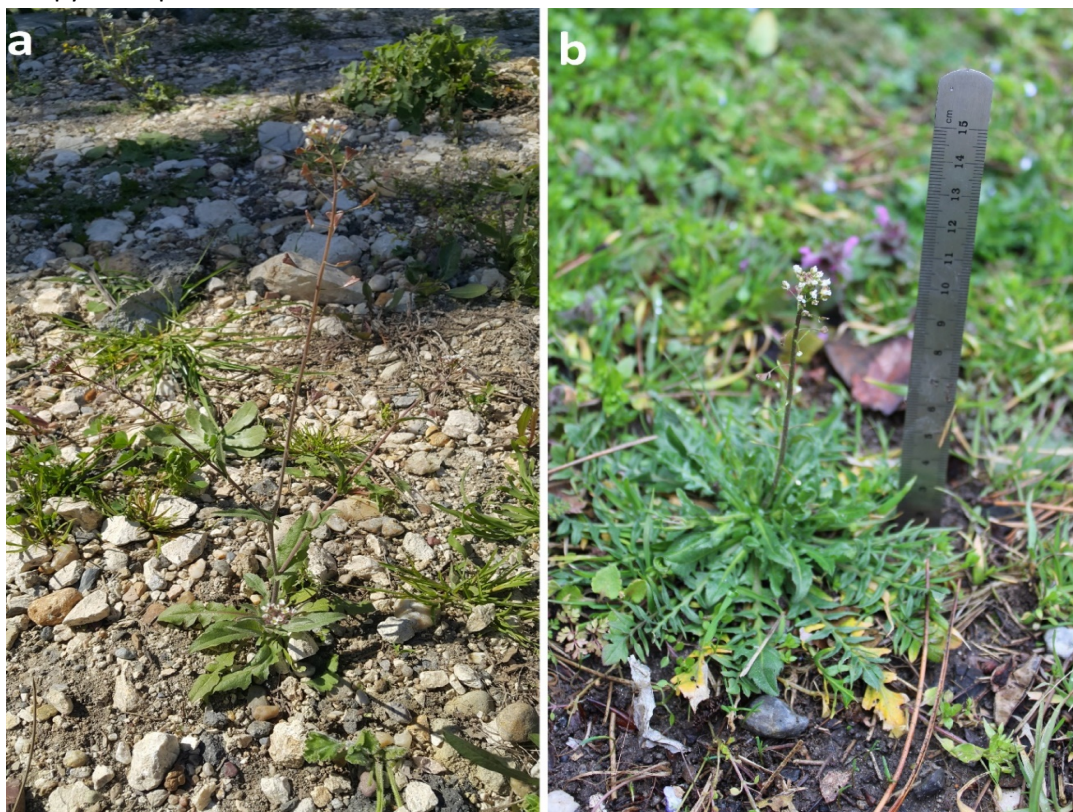


Figure 1. The population view of the studied taxa; a: *Capsella bursa-pastoris*, b: *Capsella rubella*

Table 1. The studied taxa and their locations

Taxa	Location	Voucher
<i>Capsella bursa-pastoris</i>	Gümüşhane, Kürtün, Karagöl, 1550 m, 13.07.2014	Karaismailoğlu 86
<i>Capsella bursa-pastoris</i>	Gümüşhane, Kürtün, roadsides 750 m, 13.07.2014	Karaismailoğlu 79b
<i>Capsella bursa-pastoris</i>	Antalya, Çiğdemler, Söğüt mountain, Çataltepe, 1750 m, 11.07.2016	Karaismailoğlu 323
<i>Capsella bursa-pastoris</i>	İstanbul, Büyükçekmece, Beykent, meadows, 80 m, 06.07.2016	Karaismailoğlu 307
<i>Capsella bursa-pastoris</i>	Hatay, Dört Yol, Çökek, plateau, inclined slopes, 1550 m, 19.03.2017	Karaismailoğlu 348
<i>Capsella bursa-pastoris</i>	İstanbul, Büyükçekmece, Beykent, roadsides, 120 m, 21.03.2017	Karaismailoğlu 349
<i>Capsella bursa-pastoris</i>	Artvin, Ardanuç, Peynirli village, inclined slopes, 1500 m, 29.04.2017	Karaismailoğlu 369
<i>Capsella bursa-pastoris</i>	Artvin, Koyuncular, roadsides, inclined slopes, 900 m, 22.05.2017	Karaismailoğlu 378
<i>Capsella bursa-pastoris</i>	Trabzon, Of, Saraçlı village, roadsides, stone areas, 98 m, 08.08.2013	Karaismailoğlu 18
<i>Capsella bursa-pastoris</i>	Adana, Saimbeyli, Obruk plateau, 1472 m, 18.04.2015	Karaismailoğlu 127b
<i>Capsella bursa-pastoris</i>	Osmaniye, Düziçi, Dumanlı mountain, 1185 m, 21.04.2016	Karaismailoğlu 227a
<i>Capsella rubella</i>	Kırklareli, Vize, Hacıçeşme, roadsides, meadows, 500 m, 21.03.2015	Karaismailoğlu 112
<i>Capsella rubella</i>	Trabzon, Çaykara, Uzungöl, Demirkapı village, 1100 m, 11.07.2014	Karaismailoğlu 69

RESULTS

Descriptions

Capsella bursa-pastoris (L.) Medik.

Annual or biannual, with slender tap root, herbs, simple or furcate hairs, 5-65 cm, glaucescent. Basal leaves rosette-forming, lyrate to pinnatifid, apex obtuse or acute, narrowed into a stalk, leaf margins dentate or entire, petioles between 2-5 cm, 1.5-7 cm (length) X 0.5-2.5 cm (width). Caulin leaves ovate, amplexicaul, with two obtuse or acute auricles, leaf margin entire or dentate, 2-5.5 cm X 0.4-1.5 cm, inflorescence raceme, elongating in fruit, racemes density, 20-90 fruits, raceme length 5-30 cm, sepals not saccate, ovate-oblong, apex obtuse or acute, broadly membranous-margined green, 1.2-2 mm X 0.7-1.2 mm, petals ovate or spatulate, apex rotund, 3-5 veins, with an indistinct claw and blade, 2-2.5 mm X 0.5-1.2 mm, anthers yellow, 0.2-0.5 mm, filament without appendages, narrow and linear, 1.5-2 mm, stigma capitate. Ovary elliptic, 1-1.2 mm X 0.8-1 mm, fruiting pedicels 4-14 mm, spreading-ascending. Fruit a strongly compressed silicle. Silicle obcordate-triangular, margins of fruit straight or slightly convex, wing absent, apex rotund or obtuse, 4-10 mm X 2.5-8 mm, apical sinus broad and shallow. Style not exceeding sinus or in same length. Septum 3-7 mm X 1-2 mm, seeds 7-15 in each loculus (Figure 2). Seeds ovate-

elliptic, brown, 0.9-1.1 mm X 0.4-0.6 mm, smooth, mucilaginous (Figure 2). Flowering and Fruiting times 1.-12.

Capsella rubella Reuter

Annual or biannual, with slender tap root, herbs, simple, furcate or stellate hairs, or glabrous, 10-32 cm, glaucescent. Basal leaves rosette-forming, lyrate to pinnatifid, apex obtuse, narrowed into a stalk, leaf margins dentate, petioles between 1-4 cm, 1.5-3 cm X 1-1.5 cm, cauline leaves lanceolate, amplexicaul, with two acute auricles, leaf margin entire, 1-2 cm X 0.5-1 cm, inflorescence raceme, elongating in fruit, raceme density, 14-70 fruits, raceme length 4-25 cm, sepals not saccate, ovate-oblong, apex obtuse or rotund, broadly membranous-margined red or brown, 1-1.2 mm X 0.8-1 mm, petals ovate or spatulate, apex rotund, 1-2 mm X 0.8-1 mm, anthers yellow, 0.15-0.25 mm, filaments narrow and linear, 1-1.5 mm, stigma capitate. Ovary obcordate-elliptic, 1-1.5 mm X 1-1.2 mm, fruiting pedicel 3-5 mm, spreading-ascending. Fruit a strongly compressed silicle. Silicle obcordate, margins of fruit concave, apex rotund, absent wing, 4-6 mm X 4-6 mm, apical sinus deeply. Style not exceeding sinus. Septum 3-5 mm X 1-2 mm, seeds 4-6 in each loculus (Figure 2). Seeds elliptic, light brown, 0.6-0.8 mm X 0.4-0.6 mm, smooth, mucilaginous (Figure 2). Flowering time 3.-10. Fruiting time 3.-11.

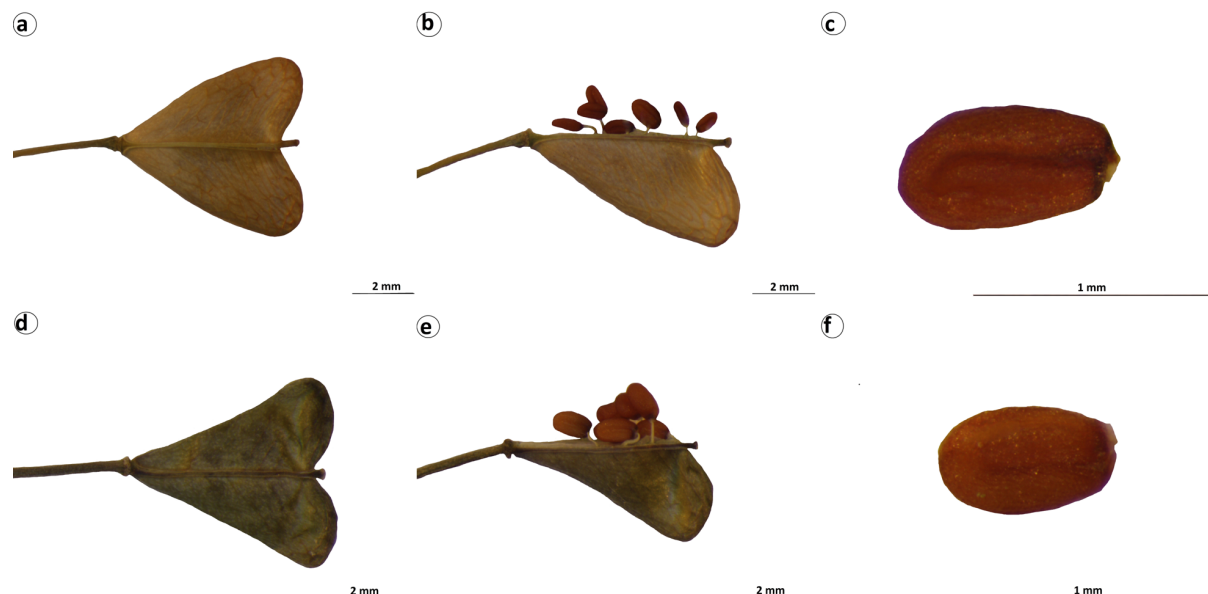


Figure 2. Fruit and seed of the studied taxa; *Capsella bursa-pastoris*: **a:** fruit, **b:** seed number in loculus, **c:** seed, *Capsella rubella* **d:** fruit, **e:** seed number in loculus, **f:** seed.

Micromorphological characters

Seed surface structures of the examined taxa were studied as micromorphologically, and diversity was noted in surface ornamentations and cell types, periclinal and anticlinal cell walls of the seeds. The seed surface ornamentations were defined as tuberculate-

reticulate in *C. bursa-pastoris* and reticulate in *C. rubella*. Also, cell shapes on the seed surfaces were recorded as alveolate or reticulate cells in *C. bursa-pastoris*, reticulate cells in *C. rubella*. Furthermore, anticlinal cell walls in studied taxa were raised, periclinal cell walls were convex or concave as well (Figure 3).

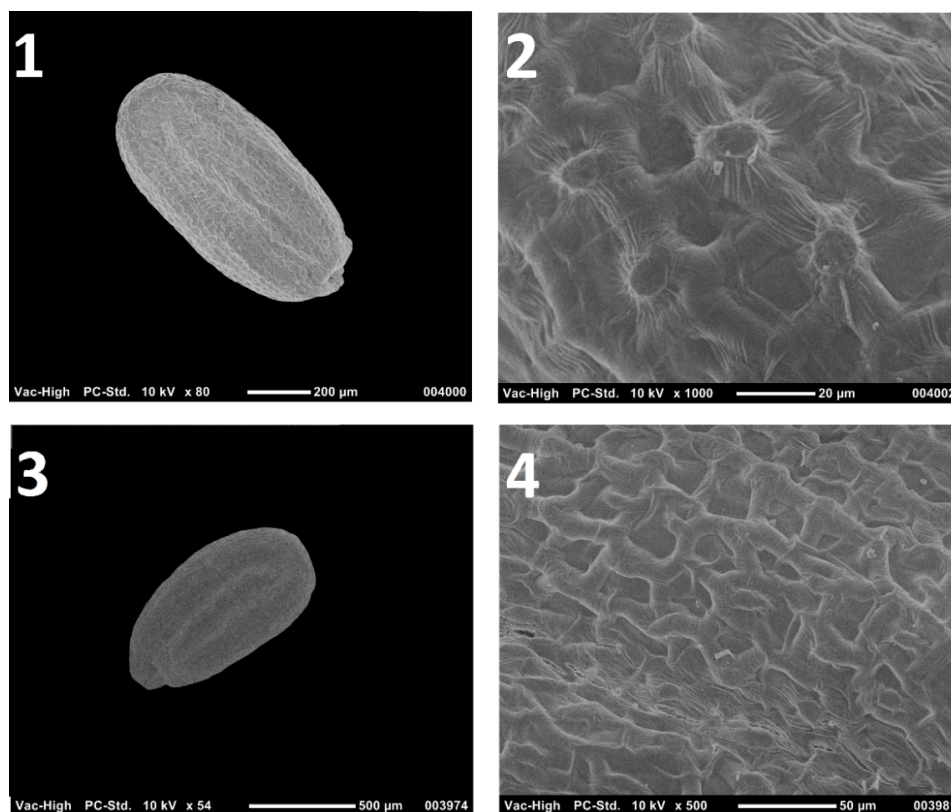


Figure 3. The micromorphological structures of seed of studied taxa: *Capsella bursa-pastoris*: **1-2**, *Capsella rubella*: **3-4**.

Mucilage features

The wetted seed examinations show that specific cells on surface of seed make mucilage. The mucilage in seeds is in cellulosic structure display a heterogenous form. The seeds dyed with safranin and methylene blue show that *Capsella* mucilage is shaped from pectin matrix and cellulosic frame (Figure 4). Safranin and Methylene blue dyeing displayed a characteristic structure. Methylene

blue enclosed with a violet or violet-blue sheath around seeds, as orange staining of mucilage was found with dyeing safranin (Figure 4).

The quantity of shaped mucilage has displayed differences in the examined *Capsella* taxa. It is 199 mg in *Capsella bursa-pastoris*, while it is 157 mg in *Capsella rubella*. Differences in mucilage creation may arise from the habitat features of the examined taxa.

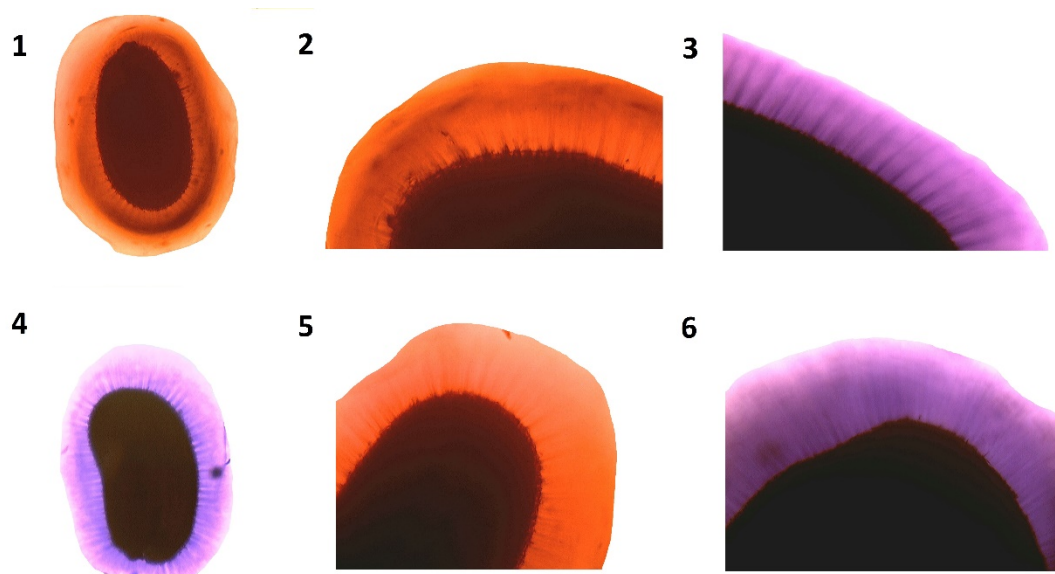


Figure 4. The mucilage structure of the studied taxa: *Capsella bursa-pastoris*: 1-3, *Capsella rubella*: 4-6 (1,2 and 5 dyed with safranin, 3, 4 and 6 dyed with methionine blue).

DISCUSSION

Capsella is taxonomically a distinctive genus, and frequent field trips are needed to define the status of taxa within genus. *Capsella bursa-pastoris* is a widespread weed, it is very variable in all characters and morphologically related to other taxa in the genus. In this study, morphological features of taxon have reorganized by reviewing many characteristics with numerous plants from the populations presented in Table 1, associated with characters in Flora of Turkey (Davis 1965). Description of taxon has updated with some changes, which are related to plant length, hair structure, features of basal and cauline leaves, inflorescence, sepal, and petal characters, and fruit and seed features (Table 2).

The description of *C. rubella* had performed with very narrow-scope in Flora of Turkey (Davis 1965). In this study, the detailed description of taxon has given for the first time for flora of Turkey. At the same time, *C. rubella* is morphologically very similar to *C. bursa-pastoris*, it is separated from *C. bursa-pastoris* with its pink or red buds, smaller petals, and concave margins of the fruits (Hedge 1965). This study has presented new characters to separation between the two taxa, which are plant length, hair type, petal and sepal characters, ovary figures, fruit and seed characters (Table 2). Furthermore, this taxon has been expressed in Flora of Turkey along the Mediterranean region in Turkey (Hedge 1965), however, it has been collected from the north-east of Turkey for the first time with this study.

Table 2. New or updated characters for the examined taxa and their comparison with the descriptions in the Turkey and European Flora

Characters	<i>Capsella bursa-pastoris</i> (L.) Medik.	<i>Capsella rubella</i> Reuter
Plant length	5-65 cm (*= 4-50 cm, **= -)	10-32 cm (*= -, **= -)
Hair	simple or furcate (*= -, **= -)	simple, furcate or stellate hairs (*= -, **= -)
Basal leaves	apex obtuse or acute, leaf margins dentate or entire, petioles between 2-5 cm, 1.5-7 cm (length) X 0.5-2.5 cm (width) (*= -, **= -)	apex obtuse, leaf margins dentate, petioles between 1-4 cm, sizes 1.5-3 cm X 1-1.5 cm (*= -, **= -)
Caulin leaves	Caulin leaves ovate, amplexicaul, with two obtuse or acute auricles, leaf margin entire or dentate, 2-5.5 cm X 0.4-1.5 cm (*=Caulin leaves amplexicaul, with two acute auricles, **= -)	Caulin leaves lanceolate, amplexicaul, with two acute auricles, leaf margin entire, 1-2 cm X 0.5-1 cm (*= -, **= -)
Inflorescence	raceme, elongating in fruit, racemes density, 20-90 fruits, raceme length 5-30 cm (*= -, **= -)	Inflorescence raceme, elongating in fruit, raceme density, 14-70 fruits, raceme length 4-25 cm (*= -, **= -)
Sepals	not saccate, ovate-oblong, apex obtuse or acute, broadly membranous-margined green, 1.2-2 mm X 0.7-1.2 mm (*= - **=Sepals green)	Sepals not saccate, ovate-oblong, apex obtuse or rotund, broadly membranous-margined red or brown, 1-1.2 mm X 0.8-1 mm (*= -, **=Sepals usually reddish at least at the apex)
Petals	ovate or spatulate, apex rotund, 3-5 veins (*= -, **= -)	Petals ovate or spatulate, apex rotund, 1-2 mm X 0.8-1 mm
Anther and Filament	Anters yellow, 0.2-0.5 mm. Filament without appendages, narrow and linear, 1.5-2 mm (*= -, **= -)	Anters yellow, 0.15-0.25 mm. Filaments narrow and linear, 1-1.5 mm (*= -, **=petals 1.5-2 mm)
Stigma and Ovary	Stigma capitate. Ovary ellipticate, 1-1.2 mm X 0.8-1 mm (*= -, **= -)	Stigma capitate. Ovary obcordate-ellipticate, 1-1.5 mm X 1-1.2 mm (*= -, **= -)
Fruits	Fruiting pedicels 4-14 mm. Fruit a strongly compressed silicula. Silicula obcordate-triangular, margins of fruit straight or slightly convex, wing absent, apex rotund or obtuse, 4-10 mm X 2.5-8 mm. Apical sinus broad and shallow. Style not exceeding sinus or in same length. Septum 3-7 mm X 1-2 mm (*=Fruiting pedicels 5-12 mm, spreading-ascending. Silicula (3-)7-9 X 2.5-6 mm, septum 5-7 X 1-1.5 mm, wings absent, **=Silicula 4-10 X 4-9 mm, lateral margins usually straight or convex)	Fruiting pedicel 3-5 mm, spreading-ascending. Fruit a strongly compressed silicula. Silicula obcordate, margins of fruit concave, apex rotund, absent wing, 4-6 mm X 4-6 mm. Apical sinus deeply. Style not exceeding sinus. Septum 3-5 mm X 1-2 mm (*=concave margins of the fruit, **= Silicula c. 6 X 6 mm, usually fairly deeply emarginate at the apex)
Seeds	Seeds 7-15 in each loculus. Seeds ovate-ellipticate, brown, 0.9-1.1 mm X 0.4-0.6 mm, smooth, mucilaginous (*=Seeds many, up to 30, usually mucilaginous, **= -)	Seeds 4-6 in each loculus. Seeds ellipticate, light brown, 0.6-0.8 mm X 0.4-0.6 mm, smooth, mucilaginous (*= -, **= -)

*= the descriptions in Flora of Turkey (Hedge 1965)

**=the descriptions in The Flora European (Chater 1963)

Micromorphological characters may provide taxonomically helpful data (Heywood 1971; Karaismailoğlu 2015a and 2015b). Seed surface properties like ornamentation, anticlinal and periclinal cell wall structures, and epidermal cell figures, have provided useful characteristics in separation of taxa in many genera in Brassicaceae family (Murley 1951; Vaughan and Whitehouse 1971; Barthlott 1984; Karaismailoğlu 2016). The surface ornamentation in examined taxa is reticulate-tuberculate or reticulate type in this study (Figure 3). In addition, reticulate type is often seemed in various genera such as *Erysimum* L., *Alyssum* L. and *Camelina* Crantz within Brassicaceae (Murley 1951; Zeng et al. 2004; Moazzeni et al. 2007; Karaismailoğlu 2016).

This study is the first on the mucilage form of the genus *Capsella*. The wetted seed examines display that examined taxa are of the mucilage cells on surface of the seeds, which are in cellulosic form, and show a mixed structure. The *Capsella* seeds dyed with safranin and methylene blue have pectin matrix and cellulosic edge (Figure 4). The cellulosic mucilage is an example of colloidal dispersion cellulose and characteristically originate from pectins (Kreitschitz et al. 2009; Karaismailoğlu 2017).

Mucilage amount among the examined *Capsella* taxa is higher in *C. bursa-pastoris* scattering in mostly thirsty and rocky areas than *C. rubella*. The changes in mucilage amount can base on habitat structures of the observed taxa. This condition has been stated within Brassicaceae with a previous study (Karaismailoğlu 2017). Seeds are

linked to soil surface because of the mucilage sheet (Gutterman and Shem-tov 1997), and accordingly develop as colonized. Similar condition has been stated in *Matricaria chamomilla* (Inceer 2011), in some *Aubrieta* species (Karaismailoğlu 2017) and in some *Alyssum* species (Karaismailoğlu 2018).

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