

The Stomatal Characteristics of *Cheirolepis* section of *Centaurea* Genus (Asteraceae) and Its Relatives in Turkey

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Received: March 15, 2018 / Accepted: April 13, 2018 / Published: June 25, 2018

Abstract: The present study reveals the stomatal characteristics of *Centaurea* genus of *Cheirolepis* section and its relatives. The levels of stomatas of taxa were detected as mesomorphic and also the stomata type were determined as anomocytic or anizosytic in studied taxa. The epidermis were showed polygonal in shape and their anticlinal cell walls are straight or undulating. This arrangement was stable in the same taxon. However, it was different in point of adaxial and abaxial surface. The stomatal index were calculated and confirmed close values in taxa.

Key words: *Centaurea*, *Cheirolepis*, Stomata, *Pseudoseridia*, *Plumosipappus*, *Pteracantha*.

1. Introduction

An outstanding and relatively large genus in Flora of Turkey, *Centaurea* L., at the present time, is comprised of ca. 250 species distributed across Eurasia, particularly in the Irano-Turanian and Mediterranean region [1]. Recently, with the description of new taxa, the genus *Centaurea* has reached 200 taxa, of which 111 are endemic in Turkey [2, 3, 4, 5, 6, 7]. Hence, the endemism rate is about 56%. Section *Cheirolepis* of *Centaurea* is represented by 17 taxa, of which 6 are known only by their type locality in Turkey [4, 8, 9]. There are morphological and molecular studies about section *Cheirolepis*, in which sections *Pseudoseridia*, *Pteracantha*, and *Plumosipappus* have been merged, as they all have systematic problems. In a recent study, Garcia-Jacas et al. [10] had declared that the species of these 4 sections could be reunited in a single section, called *Cheirolepis-Pseudoseridia* complex [11]. They determined that the species have morphological differences but practically no genetic differences at a molecular level. On the basis of this work, we also selected 4 taxa (*C.*

odyseii Wagenitz, *C. kizildaghensis* E. Uzunhisarcıklı, E. Doğan & H. Duman, *C. paphlagonica* (Bornm.) Wagenitz, and *C. nallihanense* Uysal & Hamzaoğlu) from these related sections and also determined their stomatal characteristics.

Because leaves are probably the most varied anatomical organ among the angiosperms, a large number of investigations have examined the diagnostic value of leaves [12]. Of these, the taxonomic value of features such as stomata structure, surface ornamentation and epidermal cell wall configuration have been repeatedly demonstrated [13]. However, the leaf epidermis of *Centaurea* species has been little examined with the light microscope [14, 15]. Therefore, in this study we will examine the epidermal features of 21 Turkish *Centaurea* species, to see if epidermal features can provide information of taxonomic value, and whether such information supports the discrimination of the members of *Cheirolepis* and its relatives.

With the exception of *C. odyseii* the stomatal characteristics of the remaining species were examined for the first time in the present study.

2. Materials and Methods

The specimens used for the present study were collected from several localities in Turkey and were deposited in KNYA herbarium (Selçuk University) and the capitula photos were given in Figure 1. Some of the specimens were put in 70% ethyl-alcohol during the field conditions. The superficial sections were taken with a razor blade and the sections were mounted with a cover slip in glycerol. To determine the length of stomata guard cells, at least 30 randomly selected stomata from five leaves per plant were measured with using the software of Kameram 21 programme. In a similar way, 30 randomly selected microscopic field areas from five leaves were counted per plant to obtain stomatal and epidermal cell frequency. Stomatal index (SI) was calculated according to the formula of Salisbury [16]:

$$SI = S/(E+S) \times 100,$$

where S is the number of stomata per unit leaf area and E is the number of epidermal cells per unit leaf area.

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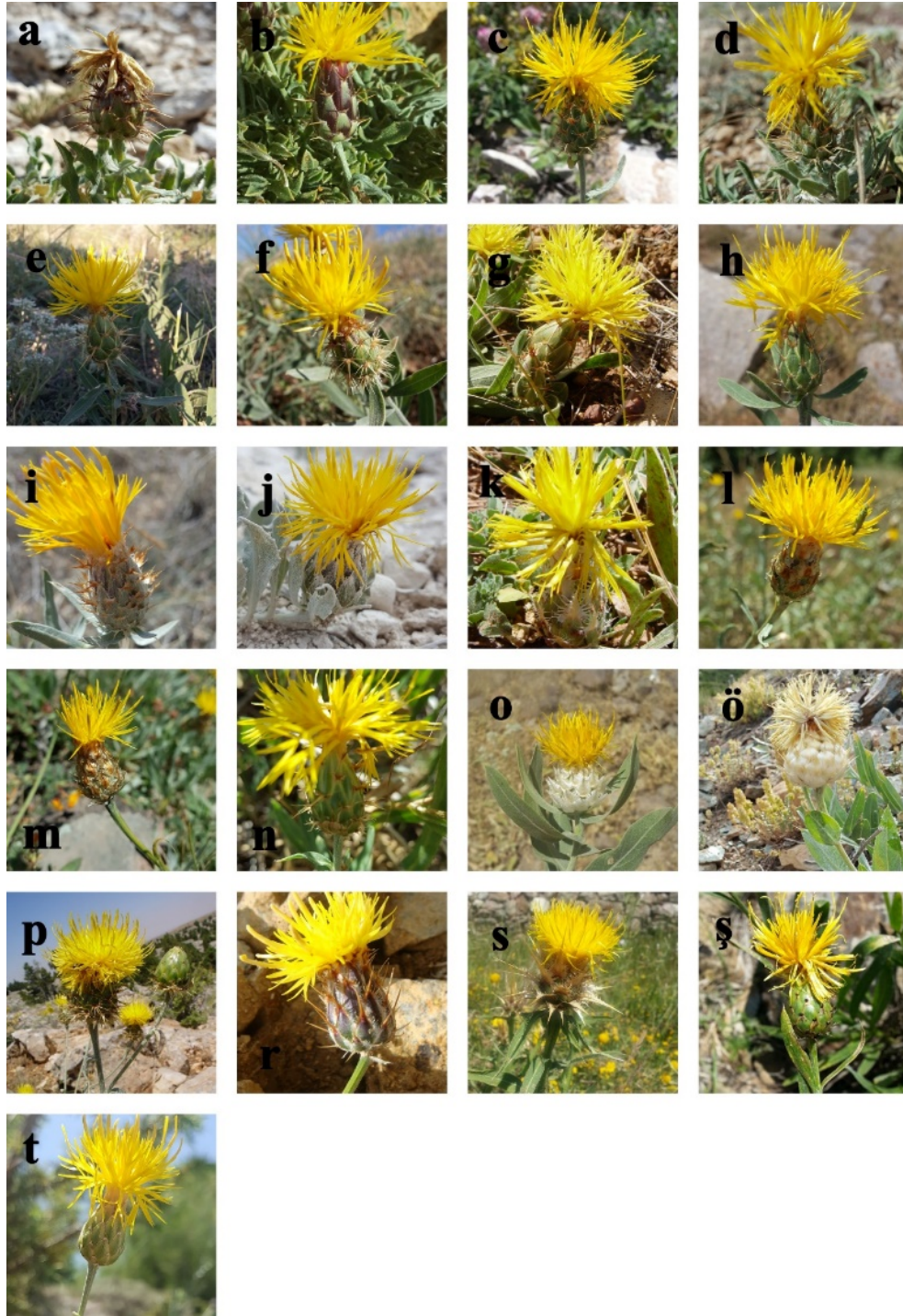


Figure 1. The photos of capitula of *Cheirolepis* and its relatives

a. *Centaurea drabifolia* subsp. *drabifolia*, b. *C. drabifolia* subsp. *austro-occidentalis*, c. *C. drabifolia* subsp. *floccosa*, d. *C. drabifolia* subsp. *cappadocica*, e. *C. kotschyi* var. *kotschyi*, f. *C. kotschyi* var. *persica*, g. *C. kotschyi* var. *decumbens*, h. *C. kotschyi* var. *floccosa*, i. *C. derderiifolia*, j. *C. nivea*, k. *C. deflexa*, l. *C. sericea*, m. *C. cankiriense*, n. *C. glabro-auriculata*, o. *C. saligna*, ö. *C. ensiformis*, p. *C. isaurica*, r. *C. odyssei*, s. *C. paphlagonica*, ş. *C. kizildaghensis*, t. *C. nallihanense*

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Table 1. The localities of studied taxa

Serial no.	Taxa <i>Cheirolepis</i>	Location	Voucher number
C1	<i>Centaurea drabifolia</i> subsp. <i>drabifolia</i>	A2 Bursa: Uludağ, 2100-2200 m., 20 August 2016	<i>B. Çitak</i> 250
C2	<i>Centaurea drabifolia</i> subsp. <i>austro-occidentalis</i>	C2 Denizli: Honaz Mountain, 2340-2500 m., 28 July 2016	<i>B. Çitak</i> 218
C3	<i>Centaurea drabifolia</i> subsp. <i>floccosa</i> Boissier	B5 Kayseri: Pinarbaşı, Şirvan Mountain, 2210 m., 5 August 2015 C3 Konya: Derebucak, Çamlık Town, 1350 m., 15 June 2016	<i>B. Çitak</i> 177 <i>H. Dural</i> 3566- <i>B. Çitak</i>
C4	<i>Centaurea drabifolia</i> subsp. <i>cappadocica</i>	B6 Sivas: Gürün, between Gürün-Kangal road, 1844 m., 14 July 2015 C3 Konya: Beyşehir, Doğanhisar-Hüyük road, 1800 m., 20 June 2016	<i>B. Çitak</i> 171 <i>H. Dural</i> 3573- <i>B. Çitak</i>
C5	<i>Centaurea kotschyi</i> var. <i>kotschyi</i>	C3 Konya: Konya-Beyşehir road, 15 June 2015	<i>H. Dural</i> 3570 <i>B. Çitak</i>
C6	<i>Centaurea kotschyi</i> var. <i>persica</i>	B5 Kayseri: Pinarbaşı, Şirvan Mountain, 1844 m., 14 July 2015 C4 Konya: 8 km from Hadim to Korualan, 1850 m., steppe, 21 July 2015	<i>B. Çitak</i> 169 <i>K. Ertuğrul</i> 5006 <i>H. Dural</i>
C8	<i>Centaurea kotschyi</i> var. <i>floccosa</i>	B5 Kayseri: Pinarbaşı, Şirvan Mountain, 2210 m., 05 August 2015	<i>B. Çitak</i> 176
C9	<i>Centaurea derderiifolia</i>	B6 Kayseri: Gürün-Divriği road, 1500-1600 m., 27 July 2003.	<i>B. Çitak</i> 172
C10	<i>Centaurea deflexa</i>	C4 Konya: Hadim-Taşkent-Alanya road, 1750-1800 m., 21 July 2015 C4 Konya: Taşkent-Ermenek road, 1800 m., 19 July 2012	<i>K. Ertuğrul</i> 5011 <i>H. Dural</i> <i>K.</i> <i>Ertuğrul</i> -4699- <i>H. Dural</i>
C11	<i>Centaurea nivea</i>	B3 Eskişehir: 20 km from Mihaliçik to Alpu, 940 m., 13 June 2016	<i>B. Çitak</i> 182
C12	<i>Centaurea sericea</i>	C3 Eskişehir: Bozüyük-Kütahya road, 1140 m., 14 July 2016.	<i>B. Çitak</i> 207
C13	<i>Centaurea cankiriense</i>	A4 Çankırı: Atkaracalar-Kalfat road, 1500 m., 13 July 2016	<i>B. Çitak</i> 201
C14	<i>Centaurea saligna</i>	C9 Hakkari: Hakkari-Van road, 1800 m., 10 July 2015	<i>B. Çitak</i> 168
C15	<i>Centaurea glabro-auriculata</i>	C3 Konya: Derebucak, Kızıldağ,	<i>B. Çitak</i> 225- <i>H.</i>

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		Tekneliyatak region, 1800-1900 m., 07 August 2016.	<i>Dural-H. Demirelma</i>
C16	<i>Centaurea isaurica</i>	C4 Konya: Seydişehir, Maden Village, 1500 m.,	<i>B. Çıtak 215</i>
C17	<i>Centaurea ensiformis</i>	C2 Muğla: Köyceğiz, Sandras Mountain, 1700 m., 25 July 2016	<i>B. Çıtak 193</i>
<i>Pteracantha</i>			
C18	<i>Centaurea odyssei</i>	B1 Çanakkale: Bayramiç, Kazdağ, Çıplak Hill, 1530 m., 05 June 2003	<i>E. Karabacak 2495</i>
<i>Plumosipappus</i>			
C19	<i>Centaurea paphlagonica</i>	B5 Yozgat: Çayıralan, Elçi Village, 1666 m., 17 July 2015	<i>B. Çıtak 174</i>
<i>Pseudoseridia</i>			
C20	<i>Centaurea kizildaghensis</i>	C3 Konya: Derebucak, Kızıldağ, Çamlık Village, 1400 m., 16 June 2015	<i>H. Dural 3575- B. Çıtak</i>
<i>Cheirolepis-Pseudoseridia complex</i>			
C21	<i>Centaurea nallihanense</i>	B2 Ankara: Nallıhan, Osmerköy-Yenice road, 10 July 2017	<i>B. Çıtak 319</i>

3. Results and Discussion

The results are summarized in Tables 2-4 and Figs. 2-5. In current study, the stomata were classified based on the criteria of Metcalfe and Chalk [17]. Also, Aydın et al [14] and Özcan et al. [15] were used for classification. The stomatal apparatus for all species was of anizocytic or anomocytic type (Figs. 2-5). Moreover, the leaves of investigated taxa are amphistomatic. Leaf epidermal cells are usually irregular or polygonal in shape. The anticlinal walls are straight, undulating or both straight and undulating in studied taxa (Figs. 2-5). The stomatal dimensions were changed 20.21-39.9 µm on the adaxial epidermis and 19.68-42.41 µm on the abaxial epidermis (Tables 2-3). The stomatal density of studied taxa varied from 7.67 to 15.78 per square millimeter on the adaxial epidermis and from 8.60 to 15.82 per square millimeter on the abaxial epidermis (Table 4). The stomatal size of the investigated taxa varied from species to species and was higher on the abaxial surface than on the adaxial surface for all species.

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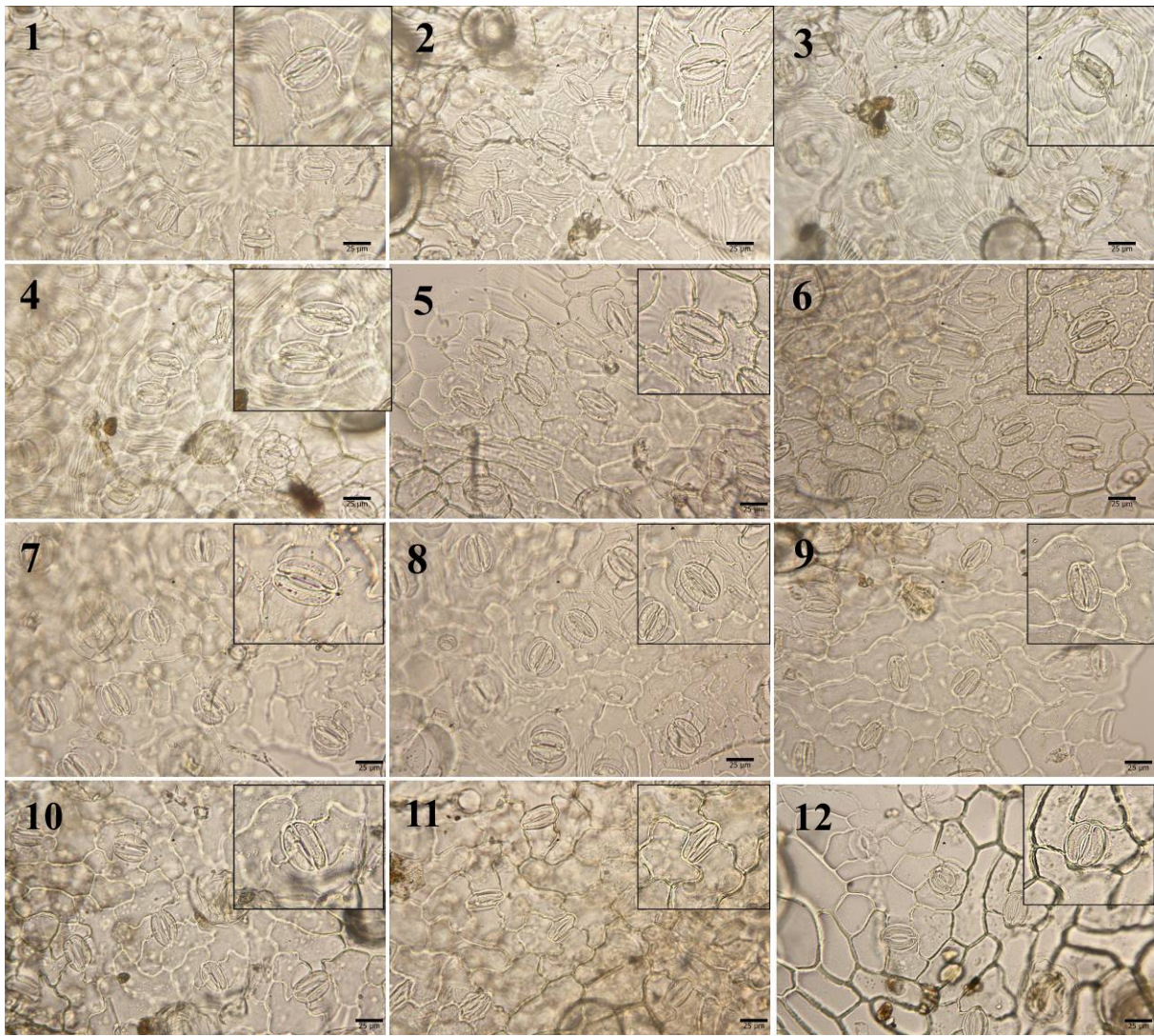


Figure 2. Stomata microphotographs of *Cheirolepis* section at light microscope. 1-*C. drabifolia* subsp. *drabifolia* (upper surface), 2-*C. drabifolia* subsp. *drabifolia* (lower surface), 3-*C. drabifolia* subsp. *austro-occidentalis* (upper surface), 4-*C. drabifolia* subsp. *austro-occidentalis* (lower surface), 5-*C. drabifolia* subsp. *floccosa* (upper surface), 6-*C. drabifolia* subsp. *floccosa* (lower surface), 7-*C. drabifolia* subsp. *cappadocica* (upper surface), 8-*C. drabifolia* subsp. *cappadocica* (lower surface), 9-*C. kotschyi* var. *kotschyi* (upper surface), 10-*C. kotschyi* var. *kotschyi* (lower surface), 11-*C. kotschyi* var. *persica* (upper surface), 12-*C. kotschyi* var. *persica* (lower surface)

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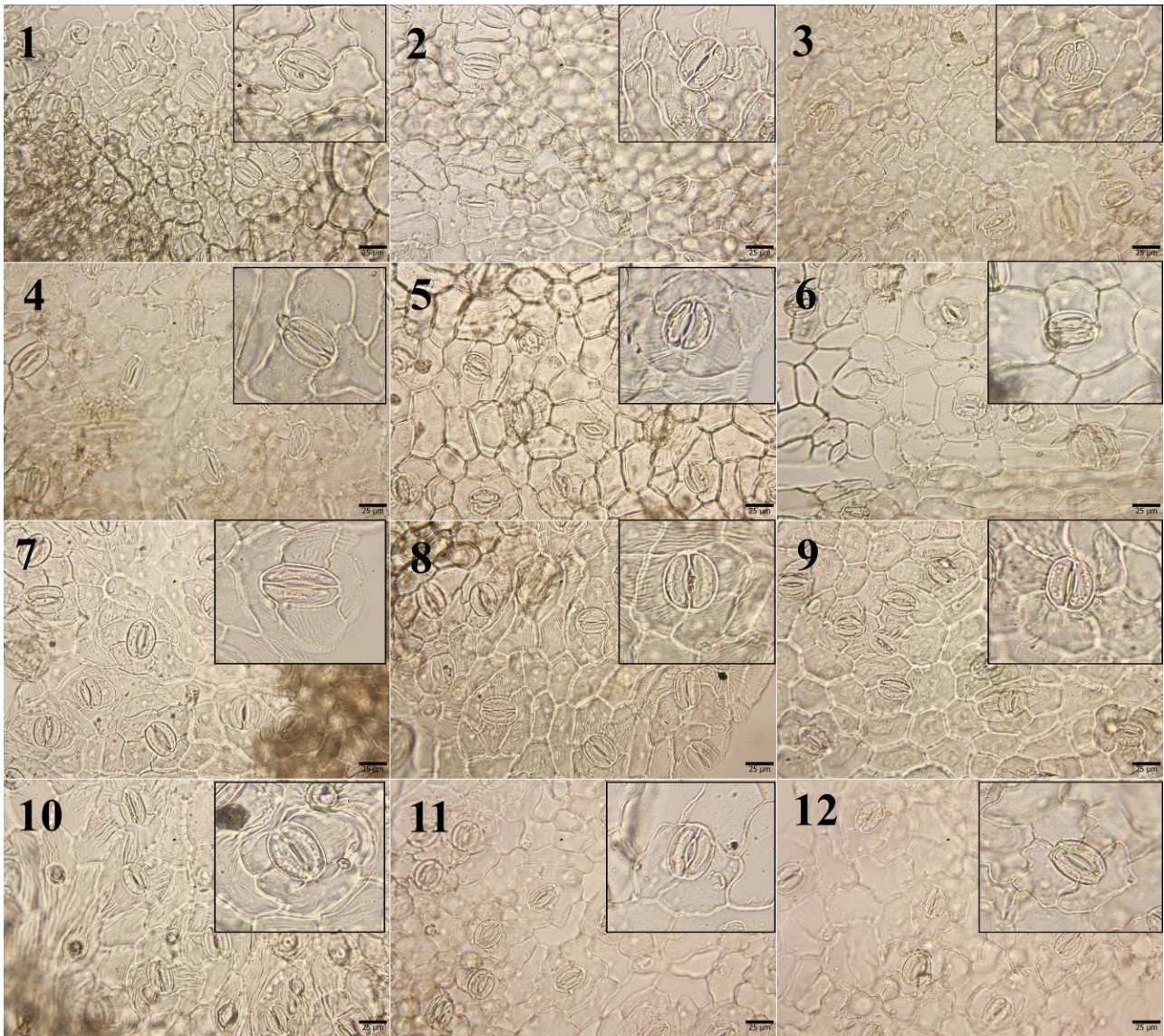


Figure 3. Stomata microphotographs of *Cheirolepis* section at light microscope. 1-*C. kotschyi* var. *decumbens* (upper surface), 2-*C. kotschyi* var. *decumbens* (lower surface), 3-*C. kotschyi* var. *floccosa* (upper surface), 4-*C. kotschyi* var. *floccosa* (lower surface), 5-*C. derderiifolia* (upper surface), 6-*C. derderiifolia* (lower surface), 7-*C. deflexa* (upper surface), 8-*C. deflexa* (lower surface), 9-*C. nivea* (upper surface), 10-*C. nivea* (lower surface), 11-*C. sericea* (upper surface), 12-*C. sericea* (lower surface)

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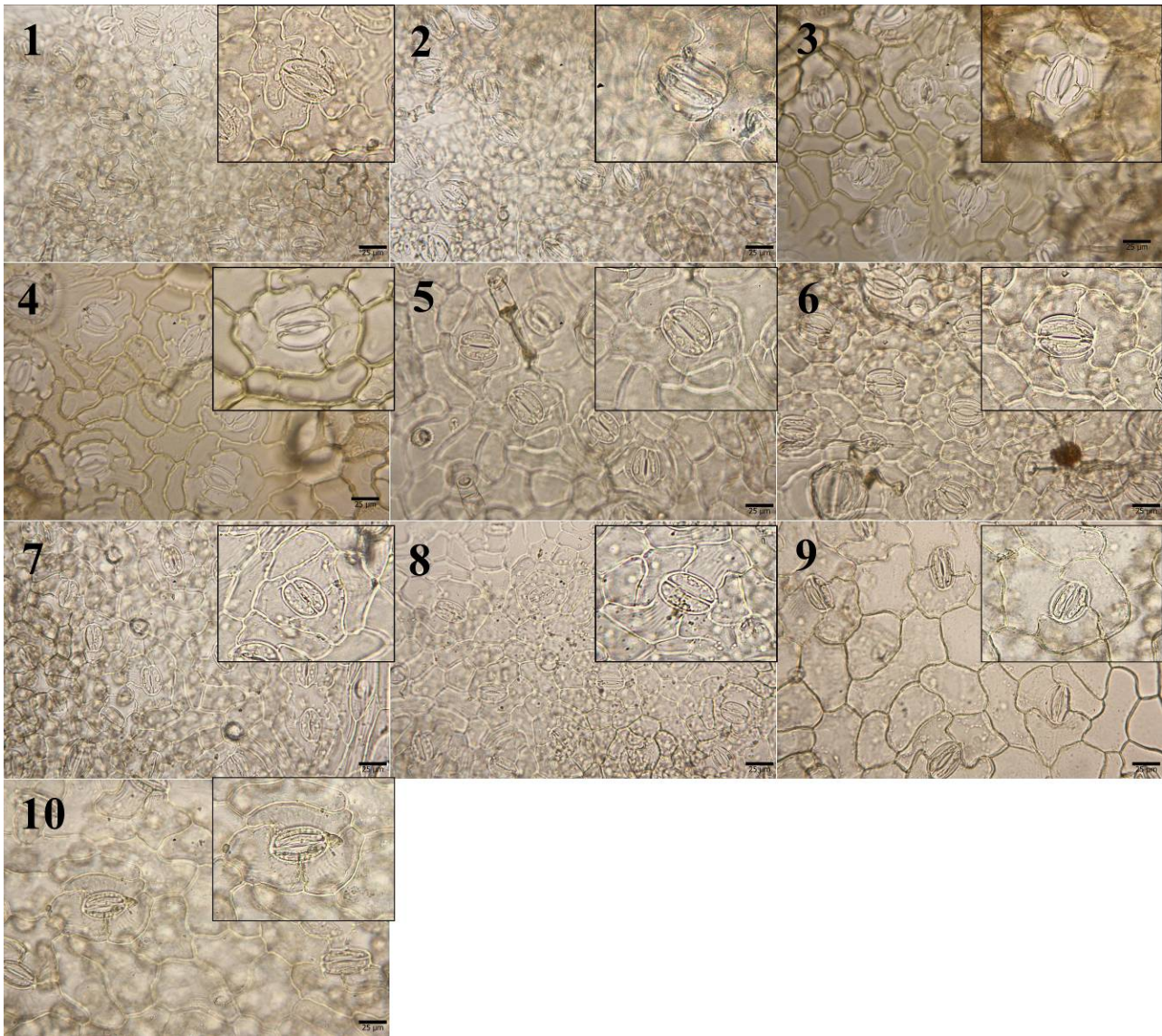


Figure 4. Stomata microphotographs of *Cheirolepis* section at light microscope. 1-*C. cankiense* (upper surface), 2-*C. cankiense* (lower surface), 3-*C. saligna* (upper surface), 4-*C. saligna* (lower surface), 5-*C. glabro-auriculata* (upper surface), 6-*C. glabro-auriculata* (lower surface), 7-*C. isaurica* (upper surface), 8-*C. isaurica* (lower surface), 9-*C. ensiformis* (upper surface), 10-*C. ensiformis* (lower surface)

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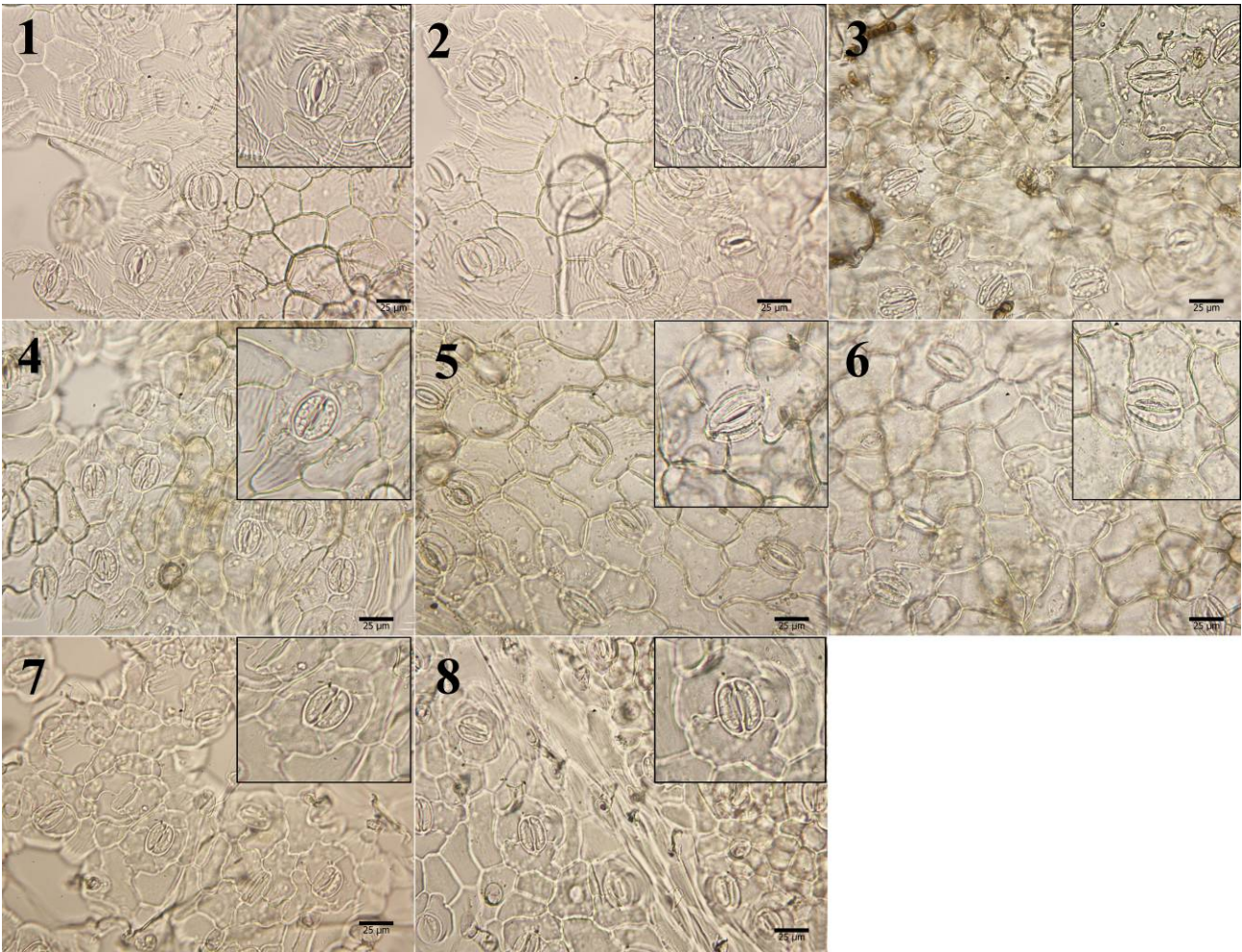


Figure 5. Stomata microphotographs of *Pseudoserida*, *Plumisopappus*, *Pteracantha* and *Plumisopappus-Cheirolepis* sections at light microscope. 1-*C. odyssei* (upper surface), 2-*C. odyssei* (lower surface), 3-*C. paphlagonica* (upper surface), 4-*C. paphlagonica* (lower surface), 5-*C. kizildaghensis* (upper surface), 6-*C. kizildaghensis* (lower surface), 7-*C. nallihanense* (upper surface), 8-*C. nallihanense* (lower surface)

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Table 2. The stomatal characteristics of the studied taxa (ST: stomata type, SEC: shape of epidermal cells, AEW: Anticlinal epidermal walls. See Table 1 for acronyms of taxa)

Taxa	Upper surface			Lower surface		
	ST	SEC	AEW	ST	SEC	AEW
C1	Anomocytic and anizosytic	Polyganal	Straight	Anomocytic and anizosytic	Polyganal	Straight
C2	Anomocytic and anizosytic	Polyganal	Straight	Anomocytic and anizosytic	Polyganal	Straight, undulating
C3	Anomocytic and anizosytic	Polyganal	Straight	Anomocytic and anizosytic	Polyganal	Straight, undulating
C4	Anomocytic and anizosytic	Polyganal	Undulating	Anomocytic and anizosytic	Polyganal	Straight
C5	Anomocytic and anizosytic	Polyganal	Undulating	Anomocytic and anizosytic	Polyganal	Straight, undulating
C6	Anomocytic and anizosytic	Polyganal	Undulating	Anomocytic and anizosytic	Polyganal	Straight, undulating
C7	Anomocytic and anizosytic	Polyganal	Undulating	Anomocytic and anizosytic	Polyganal	Straight, undulating
C8	Anomocytic and anizosytic	Polyganal	Undulating	Anomocytic and anizosytic	Polyganal	Straight, undulating
C9	Anomocytic and anizosytic	Polygonal	Undulating	Anomocytic and anizosytic	Polygonal	Straight
C10	Anomocytic and anizosytic	Polygonal	Undulating	Anomocytic and anizosytic	Polygonal	Straight
C11	Anomocytic and anizosytic	Polygonal	Undulating	Anomocytic and anizosytic	Polygonal	Straight
C12	Anomocytic and anizosytic	Polygonal	Undulating	Anomocytic and anizosytic	Polygonal	Straight, undulating

The shape of epidermal cells and the pattern of anticlinal cell walls, which vary between taxa but are stable within a taxon and also within the same section, may represent good characters for taxonomy of *Centaurea* genus or others [15]. In some taxa the anticlinal wall patterns are different on both surfaces; polygonal cells with straight anticlinal cell walls on the adaxial epidermis and polygonal cells with undulating anticlinal cell walls on the abaxial sides. This different pattern condition occurs in *C. drabifolia* subsp. *cappadocica*, *C. drabifolia* subsp. *austro-occidentalis*, *C. derderiifolia*, *C. deflexa* and *C. nivea* (Figs. 1,2). Straight to undulate epidermal shape conditions have been also reported in several *Centaurea* or related taxa [14, 15, 16, 17]. Amount of undulation is greater on the abaxial sides in these five taxa. This is because the abaxial epidermis is exposed to conditions of greater shadow and humidity [19]. The shapes of cells of *C. cheiranthifolia* var. *purpurascens* and *C. woronowii* on the adaxial epidermises with irregular and sinuous anticlinal cell walls are similar to abaxial ones [15]. Stace [13] points out that epidermal cells with straight outlines are more common in xeromorphic plants than in mesomorphic plants, where they are typically undulate (repand). In addition, Fahn [20] asserts that the epidermal cells of most leaves of shade-loving dicotyledons have sinuous anticlinal walls. It is also reported that such sinuosity is probably due to the tensions that occur in the leaf and to cuticle hardening during cell differentiation [21]. Our results are in agreement with these suggestions.

All of the studied the taxa have anomocytic-anisocytic stomatal type. Stomata cells are more abundant on the lower epidermis, whereas it is a few in the upper parts of all taxa. Number of stomata per mm² is much dense in the lower parts of *Centaurea drabifolia* subsp. *austro-occidentalis*, *C. drabifolia* subsp. *floccosa*, *C. kotschy* var. *persica*, *C. kotschy* var. *decumbens*, *C. kotschy* var. *floccosa*, *C. nivea*, *C. isaurica* and *C. ensiformis* than those of others thirteen taxa. In addition, stomata are generally in the same level with epidermises, except for *Centaurea saligna* (Fig. 3). In this species the stomata are positioned below abaxial epidermis level (Fig. 3). This characteristic is also reported in *C. calcitrapa* ssp. *cilicica* and *C. solstitialis* ssp. *carneola* by Kaya et al. [18].

C. drabifolia subsp. *drabifolia*, *C. drabifolia* subsp. *austro-occidentalis*, *C. isaurica*, *C. ensiformis*, *C. nivea*, *C. deflexa* and *C. odyssei* have wrinkled cuticular membrane ornamentation as not reported previously in *Centaurea*.

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Table 3. The stomatal characteristics of the studied taxa

Taxa	Upper surface			Lower surface		
	ST	SEC	AEW	ST	SEC	AEW
C13	Anomocytic and anizosytic	Polygonal	Undulating	Anomocytic and anizosytic	Polygonal	Straight, undulating
C14	Anomocytic and anizosytic	Polygonal	Undulating	Anomocytic and anizosytic	Polygonal	Straight, undulating
C15	Anomocytic and anizosytic	Polygonal	Undulating	Anomocytic and anizosytic	Polygonal	Straight, undulating
C16	Anomocytic and anizosytic	Polygonal	Undulating	Anomocytic and anizosytic	Polygonal	Straight, undulating
C17	Anomocytic and anizosytic	Polygonal	Undulating	Anomocytic and anizosytic	Polygonal	Straight, undulating
C18	Anomocytic and anizosytic	Polygonal	Straight	Anomocytic and anizosytic	Polygonal	Straight
C19	Anomocytic and anizosytic	Polygonal	Straight, undulating	Anomocytic and anizosytic	Polygonal	Straight, undulating
C20	Anomocytic and anizosytic	Polygonal	Straight, undulating	Anomocytic and anizosytic	Polygonal	Straight, undulating
C21	Anomocytic and anizosytic	Polygonal	Straight, undulating	Anomocytic and anizosytic	Polygonal	Straight, undulating

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Table 4. The length of stomata guard cells of the investigated taxa and stomata indexes (μm)

Taxa	Stomata index			The length of stomata guard cells					
	Upper surface	Lower surface	The ratio of stomata index	Upper surface			Lower surface		
				Min	Max	Mean \pm SD	Min	Max	Mean \pm SD
C1	15.78	11.91	1.32	25.76	33.13	28.55 \pm 2.6	26.84	29.48	30.47 \pm 2.9
C2	14.40	15.82	0.91	25.53	31.11	27.41 \pm 1.97	24.68	29.76	28.64 \pm 1.84
C3	7.67	8.44	0.90	28.22	30.57	36.02 \pm 3.57	35.95	40.16	36.44 \pm 2.43
C4	11.21	8.60	1.30	22.6	34.52	26.22 \pm 2.42	22.31	32.22	27.61 \pm 2.3
C5	14.36	14.31	1.00	23.11	37.75	30.29 \pm 2.98	25.76	34.94	31.17 \pm 1.9
C6	12.59	13.79	0.91	27.27	35.68	31.25 \pm 2.7	24	35.26	30.59 \pm 2.6
C7	14.07	14.48	0.97	24.46	36.8	30.36 \pm 2.9	25.03	41.02	34.1 \pm 3.52
C8	11.60	12.85	0.90	25.52	37.55	32.29 \pm 2.7	24.63	38.42	32.92 \pm 3.0
C9	12.87	11.01	1.16	22.78	35.15	26.42 \pm 2.73	21.24	38.24	28.58 \pm 3.63
C10	13.59	11.98	1.13	25.65	34.75	30.24 \pm 2.17	28.14	34.3	31.53 \pm 1.92
C11	11.94	14.12	0.84	22.41	31.48	27.00 \pm 1.99	20.05	35.54	27.68 \pm 4.49
C12	15.71	13.19	1.19	25.16	34.19	29.47 \pm 2.11	26.89	30.94	29.01 \pm 1.01
C13	14.02	13.04	1.07	23.86	30.44	27.71 \pm 1.81	20.89	29.15	26.61 \pm 2.26
C14	13.21	11.24	1.17	24.11	31.95	28.33 \pm 2.28	24.4	34.61	28.45 \pm 2.51
C15	13.73	12.76	1.07	26.33	33.94	31.02 \pm 1.75	28.64	38.21	32.81 \pm 2.54
C16	11.80	11.91	0.99	23.22	30.11	26.7 \pm 1.87	21.72	31.01	26.26 \pm 2.11
C17	14.02	14.49	0.96	30.87	39.9	34.76 \pm 2.11	32.22	42.41	38.37 \pm 2.34
C18	11.32	11.08	1.02	26.76	34.1	29.22 \pm 2.32	23.84	32.2	28.55 \pm 2.14
C19	12.79	11.36	1.12	22.72	31.63	27.27 \pm 2.09	20.94	31.77	27.12 \pm 2.29
C20	13.19	13.12	1.00	30.93	38.4	34.94 \pm 1.91	28.1	39.29	34.48 \pm 2.99
C21	14.33	11.34	1.26	20.21	29.48	24.15 \pm 2.11	19.68	29.58	24.4 \pm 2.05

4. Conclusion

The stomatal properties of 17 species of section *Cheirolepis* and 4 species of sections *Pseudoseridia*, *Pterecantha*, and *Plumisopappus* were observed via light microscopy, and the length of stomata guard cells and undulating on the epidermis cells were determined as the most useful characters of systematic value in *Cheirolepis* and relatives.

In conclusion, a detailed analysis of the stomatal characteristics is very useful for the classification of the taxa investigated. Moreover, changing the size of the stomata among the taxa could be associated with their different habitat types or microclimatic areas.

Acknowledgments

We would like to thank Dr. Kuddisi Ertuğrul, Dr. Tuna Uysal, Dr. Hakkı Demirelma, Dr. Bilal Şahin, and Dr. Ersin Karabacak for their valuable field work and, Selçuk University Scientific Research Unit for their financial support (Project number: 15101010).

References

- [1] Anderberg AA, Elden P. 2007. Tribe Inuleae Cass. In: Kadereit JW, Jeffrey C, Editors. *The families and genera of flowering plants*. Springer, Berlin, pp. 374-391.
- [2] Uysal T, Demirelma H, Ertugrul K, Garcia-Jacas N, Susanna A. 2007. *Centaurea glabro-auriculata* (Asteraceae), a new species from Turkey, *Annales Botanici Fennici* 44, 219-222.
- [3] Uzunhisarcıklı ME, Dogan E, Duman H. 2007. A new species of *Centaurea* L. (Cardueae: Asteraceae) from Turkey, *Botanical Journal of the Linnean Society* 153: 61-66.
- [4] Uysal T. 2012. *Centaurea* L. In: Güner A, Aslan S, Ekim T, Vural M, Babaç MT, Editors. *Türkiye Bitkileri Listesi (Damarlı Bitkiler)*. Nezahat Gökyiğit Botanik Bahçesive Flora Araştırmaları Derneği Yayını, İstanbul, pp. 127-140 (in Turkish).
- [5] Uysal, T. Hamzaoglu E, Ertugrul K, Bozkurt M. 2016. A New Species Of *Centaurea* (Asteraceae) From Turkey, *Phytotaxa* 275: 149-158.
- [6] Uysal T, Hamzaoglu E. 2016. A new *Centaurea* L. (Asteraceae) species from Turkey. *Plant Biosystems-An International Journal Dealing with all Aspects of Plant Biology* 151: 813-821.
- [7] Uysal T, Dural H, Tugay O. 2017. *Centaurea sakariyaensis* (Asteraceae), a new species from Turkey. *Plant Biosystems -An International Journal Dealing with all Aspects of Plant Biology* 151:126-130.

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- [8] Wagenitz G. 1975. *Centaurea* L. In: Davis PH, Editor. Flora of Turkey and the East Aegean Islands. Edinburg, pp. 513-518.
- [9] Ertugrul K, Uysal T, Garcia-Jacas N, Susanna A, Garnetje T. 2004. The systematic position of *Centaurea ensiformis* and *Centaurea isaurica* from Turkey and the evolution of some characters in *Centaurea*, *Israel Journal of Plant Sciences* 52: 257-263.
- [10] Garcia-Jacas N, Uysal T, Romashchenko K, Suarez-Santiago VN, Ertugrul K, Susanna A. 2006. *Centaurea* revisited: a molecular survey of the *Jacea* group, *Annals of Botany* 98: 741-753.
- [11] Uysal T, Romashchenko K, Suarez-Santiago VN, Ertugrul K, Susanna A, Garcia-Jacas N. 2005. ITS Phylogeny of The Genus *Centaurea*: The *Jacea* Group. In: Anonymous (Ed.) XVII International Botanical Congress. Abstracts. Vienna, Austria, 457 pp.
- [12] Carlquist SJ. 1961. Comparative Plant Anatomy: a Guide to Taxonomic and Evolutionary Application of Anatomical Data in Angiosperms. New York: Holt, Rinehart and Winston.
- [13] Stace CA. 1965. Cuticular studies as an aid to plant taxonomy. *B. Brit. Mus. (Nat. Hist.) Bot.*, 4: 1-78.
- [14] Aydin Ö, Coşkunçelebi K, Gültepe M, Güzel ME. 2013. A contribution to taxonomy of *Centaurea* including *Psephellus* (Asteraceae) based on anatomical and molecular data, *Turk. J. Bot.*, 37: 419-427.
- [15] Ozcan M, Unver MC, Eminagaoglu E. 2014. Comparative Anatomical And Ecological Investigations On Some *Centaurea* (Asteraceae) Taxa From Turkey And Their Taxonomic Significance, *Pakistan Journal of Botany* 46(4): 1287-1301.
- [16] Salisbury EJ. 1927. On the causes and ecological significance of stomatal frequency, with special reference to the woodland flora, *Philos Trans R Soc Lond B Biol Sci* 216: 1-65
- [17] Metcalfe CR, Chalk L. 1950. *Anatomy of the Dicotyledons*, II. Oxford University Press.
- [18] Kaya Z, Orcan N, Binzet R. 2010. Morphological, anatomical and palynological study of *Centaurea calcitrapa* L. ssp. *cilicica* (Boiss. & Bal.) Wagenitz and *Centaurea solstitialis* L. ssp. *carneola* (Boiss.) Wagenitz endemic for Turkey, *Pak. J. Bot.*, 42: 59-69.
- [19] Roth I. 1984. Stratification of tropical forests as seen in leaf structure, Junk Publ., The Hague, Boston, Lancaster.
- [20] Fahn A. 1990. *Plant Anatomy*, 4th edn. Pergamon Press, New York.
- [21] Alquini Y, Bona C, Boeger MRT, Costa CG, Barros CF. 2003. *Epiderme*. In: Appezzato-da-Glória B, Carmello Guerreiro SM. Editors. *Anatomia Vegetal Editora UFV*. Universidade Federal de Viçosa, pp. 87-107.