

## Pollen and Achene Morphology of Some *Centaurea* L. Taxa (Asteraceae), Turkey

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### A B S T R A C T

*Centaurea* is one of the largest genus of the family Asteraceae. Turkey is one of the distribution areas of this genus. This genus represented with 194 taxa in Turkey, which 105 of them are endemics. In this study, pollen morphology and achene micro and macro morphology of 5 taxa belonging to *Centaurea* (*C. iberica*, *C. virgata*, *C. cheirolopha*, *C. urvelli* subsp. *urvelli*, *C. solstitialis* subsp. *solstitialis*) were investigated. The aim of the study was to determine taxonomic value of pollen and achene micro features.

Pollen grains of *Centaurea* taxa observed as isopolar, with tricolporate aperture and subprolate and prolate-spheroidal pollen shape. Polar axis ranges between 30.4-49.9 µm while equatorial axis between 25.7-41 µm.

The achene shape was observed as ovoid and oblong in studied taxa. SEM showed that the achene surface had a striate sculpture and was depressed on both lateral surfaces, without rare hairs.

The micro characters contain polar axis, equatorial axis, pollen shape, pollen surface ornamentation, intine and exine thickness, achene length, Pappus length, achene surface ornamentation was determined as important features for systematics of taxa.

Keywords: *Centaurea*, Pollen, Achene, Light microscopy (LM), Scanning Electron Microscopy (SEM)

### Introduction

*Centaurea* L. is one of the most richest genera of the family Asteraceae. In flora of Turkey, it is third largest genus after *Astragalus* and *Verbascum* in terms of number of species. Turkey is one of the distribution centres of the genus *Centaurea*; 105 out of 194 species are endemic to Turkey [1, 2, 3].

The members of the genus are annual, biennial, or perennial plants and they are rarely evergreen large shrubs. Leaves are alternate. Leaf shapes vary from pinnatifid to pinnatipartite and sometimes they are decurrent at base. Occasionally rosette laves are present at base of the stem. The involucral bracts are multi-seriate and imbricate. Each of them has membranous or

skinny appendage which are usually hard spiny or bristly at apex. The flowers are pink, blackish-purple, blue, yellow, or whitish [4, 5].

Palynological, karyological and molecular studies are very important unravelling the taxonomic status of the genus *Centaurea*. As a result of the studies performed in recent years, some taxa of the genus *Centaurea* were transferred to other genera such as *Psephellus* Cass., *Cyanus* Mill. and *Rhaponticoides* Vaill. [6, 7, 8].

Çeter et al. (2013) examined pollen morphologies of 4 taxa belonging to the genus *Matricaria* and 28 taxa belonging to the genus *Tripleurosperum* of the family

Asteraceae using Light microscope (LM) and Scanning Electron Microscope (SEM). Pollen of taxa described as isopolar, radially symmetric with tricolporate apertures. Pollen shape observed as suboblate and oblate-spheroidal. Pollen surface ornamentation determined as echinate and ornamentation of inter-spinal area as reticulate-perforate [9].

Özbek et al. (2016) studied pollen morphologies of 22 taxa belonging to the genus *Cota* using LM and SEM. Pollen grains of *Cota* determined as radially symmetrical and isopolar. Their shape is oblate-spheroidal and aperture type are trizonocolporate. The outline is elliptic in equatorial view and triangular in polar view. Exine sculpturing is echinate. Inter-spinal region exhibits perforate and microreticulate-perforate ornamentations. [10].

Kaya (1985) examined pollen structures of two endemic species of the genus *Centaurea*, *C. derderiifolia* and *C. saligna*, using light microscopy [11]. Atar (2006) examined pollen of *Centaurea kileae* and *C. cuneifolia* using LM and SEM [12]. Pinar (2007) examined pollen of taxa belonging to 5 sub-species of *Centaurea cariensis* (*Centaurea cariensis* Boiss. subsp. *cariensis*, *Centaurea cariensis* Boiss. subsp. *longipapposa* Wagenitz, *Centaurea cariensis* Boiss. subsp. *maculiceps* (O. Schwarz) Wagenitz, *Centaurea cariensis* Boiss. subsp. *microlepis* (Boiss.) Wagenitz, *Centaurea cariensis* Boiss. subsp. *niveotomentosa* (Hub.-Mor.) Wagenitz) using LM. In general, author determined pollen of these taxa as isopolar, radially symmetric and tricolporate. Ornamentation determined as echinate or echinate-perforate [13].

Kargün (2011) investigated pollen (LM) and general morphologies of 29 taxa of the genera *Centaurea*, *Psephellus*, and *Cyanus*, which include the taxa that we studied except for *Centaurea cheirolopha* [14]. Shabestari, Attar, Riahi, and Sheidai (2013) examined pollen morphologies of 19 taxa of some *Centaurea* species using SEM and LM [15].

İnceer et al. (2012) examined anatomical and morphological character of fruit structures (Achene) of 12 endemic species belonging to the genus *Tripleurospermum* (Asteraceae). They observed that presence of corona and slime cell, achene colour and length, testa thickness, endosperm thickness, width of adaxial rib, thickness of lateral rib and achene surface ornamentation are important characters for taxonomy of taxa [16].

Tarikahya Hacıoğlu et al. (2012) examined Achene morphologies of 5 species belonging to the *Carthamus* using SEM and stereomicroscopy. Results of study indicate that achenes broadly obpyramidal, oblique, 4 angled, light brown to brown, upper part darker. Pappus, straw coloured to brown, inner pappus shorter than outer. Palea was observed as scabrous and hilum as obpyramidal or oval. Ornamentation of achene surface was observed as striate or irregularly striate. [17]

Bona (2015) examined achene morphologies of 23 species, including *C. cheirolopha* and *C. virgata* which are examined in our study as well, belonging to the taxa *Centaurea*, *Cyanus*, *Psephellus*, and *Rhaponticoides* [18]. Bona (2014) also studied *Centaurea iberica*, which is examined in this study as well, and 6 other taxa. Results determine the achene of taxa as greenish-brown when young, later black, generally with pappus except to *C.*

*sivassica*. Achene surface pattern is smoot, glebulate-ruminate and rugose. [19].

Celik et al. (2005) examined the pollen and Achene morphology of *Centaurea consanguinea*. Pollen of taxa determined as isopolar, radially symmetric and tricolporate. Surface ornamentation of pollen was observed as echinate-perforate. [20].

## Materials and Methods

The plant samples were collected from Adana province between 2005-2008 (Table 1). The pollen samples to be examined under light microscope were prepared according to the Wodehouse (1935) method [21]. The pollen slides were examined and photographed using a LEICA DM3000 light microscope. The measurements were performed based on the photographs using the AlaMet S. 0.06 software. The achene samples were examined using a Leica S8APO stereomicroscope. The pollen and achene samples were placed on a double-

In this study, pollen and achene micro- and macro-morphologies of 5 *Centaurea* taxa (*C. iberica*, *C. virgata*, *C. cheirolopha*, *C. urvillei* subsp. *urvillei*, *C. solstitialis* subsp. *solstitialis*) investigated to determine the contributions of micro-morphological characters to the systematic discrimination of taxa.

sided band attached to aluminium stubs and coated with gold for the SEM study. The stubs were examined in detail and photographed using a FEI Quanta FEG250 electron microscope. 10 samples were used for each of the polar and equatorial axis length, colpus and pore length and width, exine and intine thickness, pollen ornamentation, polar and equatorial view. The achene length and width, pappus length, achene and pappus structure were examined in detail on the achene samples.

**Table 1.** List of investigated taxa and locations.

Collector code	Taxa	Location
B.B. 4625	<i>C. iberica</i> Trev. ex Sprengel	B6 Adana: Saimbeyli,
B.B. 2105	<i>C. virgata</i> Lam.	B6 Adana: Tufanbeyli
B.B. 3939	<i>C. cheirolopha</i> (Fenzl) Wagenitz	B6 Adana: Tufanbeyli
B.B. 3022	<i>C. urvillei</i> DC. subsp. <i>urvillei</i>	B6 Adana: Tufanbeyli
B.B. 4234	<i>C. solstitialis</i> L. subsp. <i>solstitialis</i>	B6 Adana: Tufanbeyli

## Results

The data obtained from detailed examination of pollen and achene of 5 taxa belonging to the genus *Centaurea* using light and electron microscopy can be seen

in Table 2 and Table 3. The pollen and achene photographs of the species are given in Figure 1-5.

The pollen studies showed that the pollen of the taxa were isopolar and radially symmetrical and the aperture structure was tricolporate. The surface examination of the pollen showed microechinate ornamentation for *C. iberica*, microechinate-perforate ornamentation for *C. virgata*, *C. cheirolopha*, and *C. solstitialis* subsp. *solsititialis* and scabrate, microechinate-perforate ornamentation for *C. urvillei* subsp. *urvillei*. Dense perforation was detected at the bottom of spinules of *C. cheirolopha* pollen. The perforation was less and spinules were quite dense in *C. solstitialis* subsp. *solsititialis*. Spinules were more sparser and smaller in *C. urvillei* subsp. *urvillei* and *C. virgata* compared to others. The polar view was semitriangular for *C. iberica*, *C. cheirolopha*, *C. virgata*, and *C. urvillei*

subsp. *urvillei* and trilobate for *C. solstitialis*. The pollen shape was subprolate for *C. iberica*, *C. urvillei* subsp. *urvillei* and *C. solstitialis* subsp. *solsititialis* and prolate-spheroidal for *C. virgata* and *C. cheirolopha*. The *C. urvillei* subsp. *urvillei* had the largest pollen size, while *C. solstitialis* subsp. *solsititialis* had the smallest pollen size according to the measurements. Under light microscope, the equatorial axis measurements of the pollen varied between 25.7-41 µm, the polar axis measurements varied between 35.4-53 µm, the colpus length varied between 21.6-29.4 µm, the colpus width varied between 8.8-3.7 µm, the pore length varied between 10.4-7.3 µm, and the pore width varied between 12.3-8.6 µm.

**Table 2.** Measurement of pollen features of *Centaurea* taxa.

Taxa	Polar axis (P) (µm)			Ekvatorial axis (E) (µm)			P/E	Pollen shape	Ekzine(µm)		Colpus (µm)				Aperture Type	Ornamentation
	min	max	mean	min	max	mean			Elkzine	Intine	Clt	Clg	Plt	Plg		
<i>Centaurea iberica</i>	30.7	39.7	34.8	26	35	30	1.2	Subprolate	2	0.4	28.9	5.9	10.4	12.3	Tricolporate	Microechinate
<i>C. urvillei</i> subsp. <i>urvillei</i>	43.9	53	49.9	36.8	48.1	41	1.2	Subprolate	2.9	0.4	21.6	8.8	9.3	8.5	Tricolporate	Scabrate, Microechinate-perfolate
<i>C. virgata</i>	28.6	33.4	30.4	26.1	30.8	28	1.1	Prolate spheroidal	2.4	0.3	27.2	7.9	8.5	9.8	Tricolporate	Microechinate-perfolate
<i>C. cheirolopha</i>	28.1	37.2	33.9	24.1	35	31	1.1	Prolate spheroidal	2.3	0.4	29.4	6.7	9.4	9.4	Tricolporate	Microechinate-perfolate
<i>C. solstitialis</i> subsp. <i>solsititialis</i>	26.6	35.4	31.8	22.1	28.3	25.7	1.2	Subprolate	2.2	0.3	26	3.7	7.3	8.6	Tricolporate	Microechinate-perfolate

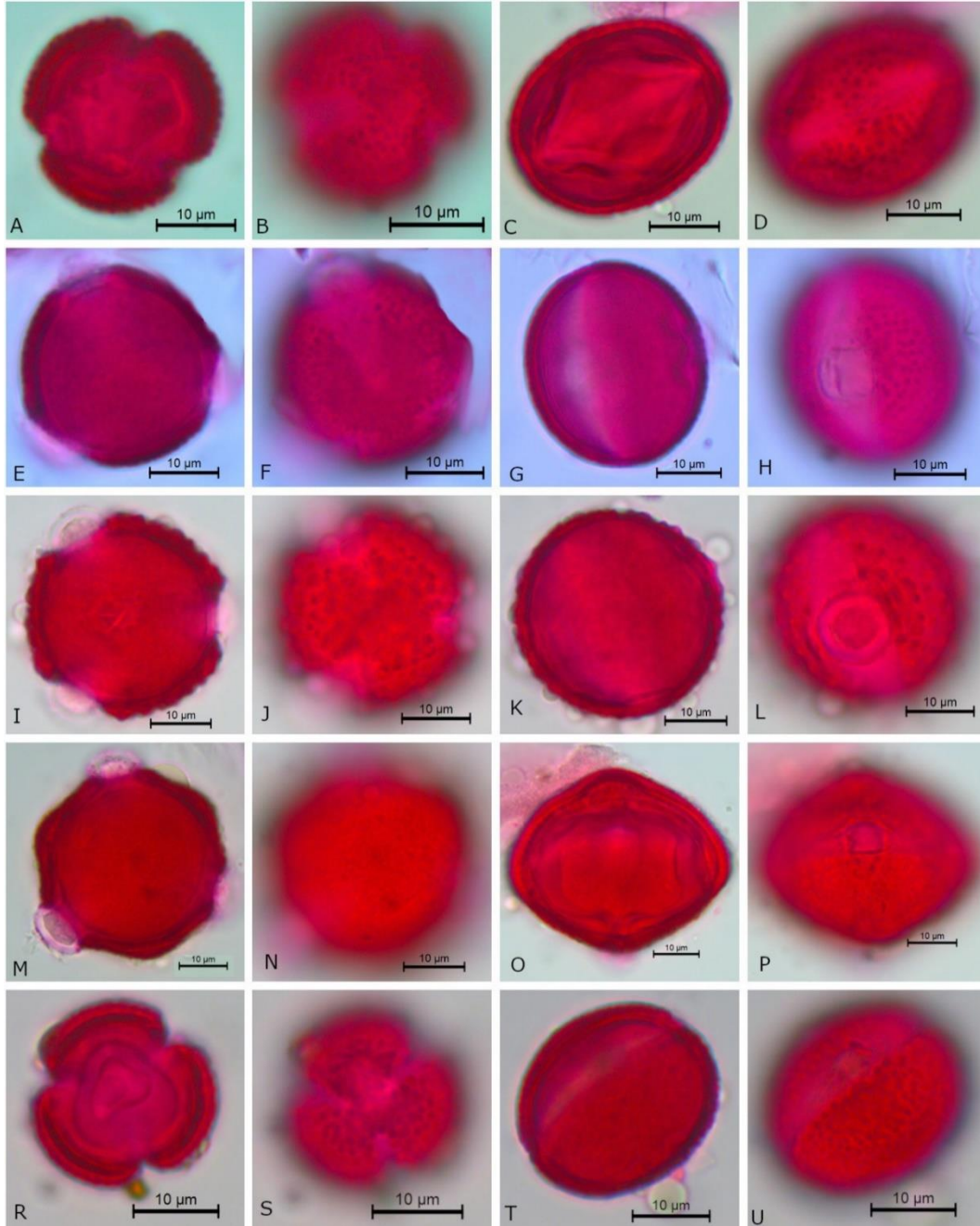
The achene of the taxa had pappus and the pappus on the inner rings were longer compared to the pappus on the outer rings. The achene surface showed striate ornamentation in *C. urvillei* subsp. *urvillei* and *C. virgata*, psilate-striate ornamentation in *C. cheirolopha* and psilate ornamentation in *C. solstitialis* subsp. *solsititialis*. The pappus were oblate on both sides and a striate ornamentation was detected on the pappus in *C. urvelli* subsp.

*urvelli*. 3 rows of serrate echinules were observed on the pappus of *C. solstitialis* subsp. *solsititialis*, while these echinules were as two rows located on the sides of the pappus in other taxa.

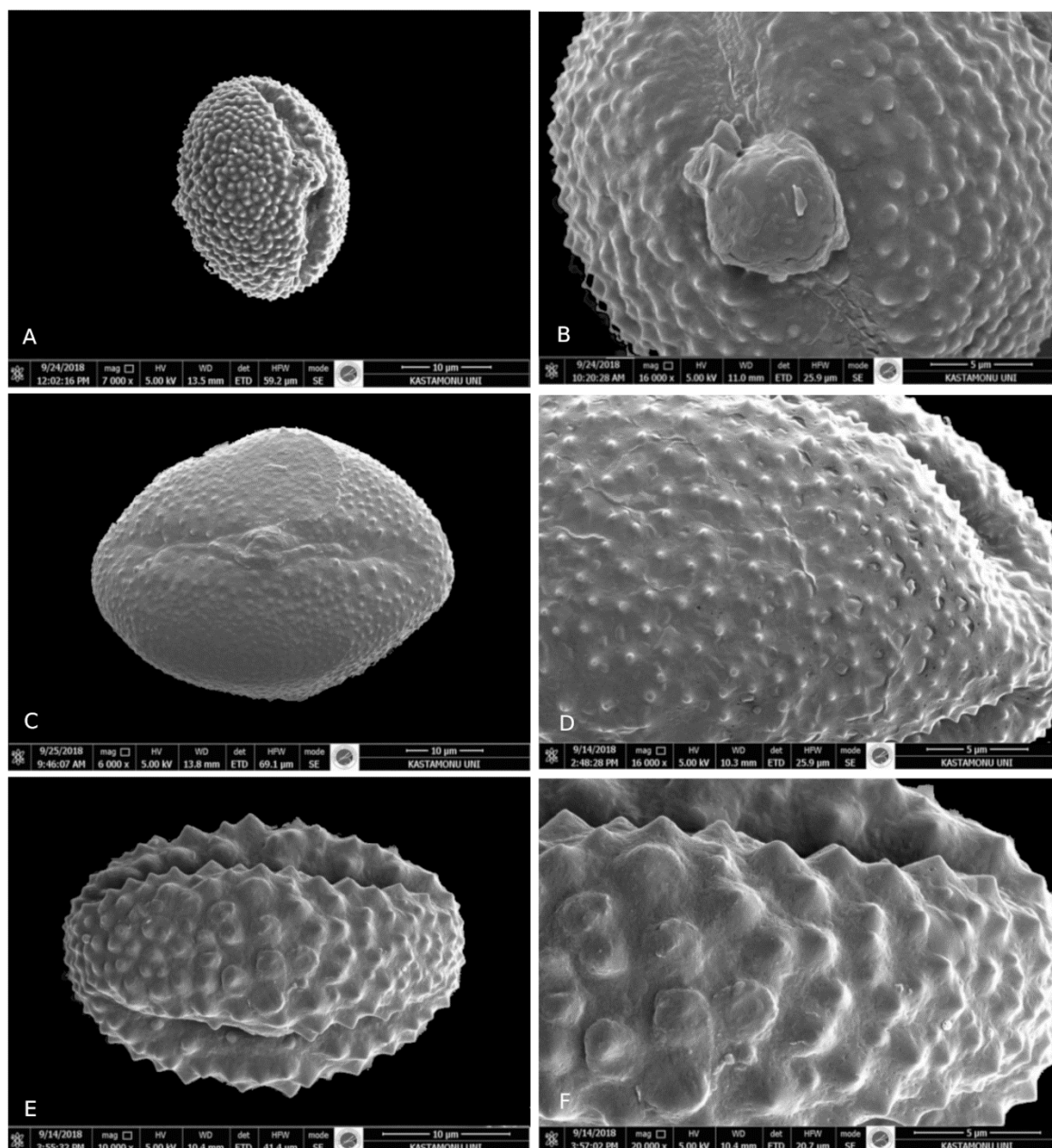
Sparse trichomes were observed on the achene of *C. iberica*, *C. virgata*, and *C. urvillei* subsp. *urvillei*, while the trichomes were denser in *C. cheirolopha*. There were no trichomes on the achene surface in *C.*

*solstitialis* subsp. *solstitialis*. *C. urvillei* subsp. *urvillei* had the longest achene (5.5 mm) among the taxa examined in this study, while *C. solstitialis* subsp. *solstitialis* had the shortest achene 2.3 mm.

The hilum aperture varied from 0.8 mm to 0.5 mm and was located laterally close to the base.



**Figure 1.** Light microscope (LM) microphotographs of *Centaurea* taxa. A-D: *C. iberica* (A: polar optic section, B: ornamentation in polar view, C: equatorial optic section, D: ornamentation and aperture in equatorial view). E-H: *C. virgata*. I-L: *C. cheirolopha*. M-P: *C. urvillei* subsp. *urvillei*. R-U: *C. solstitialis* subsp. *solstitialis*



**Figure 2.** Scanning electron microscope (SEM) microphotographs of *Centaurea* taxa. A-B: *C. iberica*. C-D: *C. virgata*. E-F: *C. cheirolapha*

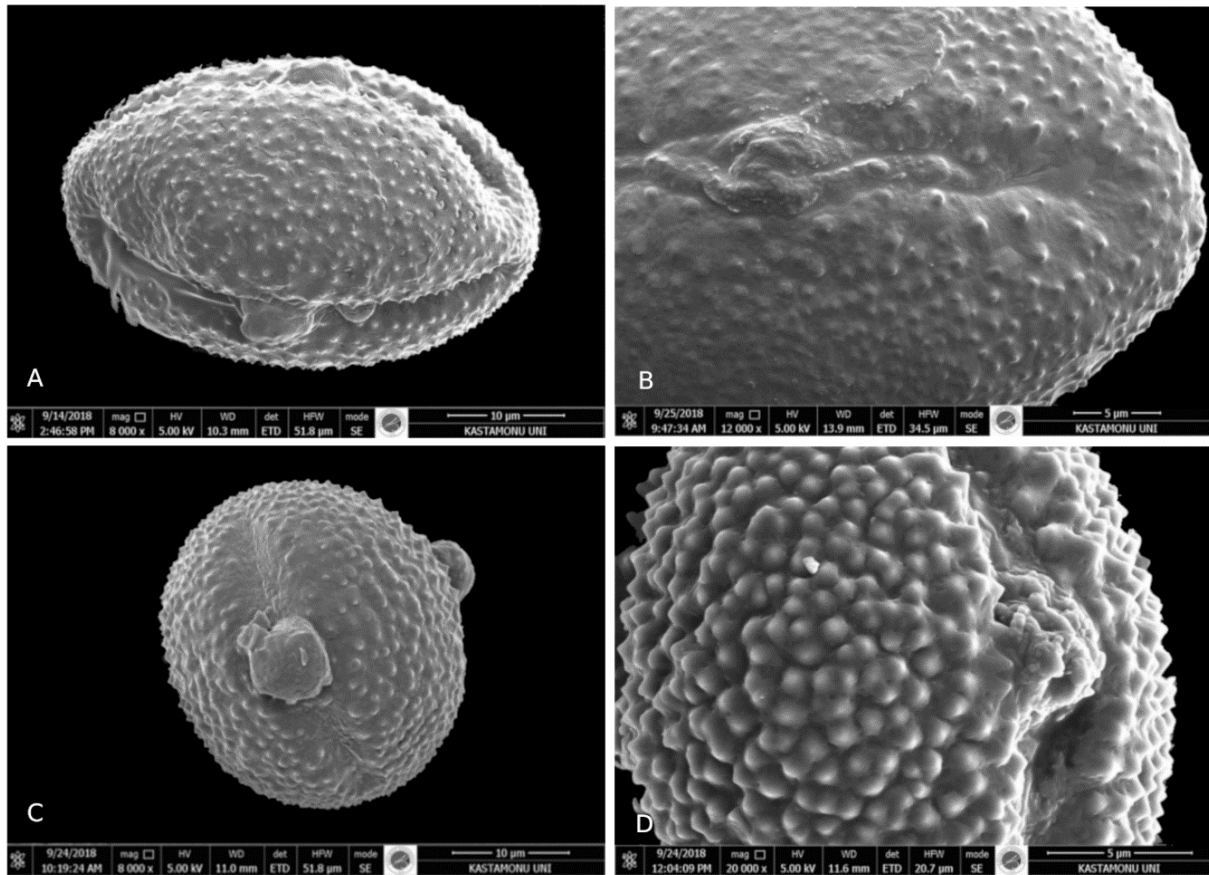
## Discussion

In agreement to the measurement results of our study, Kargün (2011) found a polar axis length of  $34.11 \pm 1.46 \mu\text{m}$  and an equatorial axis length of  $31.38 \pm 2.28 \mu\text{m}$  for *C. iberica* pollen. The polar axis length was measured as  $58.69 \pm 3.97 \mu\text{m}$  and the equatorial axis length was measured as  $52.02 \pm 3.15 \mu\text{m}$  for *C. urvillei* subsp.

*urvillei* pollen, while the pollen were smaller and the P/E ratio was higher in our study. For *C. virgata* group A pollen, Kargün (2011) found an equatorial axis length of  $26.66 \pm 2.69 \mu\text{m}$  and a polar axis length of  $27.95 \pm 2.21$  and the P/E value was given as 1.83. The polar axis length was measured as  $34.03 \pm 2.45 \mu\text{m}$  and the

equatorial axis length was measured as  $31.50 \pm 1.46 \mu\text{m}$  for *C. solstitialis* subsp *solstitialis*. The P/E ratio was found to be

higher in our study. Kargün (2011) did not perform a SEM study on the pollen [14].



**Figure 3.** Scanning electron microscope microphotographs of *Centaurea* taxa. A-B: *C. urvillei* subsp. *urvillei*. C-D: *C. solstitialis* subsp. *solstitialis*

Bona (2015) found the achene length to be 3-4 mm, the achene width to be 1-2 mm, and the pappus length to be 2 mm for *C. virgata*. While these measurement results are consistent with our study, Bona (2015) did not find a difference between inner and outer pappus length. The author also examined *C. cheirolopha* achene and found results similar to those of our study [18]. Bona (2014) examined *C. iberica* achene in another study and measured the pappus length to be 0.5-1 mm. In our study, on the other hand, the pappus length was much higher, while other achene measurements were similar with those of the author [19].

Taşar et al. (2014) examined *C. virgata* achene similar to our study and obtained results similar to ours (Figure 4).

In the previous researches on achene structures, pappus structures have not been studied in detail [21]. However echinule shape arrangement and structure and also surface ornamentation of pappus were found to be significant character for systematic of taxa in our study.

Studies show that pollen, seed, achene and fruit micromorphological characteristics of taxa reveal valuable data in systematic discrimination of taxa [22-25].

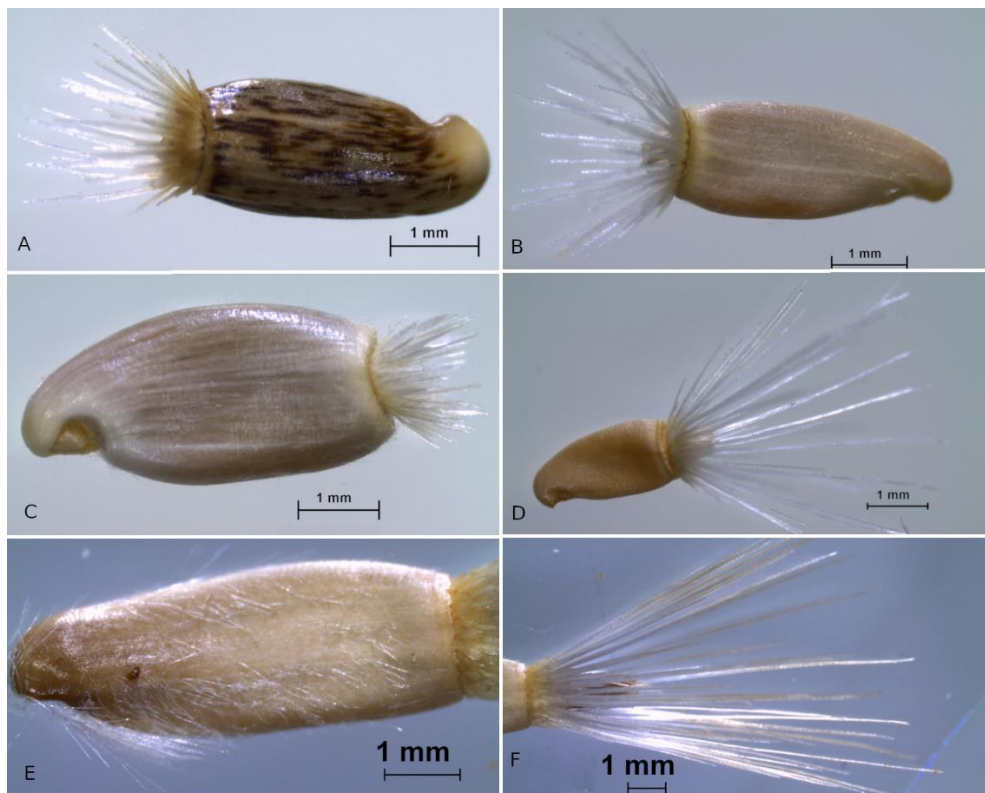
## Conclusion

As a result of this study, the characteristics such as polar and equatorial axis, polar and equatorial view, pollen shape and ornamentation, intine and exine thickness, achene length and width, pappus

length and structure and achene ornamentation and color were found to be significant in terms of taxonomic delimitation of taxa.

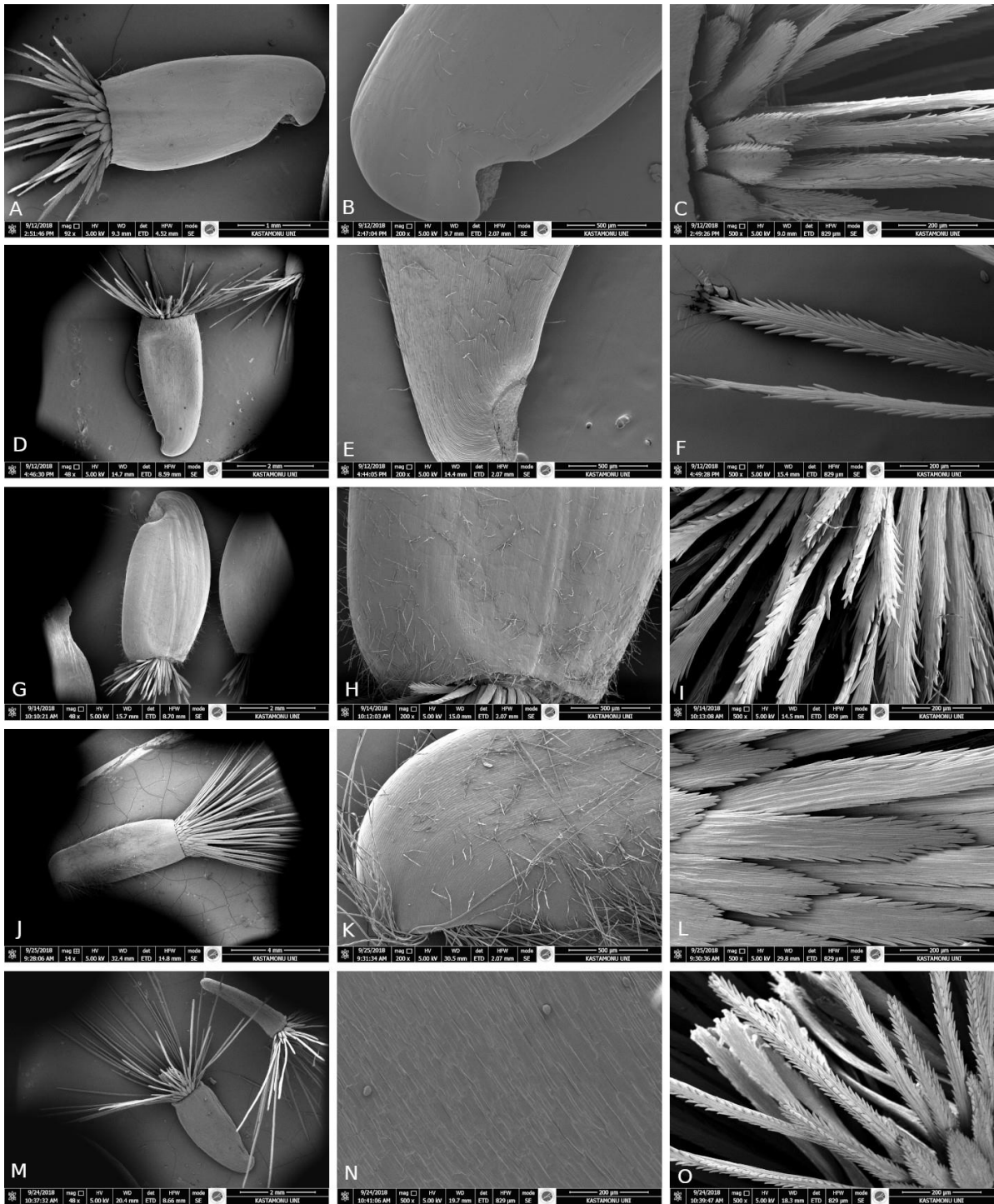
**Table 3.** Micro and macro morphological features of *Centaurea* achene (Measurement in mm).

Taxa	Achene length	Achene width	Achene colour	Outer Pappus length	Inner Pappus length	Pappus colour	Hilum
<i>C. iberica</i>	3.2±0	1.6±0.1	Black or dark brown	0.5±0.2	1.9±0.2	Bright white	0.6±0
<i>C. urvelli</i> subsp. <i>urvelli</i>	5.5±0.7	1.8±0.5	pale straw	0.5±0.1	9.6±1.6	Bright white	0.7
<i>C. virgata</i>	3.5±0.1	1.6±0	Pale brown	0.7±0.4	2±0.4	Bright white	0.5±0.1
<i>C. cheirolopha</i>	4.7±0.2	2.2±0	white- grey	0.6±0,2	1.1±0.3	White	0.8±0.1
<i>C. solstitialis</i> subsp. <i>solsititialis</i>	2.3±0.1	1.1±0	Dark brown to pale brown	1.7±1.1	4.1±0.3	Bright white	0.5±0.1



**Figure 4.** Stereomicroscope microphotograph of *Centaurea* achene. A: *C. iberica*. B: *C. virgata*. C: *C. cheirolopha*. D: *C. solstitialis* subsp. *solsititialis*. E-F: *C. urvillei* subsp. *urvelli*





**Figure 5.** SEM microphotograph of *Centaurea* achene. A-C: *C.iberica*. D-F: *C.virgata*. G-I: *C.cheirolopha*. J-L: *C.solstitialis* subsp *solstitialis*. K-M: *urvillei* subsp. *urvillei*

## Türkiye’de Yayılış Gösteren Bazı *Centaurea* L. (Asteraceae) Taksonlarının Aken ve Polen Morfolojilerinin İncelenmesi

**Öz:** *Centaurea*, Asteraceae familyası içerisinde en büyük cinslerden birisidir. Türkiye bu cinsin ana yayılış alanlarından birisini teşkil etmektedir. Türkiyede 105 tanesi endemik olmak üzere *Centaurea* cinsine ait 194 takson yayılış göstermektedir. Bu çalışmada, *Centaurea* (*C. iberica*, *C. virgata*, *C. cheirolopha*, *C. urvelli* subsp. *urvelli*, *C. solstitialis* subsp. *solstitialis*) cinsine ait 5 taksonun polen ve aken morfolojisi ışık mikroskobu ve taramalı elektron mikroskobu ile ayrıntılı olarak incelenmiştir. Çalışmanın amacı polen ve aken mikro ve makro-morfolojik özelliklerinin taksonların sistematik ayırımındaki katkılarının ortaya konulmasıdır.

Çalışılan *Centaurea* taksonlarının polenleri izopolar kutuplu, trikolporat aperture yapısına sahip olup polen şekilleri subprolat

ve prolat-sferoidal olarak saptanmıştır. Polar eksen uzunluğu 30.4-49.9 µm arasında saptanırken, ekvatorial eksen uzunluğu 25.7-41 µm arasında saptanmıştır.

Taksonların aken şekli oval veya oblong olarak saptanmıştır. SEM mikrofotograflarının analizi sonucunda akenlerin yüzeyinin striat ornamentasyon gösterdiği, trikomsuz veya seyrek trikomların olduğu ve lateral olarak iki yandan basık oldukları saptanmıştır.

Polar eksen, ekvatorial eksen, polen şekli, polen yüzey ornamentasyonu, intin ve ekzin kalınlığı, aken boyutu, pappus boyu, aken yüzey ornamentasyonu gibi mikro ve makro karakterler taksonların sistematik ayırımı açısından önemli ve ayırıcı karakterler olarak saptanmıştır.

**Anahtar Kelimeler:** Asteraceae, *Centaurea*, Polen, Aken, Işık mikroskobu, Taramalı Elektron Mikroskobu.

### REFERENCES

- [1]GÜNER, A; ASLAN, S; EKİM, T; VURAL, M; BABAÇ, M T (2012) Türkiye Bitkileri Listesi (Damarlı Bitkiler). Flora Araştırmaları Derneği ve Nezahat Gökyiğit Botanik Bahçesi Yayını; İstanbul.
- [2]WAGENITZ G (1986) *Centaurea* in South-west Asia; Patterns of distribution and diversity, Proceeeding of the Royal Society of Edinburgh Vol: 89 Section: B, 11-21.
- [3]GÜNER, A; ÖZHATAY, N; EKİM, T (2000) Flora of Turkey and the East Aegean Islands, Vol:11. Edinburg Press.
- [4]DAVİS, P H (1975) Flora of Turkey And The East Aegean Islands, Vol:5, Edinburg Univ. Pres; Edinburg.
- [5]OSKAY, G (2015) Bazı Asteraceae Familyası Bitkilerinin Yağ Asitleri Profilinin Ve Biyoaktivitelerinin Araştırılması, Yüksek Lisans Tezi, Yıldız Teknik Üniversitesi Fen Bilimleri Enstitüsü; İstanbul
- [6]TASAR, N; DOĞAN, G; KIRAN, Y (2018) Karyological Investigation on Seven *Centaurea* L. (Asteraceae) Taxa from Turkey. Cytologia, 83(3): 317-321.
- [7]WAGENİTZ, G; HELLWİG, G H (2000) The genus *Psephellus* Cass. (Compositae, Cardueae) revisited with a broadened concept. Willdenowia, 30(1): 29-44.
- [8]GREUTER, W (2003) The Euro+Med treatment of Cardueae (Compositae) — generic concepts and required new names. Willdenowia, 33(1): 49-61.
- [9]ÇETER, T; PINAR, N M; İNCEER, H; HAYIRLIOĞLU AYAZ, S; YAPRAK, A E (2013) The Comparative Pollen Morphology of Genera *Matricaria* L. and *Tripleurospermum* Sch. Bip. (Asteraceae) in Turkey. Plant Systematics and Evolution, 299(5): 959-977.
- [10]ÖZBEK, M U; ÖZBEK, F; BAŞER, B; CABİ, E; VURAL, M (2016) Pollen morphology of the genus *Cota* J.Gay (Asteraceae) in Turkey. Botany Letters, 163(4):435-448.

- [11]KAYA, Z (1985) Endemik İki *Centaurea* Türü Üzerinde Taksonomik, Ekolojik ve Palinolojik Araştırmalar. Yüksek Lisans Tezi, Marmara Üniversitesi Sağlık Bilimleri Enstitüsü / Tıbbi Biyoloji Anabilim Dalı, İstanbul.
- [12]ATAR, M (2006) *Centaurea kilaea* Boiss. ve *Centaurea cuneifolia* Sm. Üzerinde Morfolojik ve Palinolojik Araştırmalar. Yüksek Lisans Tezi, Marmara Üniversitesi Fen Bilimleri Enstitüsü; İstanbul.
- [13]PINAR, A (2007) Türkiye İçin Endemik *Centaurea cariensis* Boiss. Alttürleri Üzerinde Morfolojik Ve Palinolojik Araştırmalar. Yüksek Mühendislik Tezi, Zonguldak Karaelmas Üniversitesi Fen Bilimleri Enstitüsü; Zonguldak.
- [14] KARGÜN, K (2011) B7 Elâzığ Bölgesinde Yetişen *Centaurea*, *Psephellus* ve *Cyanus* Cinslerine Ait Türleri Üzerinde Morfolojik Ve Palinolojik Araştırmalar. Yüksek Lisans Tezi, Bartın Üniversitesi Fen Bilimleri Enstitüsü; Bartın.
- [15]SHABESTARİ, E; ATTAR, F; RİAHİ, H; SHEİDAİ, M (2013) Pollen morphology of *Centaurea* L. (Asteraceae) in Iran. *Acta Botanica Brasilica*, 27(4): 669-679.
- [16]İNCEER, H; BAL, M; ÇETER, T; PINAR, N M (2012) Fruit structure of 12 Turkish endemic *Tripleurospermum* Sch. Bip. (Asteraceae) taxa and its taxonomic implications. *Plant Systematics and Evolution*, 298(4): 845-855.
- [17]TARIKAHYA HACIOĞLU, B; ARSLAN, Y; SUBASI, İ; KATAR, D; BÜLBÜL A S; ÇETER, T (2012) Achene morphology of Turkish *Carthamus* species. *Australian Journal of Crop Sciences*, 6(8): 1260-1264.
- [18] BONA, M (2015) Systematic implications of Achene characteristics in genera *Centaurea* L., *Cyanus* Mill., *Psephellus* Cass. and *Rhaponticoides* Vaill. (Asteraceae). *Bangladesh Journal of Plant Taxonomy*, 22(2):125-136.
- [19]BONA, M (2014) Achene characteristics of Turkish *Centaurea* (Asteraceae) and their systematic application. *Bangladesh Journal of Botany*, 43(2):163-168.
- [20]CELİK, S; UYSAL, İ; MENEMEN Y; KARABACAK, E (2005) Morphology, Anatomy, Ecology, Pollen and Achene Structure of *Centaurea consanguinea* DC. (Sect. *Acrolophus*). *International Journal of Botany*, 1(1): 85-89.
- [21]WODEHOUSE, R P (1935) Pollen grains. Newyork, Mc Graw-Hill Press.
- [22]PINAR, N M; DURAN, A; ÇETER T; TUĞ, G N (2009) Pollen and Seed Morphology of the Genus *Hesperis* L. (Brassicaceae) in Turkey. *Turkish Journal Botany*, 33(2): 83-96.
- [23]PINAR, N M; EKİCİ, M; AYTAÇ, Z; AKAN, H; ÇETER T; ALAN, Ş (2009) Pollen morphology of *Astragalus* L. Sect. *Onobrychoidei* DC. (Fabaceae) in Turkey. *Turkish Journal of Botany*. 33(4): 291-30.
- [24]ÇETER, T PINAR, N M; AKAN, H; EKİCİ M; AYTAÇ, Z (2012) Comparative seed morphology of *Trigonella* L. species (Leguminosae) in Turkey. *African Journal of Agricultural Research*, 7(3): 509-522.
- [25]BANİ, M; KARAKAYA, M A; ÇETER, T (2016) Fruit micromorphological characters of the genus *Grammosciadium* DC. (Apiaceae) in Turkey. *Phytotaxa*, 246 (3): 184-191.