Turkish Journal of Botany

Volume 48 | Number 3 Article 4

5-14-2024

Cephalaria gokturkii (Caprifoliaceae), a new species from southwestern Anatolia, Türkiye

Gürkan SEMİZ
gsemiz@pau.edu.tr

Meryem BOZKURT
mbozkurt@selcuk.edu.tr

Batıkan GÜNAL
bgunal@pau.edu.tr

Tuna UYSAL
tuysal@selcuk.edu.tr

TÜBİTAK

Turkish Journal of Botany

http://journals.tubitak.gov.tr/botany/

Research Article

Turk J Bot
(2024) 48: 155-164
© TÜBİTAK
doi:10.55730/1300-008X.2804

Cephalaria gokturkii (Caprifoliaceae), a new species from southwestern Anatolia, Türkiye

Gürkan SEMİZ[1,*], Meryem BOZKURT[2], Batıkan GÜNAL[1], Tuna UYSAL[2]
[1]Department of Biology, Faculty of Science, Pamukkale University, Kinikli, Denizli, Turkiye
[2]Department of Biology, Faculty of Science, Selçuk University, Konya, Turkiye

Received: 25.12.2023 • **Accepted/Published Online:** 30.04.2024 • **Final Version:** 14.05.2024

Abstract: A new *Cephalaria* (Caprifoliaceae) species, *Cephalaria gokturkii,* is described and illustrated from Girdev Mountain (Muğla Province) for the Flora of Türkiye. Throughout this manuscript, the new species and its relatives were compared in terms of morphological, palynological and molecular features. The obtained findings indicated that the new species is similar to *C. elmaliensis* but is characterized by having larger capitula and receptacular bracts in flower (vs. 1–2 cm capitula and less than 3 mm in flower) and hairy trigonous-narrowly ovate involucral bracts (vs. glabrous and broadly ovate involucral bracts) and smaller involucels (vs. involucels longer than 10 mm in fruit). Although the new species is similar to *C. elmaliensis* in terms of pollen shape and general appearance, its pollens are larger in terms of mean equatorial diameter and polar axis. Following morphological data, molecular analyses (based on ITS and *trnL* introns) indicated that the phylogenetically closest relative of the species is also *C. elmaliensis*. Additionally, we report that taxonomic notes for this new species are provided, including distribution, ecology, and conservation status.

Key words: Anatolia, *Cephalaria*, endemic, palynology, phylogeny

1. Introduction

The genus *Cephalaria* Schrader ex Roemer & Schultes, long assumed to belong to the Dipsacaceae Juss., has been reclassified by the Angiosperm Phylogeny Group (APG III) to be a member of the Caprifoliaceae Juss. (Mabberley, 1997; Reveal and Chase 2011; Reveal 2012). The species of *Cephalaria* are found throughout the world, but they are mostly distributed in South Africa and the Holarctic Kingdom, which includes the Mediterranean region (Szabó, 1940). This genus, which includes approximately 100 species worldwide, is represented by 44 taxa in Türkiye (Matthews, 1972, 1988; Sümbül, 1991; Göktürk and Sümbül, 1997; Göktürk et al., 2003; Göktürk and Sümbül, 2003; Kuş and Göktürk, 2005; Aksoy et al., 2007; Parolly and Eren, 2007; Göktürk et al., 2012; Göktürk and Sümbül, 2014; Göktürk and Sümbül, 2016; Ranjbar and Ranjbar, 2018; Yıldırımlı, 2019; Göktürk et al., 2023).

It is widely recognized that morphological traits of pollen grains constitute additional diagnostic elements that are frequently employed in taxonomy and in reconstructing potential evolutionary patterns of different plant groups (Celenk et al., 2008; Jacobs et al., 2011; Yıldız et al., 2011; Tsymbalyuk et al., 2018, 2019a, 2019b, 2021; Cui et al., 2020). There have been few investigations of *Cephalaria* pollen morphology using light microscopy and scanning electron microscopy. The results of the investigations can be summarized as follows: pollen grains are triporate, suboblate to subprolate, large-sized, circular or eliptic in equatrial view, circular to triangular in polar view, and have lolongate to circular pores (Erdtman, 1952; Vinokurova, 1959; Halbritter and Svojtka, 2016; Mostafa et al., 2017; Halbritter and Weis, 2018; Tsymbalyuk et al., 2021).

Although morphological characterization studies are extremely beneficial in identifying species, they are occasionally influenced by environmental variables and do not always represent genetic variations. However, because molecular approaches directly identify the species' genetic traits, they can enable the identification of different species based primarily on physical similarities and differences (Kaya and Yılmaz Gökdoğan, 2016; Ahmed et al., 2017). The genetic code of the species determines the extent to which relationships between species with similar ancestry are passed down across generations. As a result, the methods used for the examination of genetic material are completely able to distinguish between genera, species, and even individuals from the same species (Göktürk et al., 2023).

* Correspondence: gsemiz@pau.edu.tr

During floristic fieldwork for plant biodiversity, the first author collected some interesting specimens from Girdev Mountain in 2020. All samples were compared to specimens from related *Cephalaria* taxa that have been deposited in different herbaria. In addition, the relevant literature was searched (Matthews, 1972, 1988; Sümbül, 1991; Göktürk and Sümbül, 1997; Göktürk et al., 2003; Göktürk and Sümbül, 2003; Kuş and Göktürk, 2005; Aksoy et al., 2007; Parolly and Eren, 2007; Göktürk et al., 2012; Göktürk and Sümbül, 2014; Göktürk and Sümbül, 2016; Ranjbar and Ranjbar, 2018; Yıldırımlı, 2019; Göktürk et al., 2023). Our samples were determined to belong to a previously unidentified species after extensive comparisons based on morphology, palynology, and genetic investigations. In this context, we compared these specimens to the closely related *Cephalaria elmaliensis* Hub.-Mor. & Matthews via morphological, palynological, and molecular assessments. Hereby, we report the morphological, palynological, and molecular differences between the *Cephalaria gokturkii* and its allied *Cephalaria elmaliensis*.

2. Materials and methods

2.1. Plant materials

Plant samples were collected by the first author from Girdev Mountain in Muğla of the southwest Turkish province (Figure 1). Using the most recent research (Göktürk et al., 2012, 2023); the specimens were recognized and compared to herbaria materials. The IPNI database (2012) was used to check plant names, Brummitt and Powell (1992) used to check plant author names, and Punt et al. (2007) utilized pollen morphology terminology.

2.2. Morphological and palynological studies

The morphological data was gathered through micro- and macromorphological analyses using light binocular and scanning electron microscopy (SEM) methods. The pollen was cleaned with 70% ethanol for the SEM analysis, then dried and mounted with gold-palladium stubs. The samples were covered with Quarum 150 RS Au-Pd, and SEM photomicrographs were captured using a Zeiss Supra 40 VP Electron Microscope.

2.3. Molecular studies

DNA extraction was carried out based on the leaves of herbarium samples of the new species and *C. elmaliensis*. For the determination of phylogenetical positions of targeted species, the ITS and *trnL* intron regions were selected and amplified (Table 1). And then, the sequences used here were downloaded from the Genbank (NCBI). Total DNA extraction was performed via 2X CTAB method described by Doyle and Doyle (1987) and modified by Soltis et al. (1991) and Cullings (1992). The universal primers (ITS1 and ITS4) were selected for the amplification of ITS regions (White et al., 1990). ITS-PCR conditions were enforced according to Garcia-Jacas et al. (2006). For the *trnL*, *trn*c-d primers were used and previous protocols were preferred (Taberlet et al., 1991). Purification and reading of DNA intron sequences were accomplished through service procurement (Macrogen, Netherlands). Alignments were performed through the use of Bioedit v.7.0.5.3 version (Hall, 1999). Typical phylogenetic trees based on both intron regions were created separately for the targeted species. Because of observed similar and common topology, ITS and *trnL* introns data were combined and, finally the phylogenetical

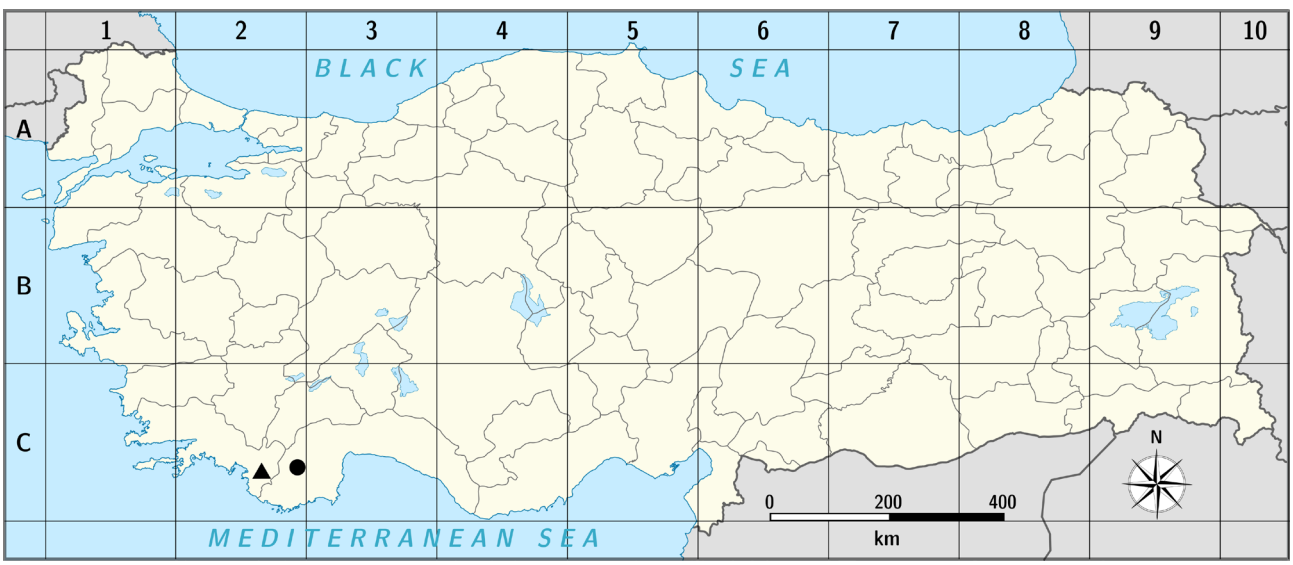

Figure 1. Distribution map of *C. gokturkii* (▲) and *C. elmaliensis* (●).

Table 1. Genbank assessions numbers of *Cephalaria* and its related taxa.

Species	**ITS**	***trnL* intron**
Cephalaria leucantha	KF993465	AJ427376
Cephalaria gokturkii	PP573510 (In this study)	PP566122 (In this study)
Cephalaria elmaliensis	PP573511 (In this study)	PP566123 (In this study)
Cephalaria squamiflora subsp. *mediterranea*	FJ379654 FJ379702	FJ379629
Cephalaria microcephala	FJ640759	FJ640657
Cephalaria paphlagonica	FJ640758	FJ640659
Cephalaria aristata	FJ640757	FJ640656
Cephalaria tenella	FJ640756	FJ640653
Cephalaria zeyheriana	FJ640755	FJ640654
Cephalaria natalensis	FJ640754	FJ640655
Cephalaria hirsuta	FJ640760 FJ640790	FJ640658
Cephalaria syriaca	AJ426525 AJ426526	AJ427377
Dipsacus mitis	AY236187	AF446977

trees were built by PAUP and MrBayes. The parsimony and Heuristic searches were performed by using of PAUP v.4.0b10 version (Swofford, 2002). By means of PAUP, the homoplasy index (HI), consistency index (CI), and retention index (RI) were determined for the strict consensus tree, with the exclusion of the uninformative characters. The MrModelTest v2.2 was useful in identifying the best-fit model regarding DNA evolution and it was determined according to Akaike information criterion (AIC) (Nylander, 2004). In Bayesian analyses, two independent runs of four Metropolis-coupled chains each were operated for 72×10^3 generations, sampling every 1000 generations. Almost, 20%of all generations sampled (20%) were discarded after they were visually examined with regard to the likelihood score plots in Tracer v.1.7.0 version (Rambaut et al., 2018). Finally, the graphical views of phylogenetic trees were created in the FigTree v1.4.0 program.

3. Results

3.1. Taxonomic treatment

Cephalaria gokturkii Semiz & Uysal *sp. nov.* (Figures 2 and 3)

Type:—TÜRKİYE. Muğla: Seydiler, Girdev Mountain, Girdev Plateau, on limestone, 1800–1900 m, 19 July 2020, G.Semiz GSE 2182 (holotype: PAUB!; isotype: KNYA!, AKDU!).

Diagnosis: *Cephalaria gokturkii* is closely related to *C. elmaliensis*. The distinctive characteristics of these species are: a) The capitula size of *C. gokturkii* is 2.0–3.2 cm diameter (not smaller than 2.0 cm); b) while the involucel is less than 10 mm long in fruit in *C. gokturkii*, it is longer than 10 mm long in *C. elmaliensis*; c) other typical characters: the lower leaves simple or lyrate; lyrate cauline leaves broadly lanceolate; lyrate leaf segments lanceolate to triangular; corolla cream; receptacular bracts oblanceolate.

Description: Slender, erect, or ascending perennial herbs. Stem 49.10–95.50 (89.50 ± 4.42) cm, simple or 2–7 branched in the upper part, longitudinally striate, minute puberulent and densely stellate (one of the hairs conspicuously longer) in stem and sericeous in nodes. Leaves coriaceous, densely stellate (one of the hairs conspicuously longer on rachis), acute at apex; lower leaves simple or lyrate; simple leaves entire or denticulate, lanceolate or oblanceolate, 7.20–47.50 (28.96 ± 2.21) × 1.70–4.60 (3.00 ± 0.19) cm; lyrate leaves broadly lanceolate in outline, 15.80–36.90 (27.96 ± 1.87) cm, with 2–7 segments, lateral segments lanceolate to triangular, entire, 0.50–5.40 (2.50 ± 0.34) × 0.2–1.8 (0.98 ± 0.13) cm, terminal segments larger than laterals, lanceolate or narrowly-lanceolate, 11.30–22.70 (15.54 ± 0.74) × 1.60–3.70 (2.6 ± 0.15) cm; cauline leaves simple or lyrate, simple leaves lanceolate or linear-lanceolate, 6.60–30.30 (19.28 ± 2.30) × 1.10–3.40 (2.19 ± 0.24) cm, lyrate leaves broadly lanceolate in outline, 6.20–32.10 (18.00 ± 1.77) cm, with 3–7 segments, lateral segments lanceolate to triangular, 0.40–6.40 (2.09 ± 0.35) × 0.10–1.70 (0.57 ± 0.10) cm, terminal segments larger than lateral ones, lanceolate or broadly lanceolate, 4.90–27.30 (13.29 ± 1.21) × 0.60–4.00 (2.63 ± 0.26) cm; upper leaves simple, sessile, linear, 1.00–8.60 (4.45 ± 0.50) × 0.10–1.10 (0.57 ± 0.07) cm. Capitula subglobose,

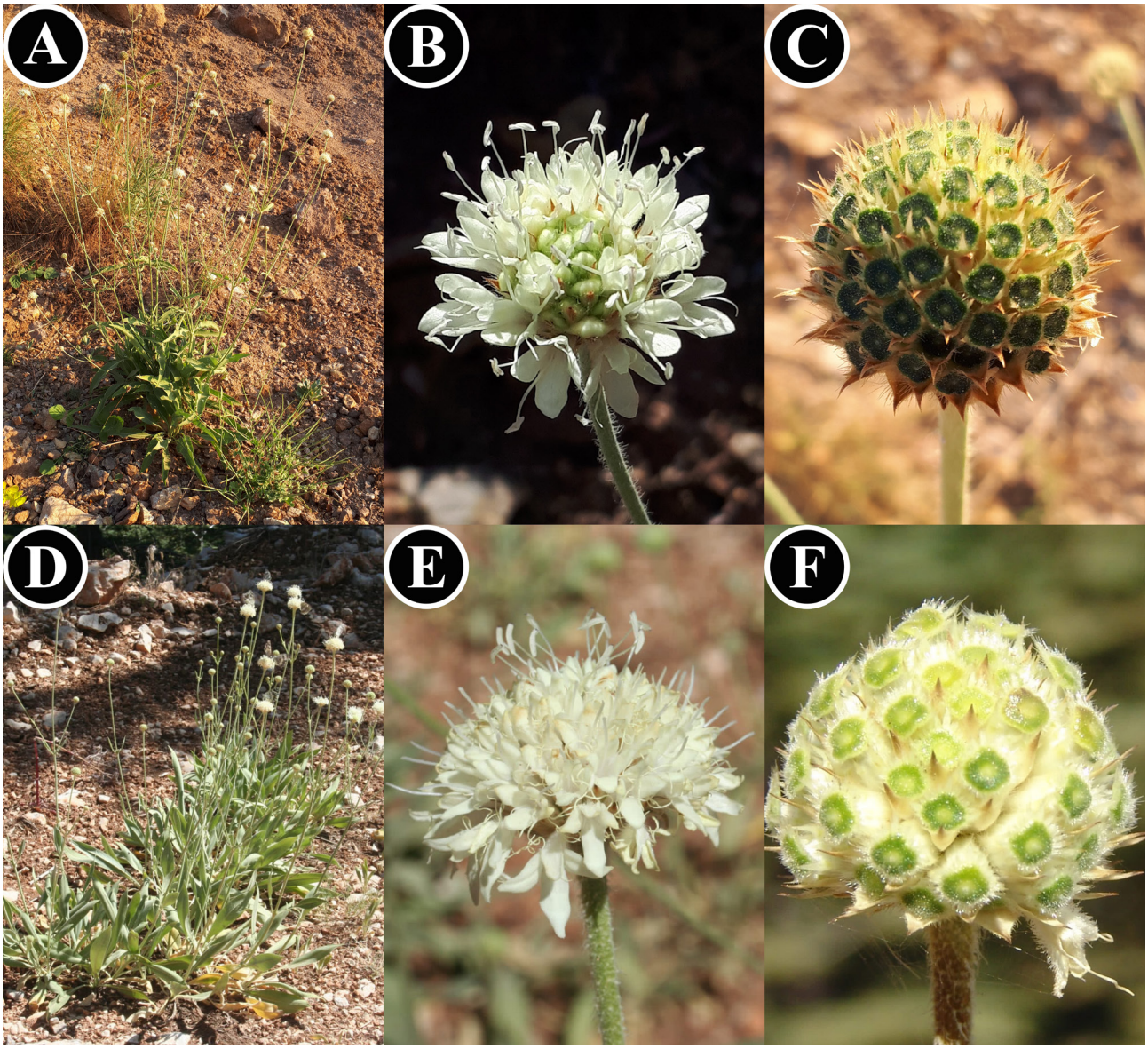

Figure 2. General habitus (A), capitula (B) and involucel (C) of *C. gokturkii*. General habitus (D), capitula (E) and involucel (F) of *C. elmaliensis*.

Figure 3. Involucels (A), Receptacular bracts (B), and Involucral bracts (C) of *C. gokturkii* (1) and *C. elmaliensis* (2).

50–80-flowered, 2.00–3.20 (2.68 ± 0.06) cm in diameter in flower, 1.70–2.80 (2.34 ± 0.06) cm in diameter in fruit. Involucral bracts hairy trigonous-narrowly ovate, 4.24–6.67 (5.25 ± 0.17) × 4.78–7.04 (5.97 ± 0.16) mm, straw-coloured, brownish in dorsal and apex, pilose, margins ciliate, obtuse at apex; receptacular bracts oblanceolate, 7.43–11.81 (10.21 ± 0.28) × 2.68–6.40 (3.87 ± 0.23) mm, straw-coloured, brownish in dorsal and apex, pilose, margin ciliate, pilose at apex, acute at apex. Calyx cupuliform, 3.08–6.52 (5.17 ± 0.21) mm, with irregular teeth. Corolla cream, 10.59–15.65 (13.62 ± 0.36) mm long, densely ± adpressed pilose outside. Involucel 4-angled, 6.82–8.80 (7.79 ± 0.12) mm in fruit, pilose, 4 long and 4 short teeth at apex; long teeth 2.89–4.27 (3.36 ± 0.07) mm long, short teeth 0.95–2.19 (1.62 ± 0.08) mm long.

Distribution and ecology: *Cephalaria gokturkii* is endemic to south-west Anatolia, Türkiye. This species grows in calcareous grasslands at altitudes between 1800 and 1900 m. This endemic new species is associated with other endemics such as *Centaurea inexpectata* Wagenitz, *Salvia chrysophylla* Stapf, and *Echinops emiliae* P.H.Davis.

Phenology: Flowering from June to July. Fruiting from July to August.

A modified Identification Key updated from Göktürk and Sümbül Revision (2014) for the taxa growing in Türkiye.

1. Perennials
8. Plant with stellate hairs
9. Only lower leaves with sparse stellate hairs, stem hollow ..... *C. demirizii*
9. Stem and leaves with dense stellate hairs, stem not hollow
10. Plant stout, taller than 1 m high
10. Plant slender, up to 1 m high
14. Lower and cauline leaves oblong-spathulate ..... *C. stellipilis*
14. Lower and cauline leaves lanceolate
15. Capitula ovoid; involucral bracts ovate-orbicular or orbicular; involucel sericeous ..... *C. elazigensis*
15. Capitula subglobose; involucral bracts ovate; involucel pilose
16. Capitula 1–2 cm diameter in flower, involucel longer than 10 mm long in fruit ..... *C. elmaliensis*
16. Capitula 2–3.2 cm diameter in flower, involucel less than 10 mm long in fruit ..... *C. gokturkii*

Etymology: The specific epithet was dedicated to Prof. Dr. Ramazan Süleyman GÖKTÜRK (Akdeniz University, Türkiye), a Turkish botanist who made an outstanding contribution to the *Cephalaria* genus in Türkiye.

Vernacular name: Girdev pelemiri (Menemen et al., 2016).

Proposed conservation status: *Cephalaria gokturkii* is known only from one locality with small subpopulations in Girdev Mountain. It is suggested that this new species should be placed under the IUCN threat category "Critically Endangered (CR)" (IUCN 2019), because the estimated area of occupancy is less than 10 km^2, and there is only one known location. The population size of the new species is estimated to be less than 50 mature individuals in each subpopulation [CR B2ab(ii, iii, v) + C2a(i)]. The population size of the new species may decrease in the near future due to intense grazing pressure and anthropogenic effects.

3.2. Morphological comparison

The new species, *C. gokturkii,* is closely related to *C. elmaliensis*. These species share some common features, such as a slender stem, a flowering stem covered by stellate hairs, subglobose capitula, ovate involucral bracts, and pilose involucels. However, the distinctive characteristics of these species are a) Capitula 2.0–3.2 cm diameter in flower in *C. gokturkii* (vs. capitula 1–2 cm); b) while the involucel is less than 10 mm long in fruit in *C. gokturkii*, it is longer than 10 mm long in *C. elmaliensis*; c) other typical characters: the lower leaves simple or lyrate; lyrate cauline leaves broadly lanceolate; lyrate leaf segments lanceolate to triangular; corolla cream; receptacular bracts oblanceolate (Table 2).

3.3. Pollen morphology

Pollen grains are triporate, with lolongate pores, defined annulus and margins, and an indistinct, diffuse wide halo; aperture membranes have long, branched stick-shaped protrusions. Pollen grains are generally prolate-sphaeroidal, occasionally subprolate in equatorial view. Polar axis: 83.19–99.01 (90.92 ± 0.93) µm, equatorial axis: 66.31–87.68 (79.01 ± 1.05) µm, and P/E ratio: 1.09–1.30 (1.15 ± 0.01). AMB shape (polar view): circular, triangular to triangular, obtuse, convex. Pore length 18.26–25.43 (21.23 ± 0.41) µm and pore width 9.38–15.19 (12.50 ± 0.37) µm. Exine 5.29–6.75 (7.17 ± 0.08) µm, structure intectate. Sculpture echinulate. Detailed pollen morphological characters of the related species are presented in Figure 4 and Table 3.

3.4. Phylogenetic analyses

Phylogenetic analyses included 13 taxa, one of which was an outgroup. The aligned combined ITS+*trnL* intron data matrix consists of 1037 base pairs long, and 914 of them are constant. While the informative character number for parsimony was 42 and the uninformative was 81. The tree created by the PAUP program has reliable tree scores (CI: 0.860, RI: 0.589, and HI: 0.140). Bayesian analysis was executed with the TIM2+I+G model according to the chosen AIC criteria. Parsimony and Bayesian trees created with ITS and *trnL* intron data were combined because their topologies were similar (Figure 5).

Table 2. Morphological comparison of *C. gokturkii* and *C. elmaliensis*.

	C. gokturkii	***C. elmaliensis***
Basal and lower leaves	simple or lyrate	simple
Cauline leaves	simple or lyrate, lyrate leaves having lanceolate to triangular segments in outline	simple or lyrate, lyrate leaves having narrowly ovate-lanceolate outline
Capitula	2–3.2 cm diameter in flower	1–2 cm diameter in flower
Corolla	cream	yellow or cream
Involucral bracts	trigonous-narrowly ovate, obtuse at the apex	ovate, acute at the apex
Receptacular bracts	Oblanceolate to oblong, broader; up to 6.4 mm in wide, acute at the apex	narrowly ovate or lanceolate, narrower; up to 3 mm in wide, acuminate at the apex
Involucel	Narrowly obovoid-oblong, 6–9 mm in fruit, long teeth 2.8–4.2 mm in long, short teeth 0.9–2.1 mm in long	Ovoid, 10–12 mm in fruit, long teeth 3 mm in long, short teeth 1 mm in long

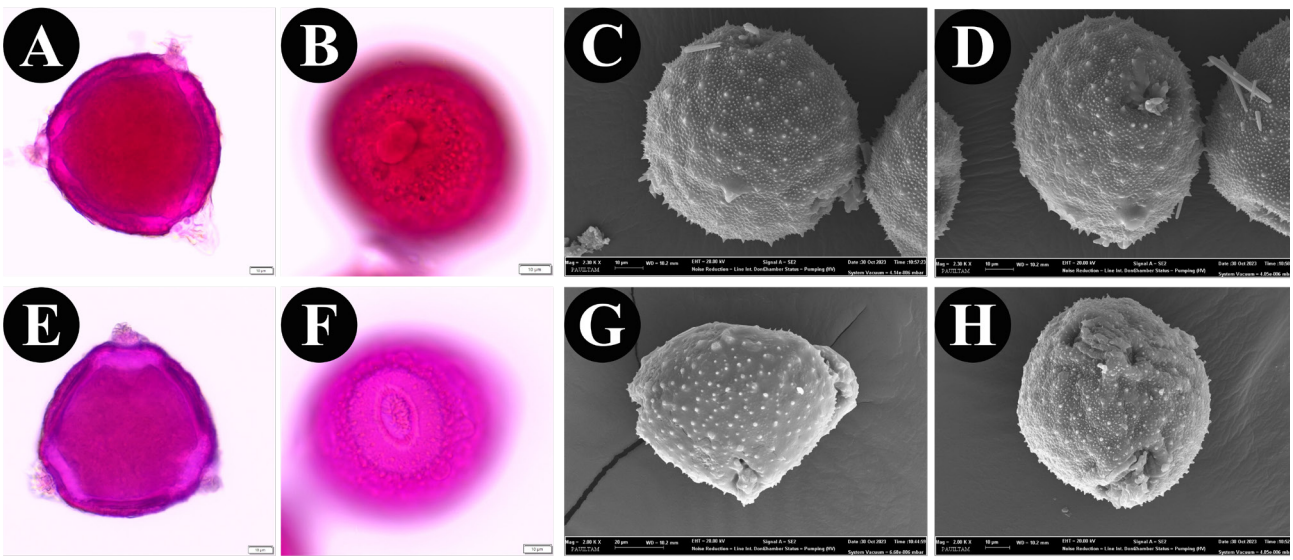

Figure 4. Pollen morphology of *C. gokturkii* and *C. elmaliensis*. A. Equatorial view of *C. elmaliensis* in LM, B. Polar view of *C. elmaliensis* in LM, C. Equatorial view of *C. elmaliensis* in SEM, D. Polar view of *C. elmaliensis* in SEM, E. Equatorial view of *C. gokturkii* in LM, F. Polar view of *C. gokturkii* in LM, G. Equatorial view of *C. gokturkii* in SEM, H. Polar view of *C. gokturkii* in SEM.

4. Discussion

Although the genus *Cephalaria* is relatively complex in taxonomic terms, it has many macro- and micromorphological characters that can be used to solve the problems of the genus. In the revision of Göktürk and Sumbul (2014), a lot of characters were presented, such as habit, life form, indumentum, calyx, flower, involucel, involucral, and receptacular bracts, which are similar diagnoses in the Flora of Türkiye (Matthews, 1972), but more distinctive and comprehensive. When we looked generally at *Cephalaria*, there are a few species with stellate hairs in the Flora of Türkiye, and among these, only *C. demirizii* has hollow stems. In this group, almost all the remaining species consist of endemic species (such as *C. davisiiana*, *C. duzceensis, C. elmaliensis, C. sumbuliana*, and *C. elazigensis*) with solid stems and simple or lyrate leaves. Among these, *C. elazigensis* and C. *elmaliensis* species are among the species whose stems are more slender and generally shorter than one m and whose leaves are mostly not divided (entire), and they are similar to the

Table 3. Measurements of pollen characters in *C. gokturkii* and *C. elmaliensis*.

	C. gokturkii				*C. elmaliensis*			
	Min.	**Max.**	**Mean**	**SE**	**Min.**	**Max.**	**Mean**	**SE**
P	83.19	99.01	90.92	0.93	78.31	89.39	82.83	0.72
E	66.31	87.68	79.01	1.05	69.09	81.39	74.89	0.72
P/E	1.09	1.30	1.15	0.01	1.04	1.17	1.11	0.01
Plg	18.26	25.43	21.23	0.41	12.10	18.95	15.67	0.39
Plt	9.38	15.19	12.50	0.37	10.14	15.47	12.35	0.36
Plg/Plt	1.33	2.51	1.73	0.07	1.13	1.51	1.27	0.02
Ex	5.29	6.75	6.17	0.08	5.22	7.51	6.60	0.12
Ann	2.33	3.14	2.79	0.05	2.13	2.93	1.52	0.05

All measurements given in µm (P: Polar axis, E: Equatorial axis, P/E: Ratio of polar axis to equatorial axis-pollen shape, Plg: Pore length, Plt: Pore width, Plg/Plt: Ratio of pore length to pore width, Ex: Exine, Ann: Annulus, Min: Minimum value, Max: Maximum value, Mean: Average of measurements, SE: Standard Error).

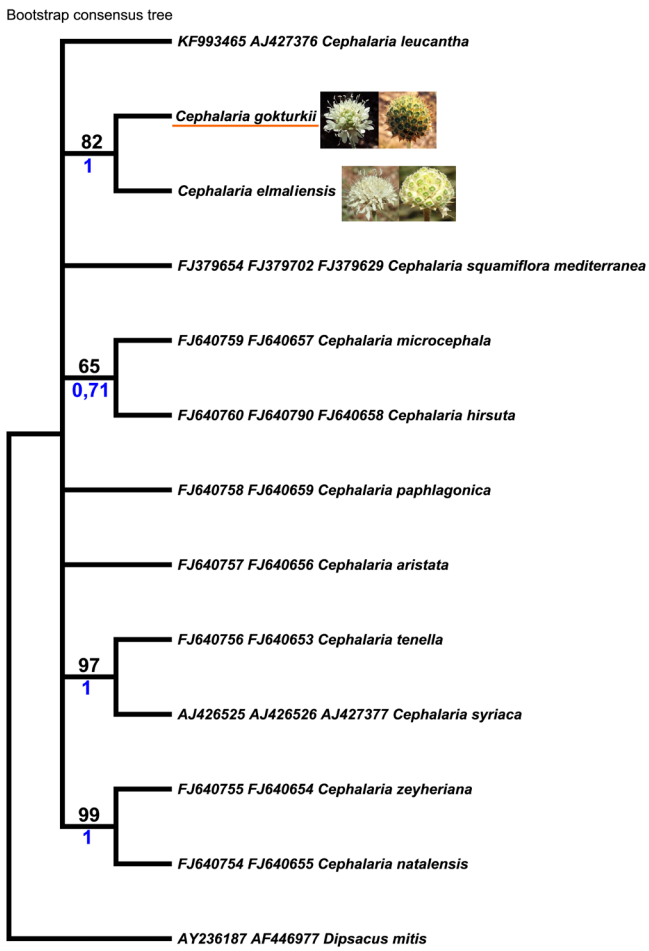

Figure 5. Phylogenetic tree obtained from the Parsimony and Bayesian analysis of combined (ITS and *trnL* intron) data. *Dipsacus mitis* was used as an outgroup. In branches, the upper value represents parsimony bootstrap, while the bottom value represents Bayesian posterior probability.

new species in terms of these features. The new species is seen as morphologically close to C. *elmaliensis*, and comprehensive comparisons are given in the diagnosis section and Table 2.

According to Khalik (2010), pollen grains of the Dipsacaceae family are heterogeneous and eurypalynous, allowing for the division of the grains into multiple groups. These classifications mostly agree with the previously hypothesized Dipsacaceae groupings based on macromorphological and phylogenetic characteristics. Our findings confirm this basic assessment that there is an important correlation among these data. Besides this conclusion, Tsymbalyuk et al. (2021) mentioned that there are some additional diagnostic characters at the species level in *Cephalaria* and they can be used for taxonomy. Currently, these palynologic characters are the size of pollen grains and pores, the shape of pores, the width of the annulus, the structure of the exine, the dimension of echini and microechini, the location of microechini, and the presence/absence of nanoechini. In terms of exin sculpture, two main structures in *Cephalaria* that could be classified as echinate-microechinate and echinate-microechinate-nanoechinates. The first sculpture type is seen commonly in the majority of Dipsacaceae (now Caprifoliaceae) species. It is clear that C. *elmaliensis* has a second pollen type in consideration of sculpture ornamentations, but the new species has the first type commonly seen in most of Honeysuckle family type. The facial ornamentation in *C. gokturkii* is fairly sparse compared to that in *C. elmaliensis*.

According to prior molecular phylogenetic analysis, *Cephalaria* is sister to *Dipsacus* L. (Avino et al., 2009). It differs from *Dipsacus* anatomically by having a more or less continuous subepidermal sclerenchyma layer in the epicalyx and morphologically by having softer indumentum on the vegetative parts and floral bracts that are less pungent and roughly as long as the flowers (Mayer and Ehrendorfer, 2013). The Mediterranean Basin and surrounding western Eurasia are home to the family's center of diversity, while species can also be found in Asia, and eastern and southern Africa. According to Rosselló et al. (2009), there is a good reason for the recent publication of many new species in the Mediterranean basin: both cpDNA and ribosomal sequences have revealed a highly structured pattern of molecular variation made up of sister monophyletic lineages that resemble major biogeographic units. Our molecular analyses showed that the new species is not only morphologically but also phylogenetically related to *C. elmaliensis*. The closest positions to the monophyletic clade (*C. gokturkii* and *C. elmaliensis*) are other two Mediterranean species, *C. squamiflora* and *C. leucantha*.

Specimen examined:

Cephalaria elmaliensis:—TÜRKİYE. Antalya: Elmalı, Keçova, hillsides, vii 1964, Fahri Demirdöğen 2577 (E!). Antalya, Elmalı, Çığlıkara Cedar forests, 1110 m, Avlan lake north-eastern slopes, limestone, 02 vii 1974, R. Çetik 2197 (KNYA!). Antalya: Elmalı, Çığlıkara, around the guardhouse, *Cedrus libani* clearings,1700–1900 m, 25 viii 1993, H. Duman 5345, Z. Aytaç & A.A.Dönmez (GAZI!, AKDU!). Antalya, Elmalı, Çığlıkara, around the guardhouse, 1900 m, rocky places and *Cedrus libani* clearings, 12 viii 1995, R.S.Göktürk 3532 (AKDU!).

Acknowledgments

This research was financially supported by the Pamukkale University Scientific Research Coordination Unit (project no: 2022FEBE022). The authors are thankful to the curators GAZI, AKDU, and KNYA herbaria. The authors are thankful to the editor and the referees for their careful reading of the manuscript and for the useful remarks that allow us to improve the text and clarify some of the results.

Author contribution statement

G.S. and B.G.–Collection of plant material in the field, identification of plant material, preparation of the first draft of the manuscript; M.B and T.U.–Molecular and phylogenetic assays; G.S., M.B., B.G., and T.U. –Writing, review and editing of the manuscript. All authors contributed equally to the final version of the manuscript.

References

Ahmed S, Rattanpal HS, Kumari P, Singh J (2017). Study of genetic variability in *Citrus* fruit crop by molecular markers - a review. Indian Journal of Pure & Applied Biosciences 5 (1): 111–128. https://doi.org/10.18782/2320-7051.2480

Aksoy N, Göktürk RS, Açık L, Çelebi A (2007). *Cephalaria duzceënsis* (Dipsacaceae), a new species from the western Black Sea Region, Turkey. Nordic Journal of Botany 25: 64–69.

Avino M, Tortoriello G, Caputo P (2009). A phylogenetic analysis of Dipsacaceae based on four DNA regions. Plant Systematics and Evolution 279: 69–86. https://doi.org/10.1007/s00606-009-0147-y

Brummitt RK, Powell CE (1992). Authors of plant names. A list of authors of scientific names of plants, with recommended standard forms of their names, including abbreviations. Kew, UK: Royal Botanic Gardens. 732 pp.

Celenk S, Dirmenci T, Malyer H, Bicakci A (2008). A palynological study of the genus *Nepeta* L. (Lamiaceae). Plant Systematics and Evolution 276: 105–123. https://doi.org/10.1007/s00606-008-0062-7

Cui X, Hu Z, Ren S, Liu J (2020). Pollen morphology of Chinese *Pseudostellaria* (Caryophyllaceae) and its systematic significance. Microscopy Research and Technique 83 (5): 481–489. https://doi.org/10.1002/jemt.23436

Cullings KW (1992). Design and testing of a plant-specific PCR primer for ecological and evolutionary studies. Molecular Ecology 1: 233–240. https://doi.org/10.1111/j.1365-294X.1992.tb00182.x

Doyle JJ, Doyle JL (1987). A rapid DNA isolation procedure for small quantities of fresh leaf tissue. Phytochemical Bulletin, Botanical Society of America 19: 11–15.

Erdtman, G (1952). Pollen Morphology and Plant Taxonomy, Geologiska Föreningen i Stockholm Förhandlingar 74 (4): 526–527. https://doi.org/10.1080/11035895209453507

Felsenstein J (1985). Confidence limits on phylogenies: An approach using the bootstrap. Evolution 39: 783–791. https://doi.org/10.2307/2408678

Garcia-Jacas N, Uysal T, Romashchenko K, Suárez-Santiago VN, Ertuğrul K et al. (2006). *Centaurea* revisited: A molecular survey of the Jacea group. Annals of Botany 98: 741–753. https://doi.org/10.1093/aob/mcl157

Göktürk RS, Sümbül H (1997). A new species of *Cephalaria* (Dipsacaceae) from South Anatolia, Turkey. Annales Botanici Fennici 34: 153–155.

Göktürk RS, Sümbül H (2003). *Cephalaria aytachii* (Dipsacaceae), a new species from Central Anatolia, Turkey. Annales Botanici Fennici 40: 123–127.

Göktürk RS, Sümbül H (2014). A taxonomic revision of the genus *Cephalaria* (Caprifoliaceae) in Turkey. Turkish Journal of Botany 38: 927–968. https://doi.org/10.3906/bot-1310-6

Göktürk RS, Sümbül H (2016). *Cephalaria anamurensis* (Caprifoliaceae), a new species from south Anatolia, Turkey. PhytoKeys 65: 25–33. https://doi.org/10.3897/phytokeys.65.8571

Göktürk RS, Sümbül H, Açık L (2003). A new species of *Cephalaria* Schrad. ex Roem. & Schult. (Dipsacaceae), including a new variety from East Anatolia, Turkey. Israel Journal of Plant Sciences 51: 59–65.

Göktürk RS, Sümbül H, Çelebi A, Açık L (2012). Two new species of *Cephalaria* (Caprifoliaceae) from Turkey. Turkish Journal of Botany 36: 311–321. https://doi.org/10.3906/bot-1101-4

Göktürk RS, Yüceol F, Galatali S, Kaya E, Hamzaoğlu E et al. (2023). A New *Cephalaria* (Caprifoliaceae) *Species* from Turkey. Phytotaxa 587 (2): 173–183. https://doi.org/10.11646/phytotaxa.587.2.6

Halbritter H, Svojtka M (2016). *Cephalaria transylvanica*. PalDat–A palynological database. Retrieved from https://www.paldat.org/pub/Cephalaria_transylvanica/301808.

Halbritter H, Weis B (2018). *Cephalaria leucantha*. PalDat–A palynological database. Retrieved from https://www.paldat.org/pub/Cephalaria_leucantha/303191

Hall TA (1999). BioEdit: a user-friendly biological sequence alignment editor and analysis program for Windows 95/98/NT. Nucleic Acids Symposium Series 41: 95–98.

IPNI (2012). International Plant Names Check-List [online]. Available from http://www.ipni.org/ipni/authorsearchpage.do. [Accessed 18 September 2023].

IUCN (2019). Guidelines for using the IUCN Red List Categories and Criteria. Version 15.1. Prepared by the Standards and Petitions Subcommittee. https://www.iucnredlist.org/resources/redlistguidelines [accessed on 22 December 2023].

Jacobs B, Geuten K, Pyck N, Huysmans S, Jansen S et al. (2011). Unraveling the phylogeny of *Heptacodium* and *Zabelia* (Caprifoliaceae): an interdisciplinary approach. Systematic Botany 36(1): 231–252. https://doi.org/10.1600/036364411X553306

Kaya E, Yılmaz Gökdoğan E (2016). Using two retrotransposon based marker systems (IRAP and REMAP) for molecular characterization of olive (*Olea europaea* L.) cultivars. Notulae Botanicae Horti Agrobotanici Cluj-Napoca 44 (1): 167–174. https://doi.org/10.15835/nbha44110158

Khalik KA (2010). A palynological study of the family Dipsacaceae in Egypt and its taxonomic significance. Feddes Repertorium 121 (3–4): 97–111. https://doi.org/10.1002/fedr.201000004

Kuş S, Göktürk RS (2005). A new *Cephalaria* species (Dipsacaceae) from the European part of Turkey. Nordic Journal of Botany 23: 427–430. https://doi.org/10.1111/j.1756-1051.2003.tb00415.x

Mabberley DJ (1997). The plant-book: A portable dictionary of the vascular plants. Cambridge, England: Cambridge University Press.

Matthews VA (1972). *Cephalaria* Schrad. ex Roem. & Schult. In: Davis PH (editor). Flora of Turkey and the East Aegean Islands, Vol. 4. Edinburgh, UK: Edinburgh University Press, pp. 585–597.

Matthews, V.A. (1988) *Cephalaria* Schrad. ex Roem. & Schult. In: Davis PH, Mill RR, Tan K (editors). Flora of Turkey and the East Aegean Islands, Vol.10, suppl. Edinburgh, UK: Edinburgh University Press, pp. 156.

Mayer V, Ehrendorfer F (2013). The phylogenetic position of *Pterocephalidium* and the new African genus *Pterothamnus* within an improved classification of Dipsacaceae. Taxon 62: 112–126. https://doi.org/10.1002/tax.621010

Menemen Y, Kandemir A, Aytaç Z (2016). Türkçe bilimsel bitki adları yönergesi (Directive of Turkish scientific plant names). Bağbahçe Bilim Dergisi 3: 1–3 (in Turkish).

Mostafa EN, Sedigheh NS, Rosa E (2017). Pollen characters as taxonomic evidence in some species of Dipsacaceae from Iran. Bangladesh Journal of Plant Taxonomy 24 (2): 129–136. https://doi.org/10.3329/bjpt.v24i2.35108

Nylander JAA (2004). MrModel test. Version 2.2. Computer Program Distributed by the Author.

Parolly G, Eren Ö (2007). Contributions to the Flora of Turkey, 2. Willdenowia 37: 243–271. https://doi.org/10.3372/wi.37.37114

Punt W, Hoen PP, Blackmore S, Nilsson S, Le Thomas A (2007). Glossary of pollen and spore terminology. Review of Palaeobotany and Palynology 143 (1-2): 1–81. https://doi.org/10.1016/j.revpalbo.2006.06.008

Rambaut A, Drummond AJ, Xie D, Baele G, Suchard MA (2018). Posterior summarisation in Bayesian phylogenetics using Tracer 1.7. Systematic Biology 67 (5): 901–904. https://doi.org/10.1093/sysbio/syy032

Ranjbar M, Ranjbar Z (2018). A contribution to the taxonomy of *Cephalaria* subgen. *Cephalaria* (Caprifoliaceae) in eastern Turkey. Feddes Repertorium 129: 13–24. https://doi.org/10.1002/fedr.201700004

Reveal JL (2012). An outline of a classification scheme for extant flowering plants. Phyton 37: 1–221. Retrieved from https://www.phytoneuron.net/PhytoNMagnoliidae.pdf

Reveal JL, Chase MW (2011). APG III: Bibliographical information and synonymy of Magnoliidae. Phytotaxa 19: 71–134. https://doi.org/10.11646/phytotaxa.19.1.4

Rosselló JA, Cosín R, Bacchetta G, Brullo S, Mayol M (2009). Nuclear and chloroplast DNA variation in *Cephalaria squamiflora* (Dipsacaceae), a disjunct Mediterranean species Taxon 58 (4): 1242–1253. https://doi.org/10.1002/tax.584015

Soltis DE, Soltis PS, Collier TG, Edgerton ML (1991). Chloroplast DNA variation within and among genera of the *Heuchera* group (Saxifragaceae): evidence for chloroplast transfer and paraphyly. American Journal of Botany 78: 1091–1112. https://doi.org/10.2307/2444898

Sümbül H (1991). Ten new species from Anatolia and two new records for the flora of Turkey. Edinburgh Journal of Botany 48 (1): 27–40. https://doi.org/10.1017/S0960428600003577

Swofford DL (2002). PAUP*. Phylogenetic Analysis Using Parsimony (* and other methods), ver. 4.0b10. Sinauer Associates, Sunderland.

Szabó Z (1940). *Cephalaria*-génusz monográfiája. Budapest, Hungary: Kiadja A Magyar Tudományos Akadémia Press.

Taberlet P, Gelly L, Pautou G, Bouvet J (1991). Universal primers for amplification of three noncoding regions of chloroplast DNA. Plant Molecular Biology 17: 1105–1109. https://doi.org/10.1007/BF00037152

Tsymbalyuk ZM, Bezusko LG, Nitsenko LM (2018). Pollen morphology of species of the genus *Knautia* (Dipsacaceae) in Ukraine: an assessment for taxonomy and spore pollen analysis. Ukrainian Botanical Journal 75 (3): 248–259. https://doi.org/10.15407/ukrbotj75.03.248

Tsymbalyuk ZM, Bezusko LG, Mosyakin SL, Nitsenko LM (2019a). Pollen morphology of species of *Dipsacus* (Dipsacaceae) in the flora of Ukraine: significance for taxonomy and spore-pollen analysis. Ukrainian Botanical Journal 76 (1): 9–23. https://doi.org/10.15407/ukrbotj76.01.009

Tsymbalyuk ZM, Mosyakin SL, Nitsenko LM (2019b). Taxonomic significance of pollen morphology in *Succisa* and *Succisella*. Biodiversity Research and Conservation 55 (1): 1–6. https://doi.org/10.2478/biorc-2019-0010

Tsymbalyuk ZM, Celenk S, Mosyakin SL, Nitsenko LM (2021). Pollen morphology of some species of the genus *Cephalaria* Schrad. (Caprifoliaceae) and its significance for taxonomy. Microscopy Research and Technique 84 (4): 682–694. https://doi.org/10.1002/jemt.23627

Vinokurova LV (1959). Palinologicheskie dannye k sistematike semeystv Dipsacaceae i Morinaceae. In: Problemy botaniki (Vol. 4). Moscow, USSR: Akademiya Nauk SSSR, pp. 51–67.

White TJ, Bruns T, Lee S, Taylor J (1990). Amplifcation and direct sequencing of fungal ribosomal RNA genes for phylogenetics. In: Innis MA, Gelfand DH, Sininsky JJ, White TJ (editors). PCR Protocols: A Guide to Methods and Applications, London, UK: Academic Press, pp. 315–322.

Yıldırımlı Ş (2019). Two new species of *Cephalaria* (Dipsacaceae/Caprifoliaceae) from Turkey. The Herb Journal of Systematic Botany 26 (2): 105–111.

Yıldız B, Arabacı T, Dirmenci T, Celenk S (2011). *Cirsium sivasicum* sp. nov. and *C. peshmenianum* sp. nov. (Asteraceae) and their allies from Turkey. Nordic Journal of Botany 29 (1): 26–37. https://doi.org/10.1111/j.1756-1051.2010.00811.x