Türler ve Habitatlar

(2022) 3(2): 119–136
e-ISSN: 2717-770X
https://dergipark.org.tr/tr/pub/turvehab

Research Article

https://doi.org/10.53803/turvehab.1189144

Macro- and Micro-morphological Studies on *Campanula lyrata* subsp. *icarica* (Campanulaceae) and *Erysimum aureum* (Brassicaceae), Recently Given as a New Record from Türkiye

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Received: 14.10.2022 Accepted: 12.11.2022 Published Online: 31.12.2022

Abstract

This study is based on micro- and macro-morphological features of *Campanula lyrata* subsp. *icarica* and *Erysimum aureum* taxa that have recently been reported in the flora of Türkiye. *Campanula lyrata* subsp. *icarica* is distributed mainly in the Eastern Aegean Islands, as well as in İzmir and Muğla provinces. *Erysimum aureum* is native to Central European Russia, Iran, North Caucasus, Northwest European Russia, South European Russia, Transcaucasus, and Ukraine, and is also distributed in Türkiye. Diagnostic characteristics, detailed descriptions, micro-morphological features (seeds and pollen grains) as well as differences between closely related species, diagnostic keys, locality information, and distribution maps of these taxa are provided in the present study.

Keywords: *Campanula,* Campanulaceae, *Erysimum,* Brassicaceae, micro-morphology, macro-morphology

Türkiye'den Yakın Zamanda Yeni Kayıt Olarak Verilen *Campanula lyrata* subsp. *icarica* (Campanulaceae) ve *Erysimum aureum* (Brassicaceae) Üzerine Makro- ve Mikro-morfolojik Çalışmalar

Özet

Bu çalışma, Türkiye'deki varlığı yakın zamanda belirlenen *Campanula lyrata* subsp. *icarica* ve *Erysimum aureum* taksonlarının mikro- ve makro-morfolojik özelliklerine dayanmaktadır. *Campanula lyrata* subsp. *icarica*, başlıca Doğu Ege adalarında, ayrıca İzmir ve Muğla illerinde yayılış göstermektedir. *Erysimum aureum*, Orta Avrupa Rusya, İran, Kuzey Kafkasya, Kuzeybatı Avrupa Rusya, Güney Avrupa Rusya, Transkafkasya ile Ukrayna'ya özgüdür ve ayrıca Türkiye'de de yayılış göstermektedir. Bu çalışmada taksonların ayırt edici özellikleri, detaylı betimlemeleri, mikro-morfolojik özellikleri (tohum ve polen) yanı sıra yakın akraba türler arasındaki farkları, teşhis anahtarları, lokalite bilgileri ve yayılış haritaları verilmiştir.

Anahtar kelimeler: *Campanula,* Campanulaceae, *Erysimum,* Brassicaceae, mikro-morfoloji, makro-morfoloji

INTRODUCTION

Campanula L., the largest genus in the family Campanulaceae Juss., contains about 420 species worldwide. The distribution of *Campanula* covers primarily temperate and subtropical areas of the Northern Hemisphere and also South Asia and Northern Mexico (Lammers 2007a; 2007b; Alçıtepe 2011; Yıldırım 2018). One of the temperate zone countries of the Mediterranean basin including Türkiye has the richest diversity of *Campanula*. The genus is represented in Türkiye by

Suggested Citation:
Özdöl, T., Sefalı, A. & Yıldırım, H. (2022). Macro- and Micro-morphological Studies on *Campanula lyrata* subsp. *icarica* (Campanulaceae) and *Erysimum aureum* (Brassicaceae), Recently Given as a New Record from Türkiye. *Türler ve Habitatlar* 3(2): 119–136.

approximately 140 taxa, about 53% of which are endemic (Damboldt 1978; Davis et al. 1988a; Güner 2000; Akçiçek et al. 2005; İkinci 2012; Yıldırım 2013; 2018; Mutlu & Karakuş 2015; Yıldırım et al. 2019; Yıldırım & Özdöl 2019; Özdöl et al. 2022a; 2022b; 2022c). *Campanula lyrata* subsp. *icarica* Runemark ex Phitos is one of the taxa of *Campanula* subgen. *Campanula* sect. *Quinqueloculares* (Boiss.) Phitos. This taxon was first described by Phitos from the Icaria Island of the Aegean Sea (Damboldt 1976). *Campanula lyrata* subsp. *icarica* is distributed mainly in the East Aegean Islands (Figure 1) (GBIF 2022; POWO 2022). According to Özdöl et al. (2022c), *Campanula lyrata* subsp. *icarica* is distributed in İzmir and Muğla provinces in Türkiye (Figure 2). Several specimens of *C. lyrata* subsp. *icarica* were collected during fieldwork from İzmir provinces in 2019.

The genus *Erysimum* L. (Brassicaceae) contains about 180 species worldwide (Al-Shehbaz 1988; 2010; 2012; Polatschek & Snogerup 2002). The distribution area of the genus *Erysimum* is all over the Northern hemisphere and it is concentrated in Eastern Europe and the Middle East (Polatschek 1986; Warwick et al. 2006; Koch & Al-Shehbaz 2002). It has a major center of diversity stretching from the Mediterranean Basin to Central Asia (Moazzeni et al. 2014). *Erysimum* is represented by 66 taxa in Türkiye, 34 of which are endemic, giving it an endemism ratio of 51.5%. Marschall Bieberstein first described *Erysimum aureum* M.Bieb. from the forests along the Terek River in Russia, between Mozdok and Kizlyar in 1808 (Bieberstein 1808). *Erysimum aureum* is distributed mainly in Central European Russia, Iran, North Caucasus, Northwest European Russia, South European Russia, Transcaucasia and Ukraine (Figure 1) (GBIF 2022; POWO 2022). According to Özdöl et al. (2022c), *Erysimum aureum* is distributed in Bayburt province in Türkiye (Figure 2).

Figure 1. Worldwide distribution map of *Campanula lyrata* subsp. *icarica* (triangle) and *Erysimum aureum* (square) (map is obtained from GBIF 2022, data is obtained from GBIF 2022 and POWO 2022).

There are some macro-morphological (Damboldt 1976; 1978; Alçıtepe 2011) and micro-morphological studies on *Campanula lyrata* subsp. *icarica* (Liveri et al. 2020), but this study is the first macro- and micro-morphological study on Türkiye populations of *C. lyrata* subsp. *icarica*. Also, there are some macro-morphological studies on *Erysimum aureum* (Vasilchenko 1939; Ball 1964; Polatschek 2010) and there are some micro-morphological studies of species related to *E. aureum* (Maciejewska-Rutkowska et al. 2007; Halbritter 2016; Song et al. 2018), but there are no detailed micro-morphological studies on *Erysimum aureum*. As a result, this study is the first detailed micro-morphological study on *Erysimum aureum*.

MATERIAL AND METHOD

The materials used in this study are herbarium specimens of *Campanula lyrata* subsp. *icarica* and *Erysimum aureum* collected from natural populations during field studies in 2018-2020. Specimens of *C. lyrata* subsp. *icarica* were collected in 2019 from Karacadağ, İzmir during field studies for the MSc "Flora of the region between Menderes, Seferihisar and Özdere in İzmir province" (Özdöl 2020) (Figure 2). Specimens of *Erysimum aureum* were collected in different areas in Bayburt between 2018 and 2020 (Figure 2). According to the latest research, both taxa are mentioned as a new record for the flora of Türkiye (Özdöl et al. 2022c).

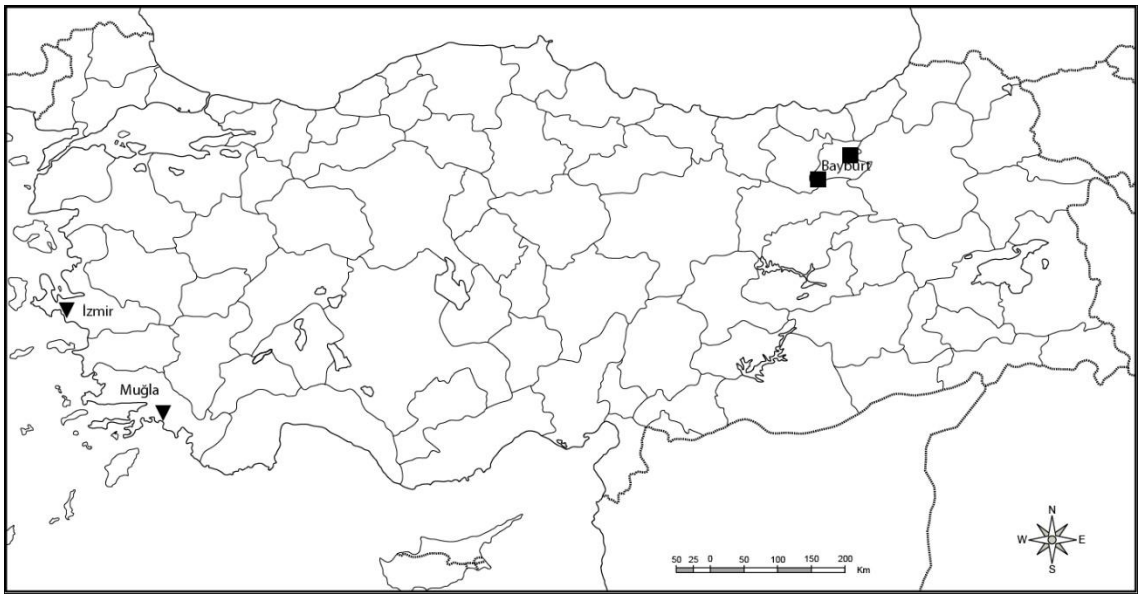

Figure 2. Distribution map of *Campanula lyrata* subsp. *icarica* (triangle) and *Erysimum aureum* (square) in Türkiye (Map is obtained from "CoğrafyaHarita 2022", location data of species just added to the map according to herbarium specimens examined).

Macro-morphological Methods

Morphological characters were measured by a millimetric ruler under stereo binocular microscope. Photographs of plant specimens and their parts were taken at herbaria and in their natural habitats (Appendix 1). During the field studies, photographs of living material of the species and its related taxa were taken with a Nikon D300 digital camera. Photographs of plant parts were taken from herbarium specimens with Samsung NX Mini digital camera. In addition, relevant literature (Boissier 1879; Polatschek & Rechinger 1968; Vasilchenko 1939; Fedorov 1957; Phitos 1963a; 1963b; 1964a; 1964b; 2016; Ball 1964; Rechinger & Schiman-Czeika 1965; Papatsou & Phitos

1975; Fedorov & Kovanda 1976; Damboldt 1976; 1978; Davis et al. 1988a; 1988b; Runemark & Phitos 1996; Güner 2000; Lammers 2007b; Yıldırımlı 2008; Mutlu 2010; 2012; 2018; Polatschek 2010; Güner et al. 2012; İkinci 2012; Güner & Ekim 2014; Güner et al. 2018, IPNI 2022) was evaluated. Plant materials for this study were compared with specimens stored in national (EGE and GAZI) and international (AMD, B, MW, L, LD, U and UPA) herbaria (acronyms according to Thiers 2022).

Micro-morphological Methods

At least 50 pollen grains and 30 mature seeds were measured per taxa using a light microscope and a scanning electron microscope (SEM). For SEM observations, seed and pollen grains were placed on aluminium stubs with double-sided adhesive tape, sputter coated with gold using a Emiteck K550 and then examined using an FEI Quanta 250 FEG SEM. In addition, relevant literature (Maciejewska-Rutkowska et al. 2007; Alçıtepe 2011; Halbritter 2016; Song et al. 2018; Liveri et al. 2020) was evaluated.

RESULTS

Macro-morphological Results

Campanula lyrata subsp. ***icarica*** Runemark ex Phitos in Notes R.B.G. Edinb. 35: 44 (1976) / *ikaryamemeği* (Özdöl et al. 2022c) (Figures 3 and 4).

Type: GREECE. Ikaria: 1–1·5 km W. of Petropoulis cliffs, c. 250 m, Runemark & Snogerup 7049 (holo. LD, LD1213441!). **For this record see also**: http://herbarium.emg.umu.se/record.php?Genus=Campanula&Species=lyrata&SspVarForm=subsp.+icarica&Page=33&AaccNr=1213441&Ainst=LD&Acoll=&Aid=94087311&nrRecords=33.

Description: Perennial herbs. Stem 25–45 cm long, erect or ascending, branched from above, pubescent to tomentose. Leaves pubescent-tomentose on both side. Rosette leaves 4–11 (including petiole) × 0.8–2.5 cm, lyrate, terminal lobe cordate, acute at apex, midvein winged, lateral segments 2-4 mostly absent. Cauline leaves 1–4.5 × 0.3–1.5 cm, sessile to 2.5 cm long petiolate, pubescent-tomentose on both surface; lower cauline leaves similar to rosette leaves, lyrate, terminal lobe ovate, dentate acute at apex; upper cauline leaves ovate, linear-lanceolate, lanceolate, acute, dentate to serrate. Inflorescence spike, panicle, sometimes raceme, rarely compound heads on axils, sometimes dense fascicles, 5–40 flowered per each stem. Pedicel to 1.7 cm long mostly sessile. Bract 4–15 × 1.5–5 mm pubescent-tomentose. Calyx 3–13 × 1–5 mm, as long as or shorter than 1/2 corolla length, triangular, triangular-ovate, ovate-lanceolate, acuminate, acute, subhispid on margins and midvein. Appendage 1–7 × 1–4 mm, ovate to elliptical, obtuse at apex, sparsely subhispid, enclosing capsule. Corolla cylindrical to narrowly infundibular, 1.3–3 × 5–2.5 cm, violet-blue to pinkish-mauve, pubescent outside, glabrous inside; lobes 1–8 × 2.5–10 mm, triangular, pubescent on margins; tube 0.3–1 cm on diam. Ovary ca. 5 × 3 mm, cylindrical, completely hidden by enlarged calyx appendages, densely pubescent-tomentose. Style 1–2 cm long, light yellow to brownish yellow. Stigma distinctly 5 lobed, curved. Stamen 5.5–10 mm long; filament 1.5–3 mm long, with triangular to lanceolate at base; base of filament 1.5–2 × 1–2.5 cm and ciliate to pubescent on margins, creamy white; anthers 4-7 mm long, creamy to bright yellow. Capsule ca. 2 × 1.5 cm, semi-spherical, conical, densely pubescent-tomentose, opening by 5 basal pores; usually hidden by enlarged calyx appendages.

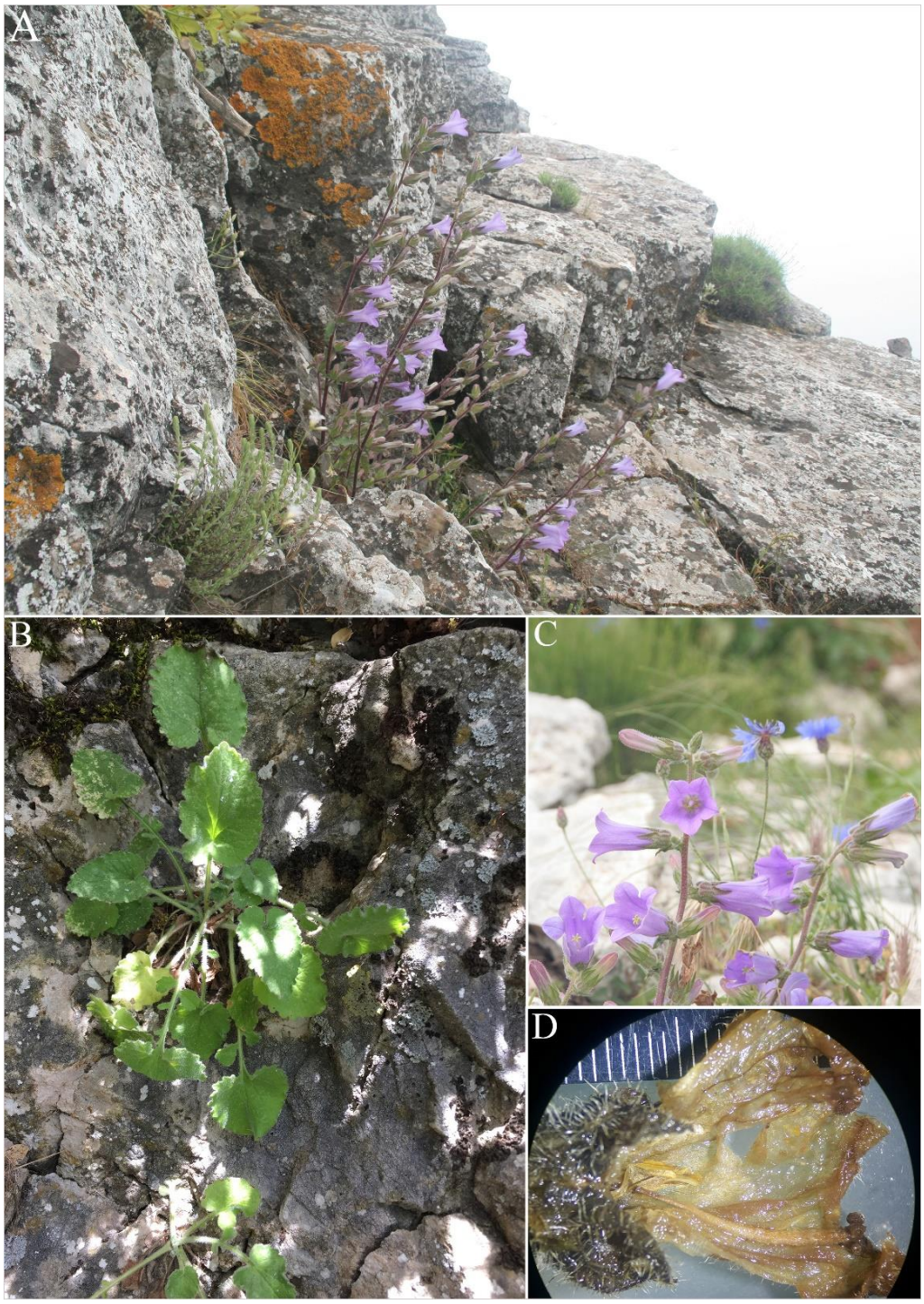

Figure 3. *Campanula lyrata* subsp. *icarica* from İzmir province [T.Özdöl 1923 (EGE); T.Özdöl 2104 & H.Yıldırım (EGE), T.Özdöl 2199 & H.Yıldırım (EGE)]. Habitat and habitus (A), rosette leaves (B), flower and stem (C), and flower (D, microscope view).

Additional Specimens Examined: TÜRKİYE. **İzmir**: Menderes, Karacadağ, peak, E, 828 m, 10.05.2019, T.Özdöl 1923 (EGE!); ibid., E, 805 m, 24.05.2019, T.Özdöl 2104, H.Yıldırım (EGE!); ibid. around the fire watchtower, 840 m, 17.07.2019, T.Özdöl 2199, H.Yıldırım (EGE!). Muğla: Köyceğiz, Kaunos ruins, on the walls and rocks, 25 m, 06.04.2019, Ö.Güner 3100 (GAZI!). GREECE. **Ikaria**: in ditione pagi Hagios Kirykos, 23.05.1975, D.Tzanoudak 1608 (UPA 2860!);

ibid. Therma, 23.04.1975, D.Tzanoudak 1609 (UPA 2861!, UPA 2862!); in ditione pagi Hagios Kirykos, 23.04.1975, D.Tzanoudak (UPA 2865!, UPA 2866!, UPA 2867!); mons Atheras, ca. 600 m, in saxosis, 23.04.1975, D.Tzanoudak 1610 (UPA 2864!).

Phenology: Flowering and fruiting from April to July.

Ecology and Distribution (in Türkiye): *Campanula lyrata* subsp. *icarica* is distributed in Köyceğiz / Muğla and Menderes / İzmir. These two localities are close to the islands of Icara and Samos in the Eastern Aegean, the main distribution area of *C. lyrata* subsp. *icarica*. It grows mostly on limestone cliffs and rock crevices, and it belongs to the east Mediterranean element.

Identification key for infraspecific taxa of the species *Campanula lyrata*

1. Plant subhispid, scabrid; terminal lobes of basal leaves oblong-ovate ..... subsp. ***lyrata***

–. Plant pubescent to pubescent-tomentose; terminal lobes of basal leaves cordate …. subsp. ***icarica***

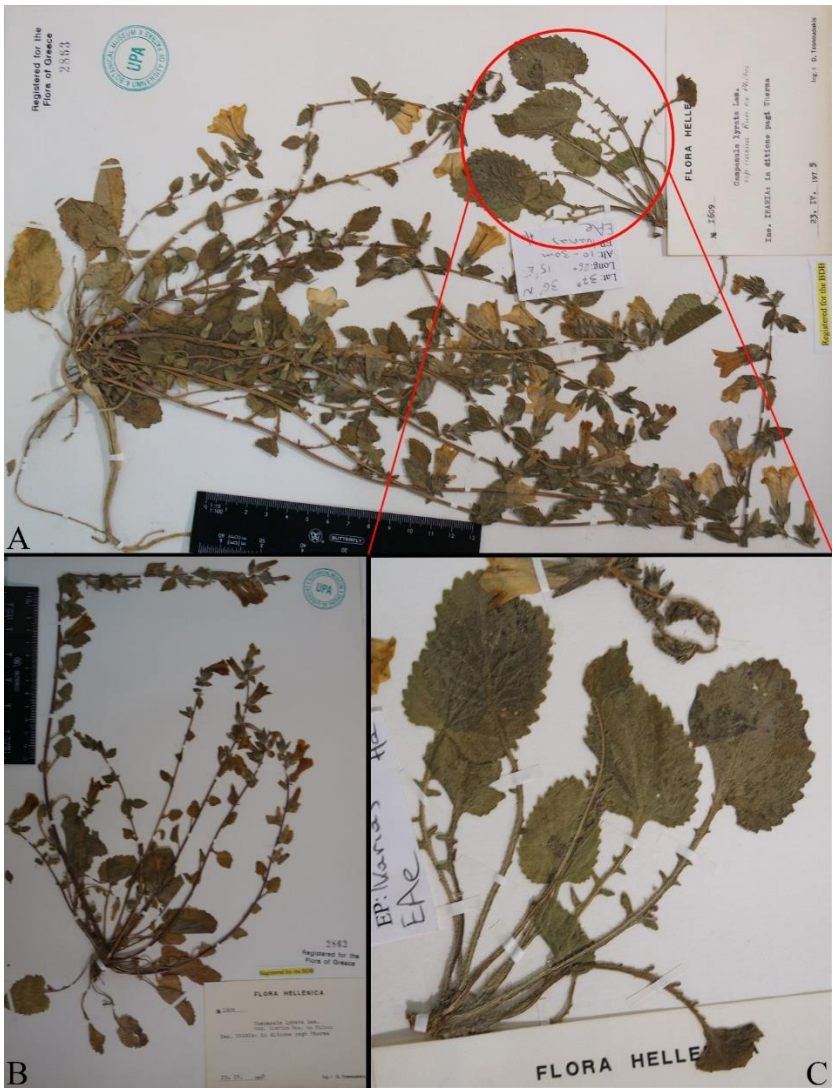

Figure 4. Herbarium specimens of *Campanula lyrata* subsp. *icarica*) from UPA Herbarium [D.Tzanoudak 1609 (UPA 2861!, UPA 2862!)]. Herbarium samples (A and B, general review) and rosette leaves (C, close review).

Erysimum aureum M.Bieb. in Fl. Taur.-Caucas. 2: 117 (1808) / *bayburtzarifesi* (Özdöl et al. 2022c) (Figures 5 and 6).

Type: Lectotype (designated by V.L.Dorofeyev in Dorofeyev (1986)): RUSSIA. habitat in dumentis promontorii caucafici, inter Mofdok et Kifljar, ad fluuium Terek; etiam ad Kumam riuum minime rarum, Ex Caucaso rutheno, Herb. M.Bieberstein (LE; Isolectoype W19287).

Description: Biennial herbs. Stems erect, often branched, 60–170 cm long; trichomes 2–3 rayed. Rosette leaves of sterile individuals elliptic to oblong, 5–3 × 0.8–2 cm, petiolate; petiole 1–4 cm long; trichomes dense, 2–4 rayed. Cauline leaves oblong-lanceolate, 1.5–12 × 0.4–3.5 cm, base cuneate, margins usually subentire or small denticulate, rarely sinuate-dentate, apex acute, shortly petiolate or sessile; trichomes 2–4 rayed. Racemes considerably elongated in fruit. Fruiting pedicels divaricate or ascending, 1–2 cm long, slender, much narrower than fruit. Sepals oblong-lanceolate to oblong, 4–5 × 1.5–2 mm, hairy on outer surface; lateral pair not saccate basally. Petals yellow, widely spathulate, 8-11 mm long, with linear base, slightly hairy on outside; claw 3–5 × 3–4 mm, apex rounded. Filaments 6–7 × 0.8–1 mm; anthers oblong, 1–2 mm; anther and pollen bright yellow. Fruits suberect or divaricate-ascending, linear, straight, 3–4 cm × 1.5–2 mm, 4-angled; valves with prominent midvein, 2–3-fid hairy outside, densely 3–4-rayed stellate hairy inside; trichomes 2–4 rayed, densely pubescent inside; ovules 18–40 per ovary; style cylindrical, slender, 1.5–2 mm long; stigma entire or slightly 2-lobed, lobes as long as wide.

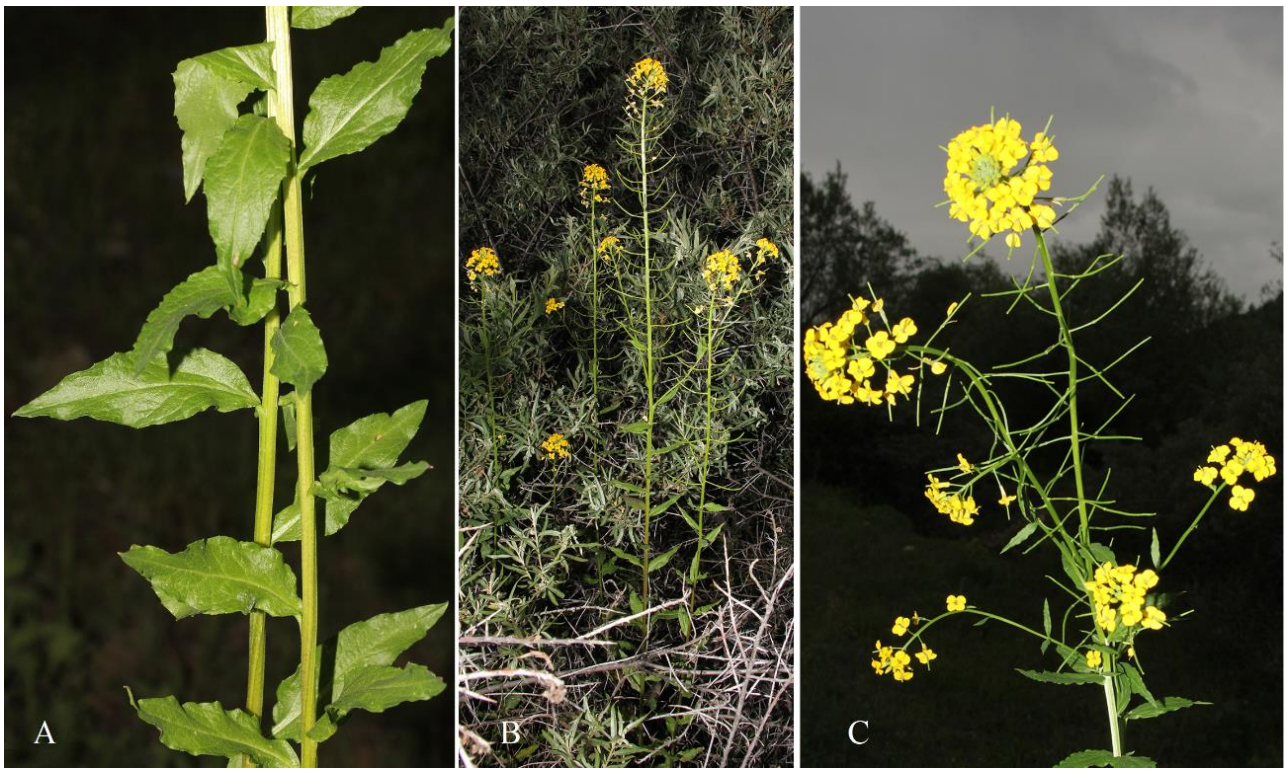

Figure 5. *Erysimum aureum* from Bayburt province [A.Sefalı 421, 619 (EGE)]. Cauline leaves (A), habitat and habitus (B), and inflorescence (C).

Additional Specimens Examined: TÜRKİYE. **Bayburt**: provincial border Gümüşhane, between Sadak Lake and Çamur village, under the *Elaeagnus rhamnoides*, streamside, 18.06.2018, 390 E, 1700 m, A.Sefalı 421 (EGE!); Kopus Bridge, under the *Elaeagnus rhamnoides*, streamside, 20.07.2020, 1588 m, A.Sefalı 619 (EGE!). RUSSIA. Habitat in dumentis promontorii caucafici,

inter Mofdok et Kifljar, ad fluuium Terek; etiam ad Kumam riuum minime rarum; F.A.M.Bieberstein 1808 (MW, MW0592630!); Kaukasus, Teberda, Grober Chatipara, Mischwald bis subalpine, 1700 m, 09.07.1974, Ch.Beck (B, B100068571!); Steiermark: eingebürgert am Schloberg in Graz, Belverde-Wien, 02.06.1997, H.Melzer (B, B100068577!).

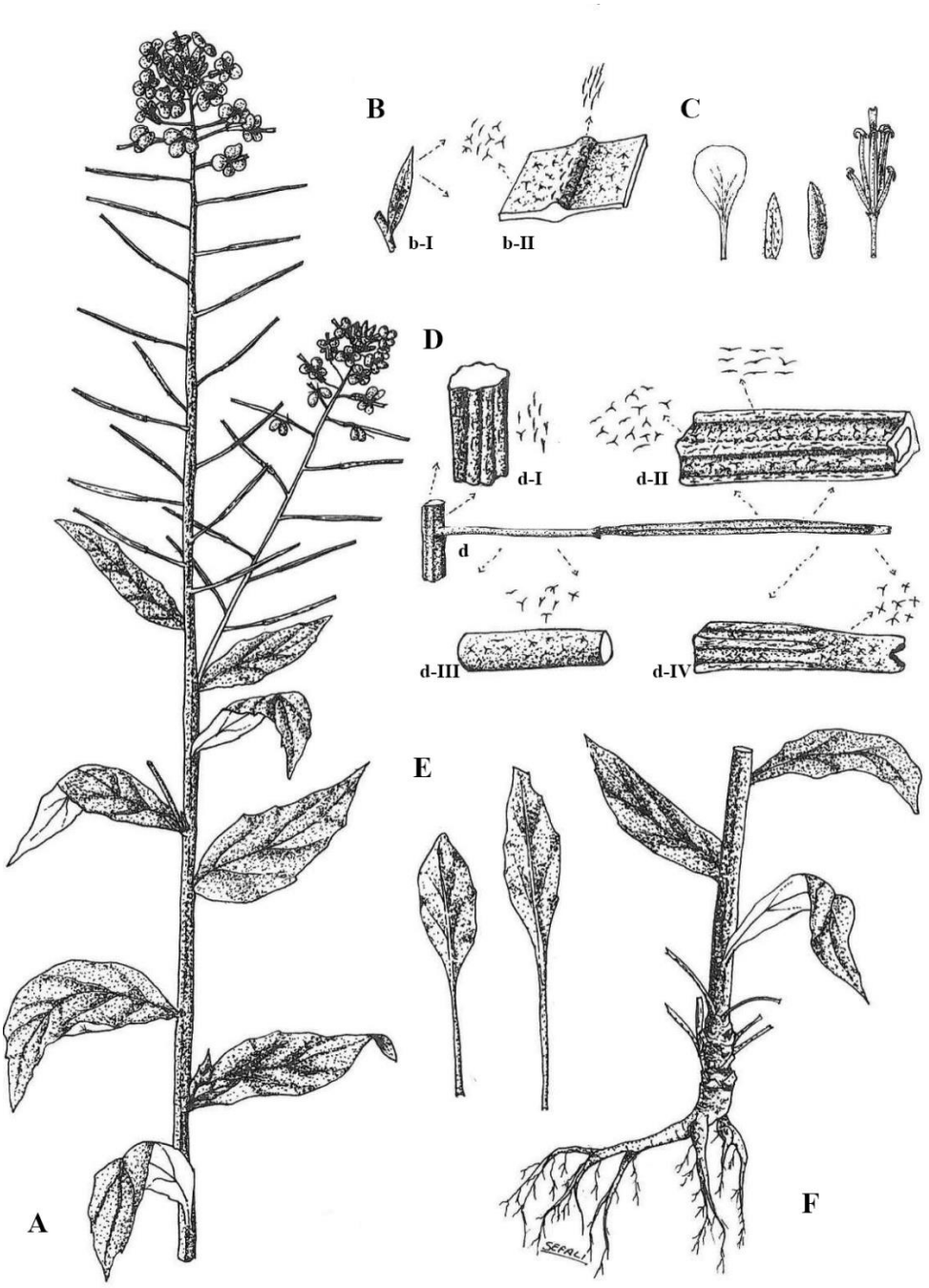

Figure 6. Illustration of *Erysimum aureum*. Stem, cauline leaves and inflorescence (A), cauline leave (B, b-I: cauline leave, b-II: section view of cauline leave and indumentum), periant segments (C), stem, pedicel and siliqua (D, d-I: stem section and indumentum, d-II and d-IV: siliqua section and indumentum, d-III; pedicel section and indumentum), rosette leaves (E), and root, stem and lower cauline leaves (F).

Phenology: Flowering and fruiting from May to June.
Ecology and Distribution (in Türkiye): *Erysimum aureum* is distributed in two localities in Bayburt provinces in Türkiye. The species grows in forest openings, shady areas near rivers, shrubs, undergrowths, shady forest margins, streamsides in Northern Anatolia. It is an element belonging to the European-Siberian floristic region.

Identification key for *Erysimum aureum* within the *Erysimum* genus

1. Plant annual; petals up to 5 mm long; outer surface hairs of siliqua 3–4 fid …….. ***cheiranthoides***
1. Plant biennial; petals longer than 5 mm; outer surface hairs of siliqua 2–3 fid ……. 2
2. Petal 8–11 mm long; inner surface hairs of siliqua 3–4 fid ……...……. ***aureum***
2. Petal 13–16 mm long; inner surface hairs of siliqua mostly 2 fid …….. ***odoratum***

Micro-morphological Results

Campanula lyrata* subsp. *icarica: Pollen creamy white to bright yellow; pollen grain triporate, spheroidal, diameter 22.3±1.76 µm, spinulate, spinule length 0.1–0.4 µm. Seeds ca. 0.5 × 0.2 mm, oblong-oval to oblong-elliptic, shiny brown to light brown, strongly striate (Figures 7 and 9).

Erysimum aureum: Pollen creamy to yellow, pollen grain tri-zonocolpate, spheroidal to prolate spheroidal, polar axis 19.3–23.1, equatorial axis 17.2–20.1, reticulate. Seeds golden yellow, oblong, 1.5–2 × 0.8–1 mm; unwinged; glabrous, micropitted (Figure 8).

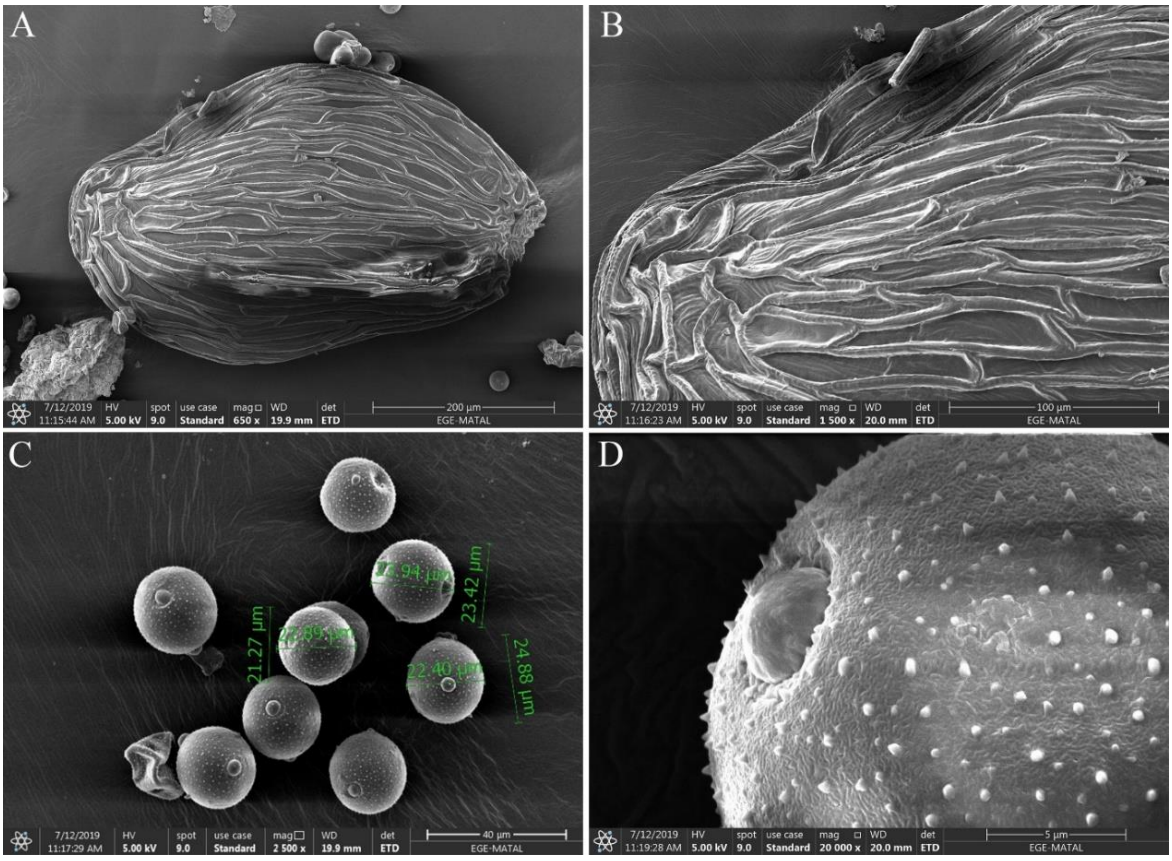

Figure 7. Seed and pollen micromorphology of *Campanula lyrata* subsp. *icarica*. Seed micromorphology (A: general review, B: close review) and pollen micromorphology (C: general review with measurements, D: close review].

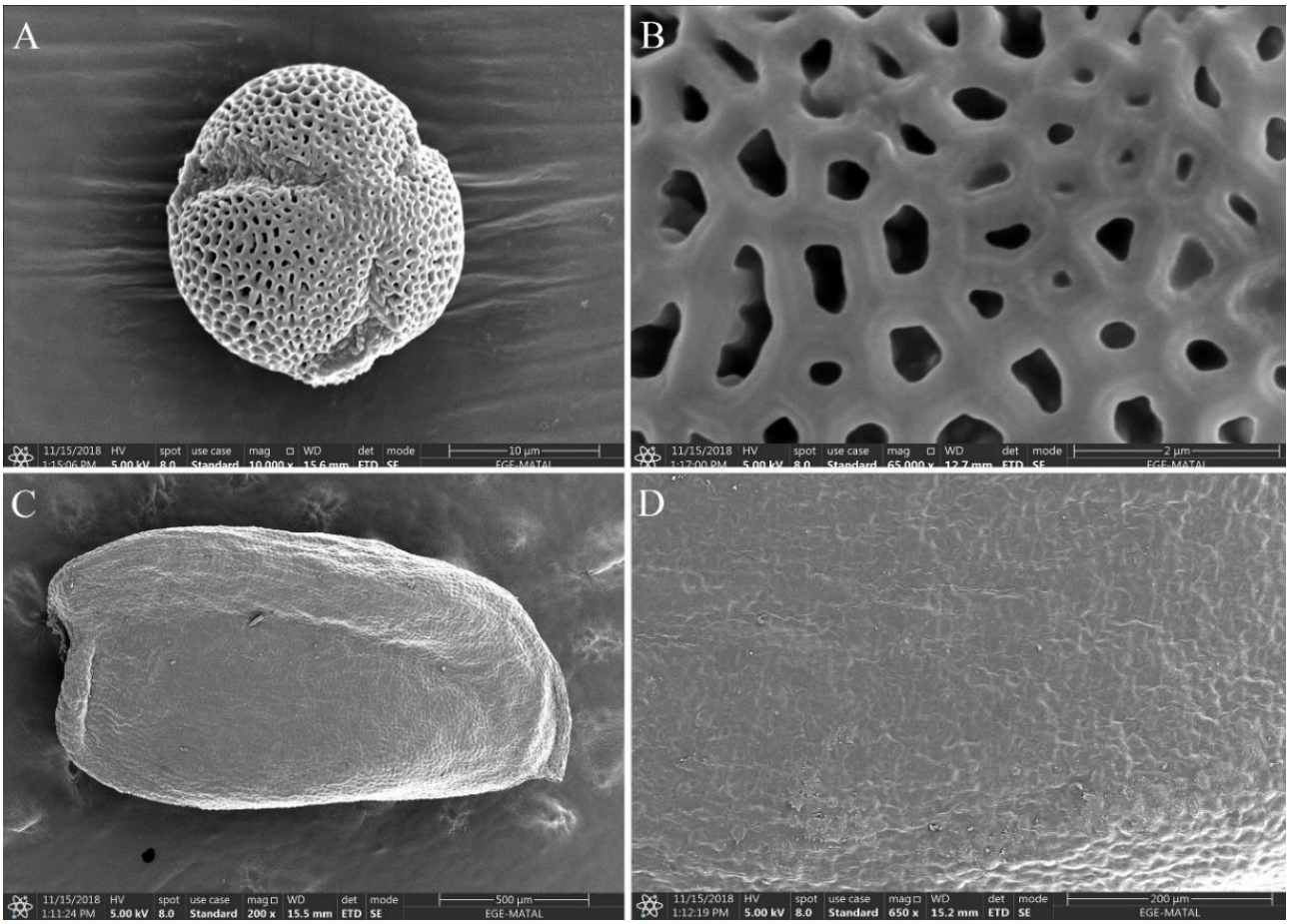

Figure 8. Pollen and seed micromorphology of *Erysimum aureum*. Pollen micromorphology (A: general review, B: close review) and seed micromorphology (C: general review, D: close review).

DISCUSSION

Taxonomical Notes

Specimens *of Campanula lyrata* subsp. *icarica*, which grows on calcareous rock cliffs, were collected during flowering and fruiting phases at Karacadağ in the Menderes district of İzmir province and in the Köyceğiz district of Muğla province in Türkiye. *Campanula lyrata* subsp. *icarica* is treated under subgen. *Campanula* sect. *Quinqueloculares*. According to Dambolt, *C. lyrata* is a very variable species with a wide range of distribution and is closely related to *C. hagielia* Boiss. Some forms of *Campanula lyrata* Lam. may be considered intermediates between *C. lyrata* and *C. hagielia* (Damboldt 1978). The two subspecies of *Campanula lyrata* are not clearly separated geographically, but *C. lyrata* subsp. *icarica* can easily be distinguished from *C. lyrata* subsp. *lyrata* by its cordate rosette leaves and pubescent and pubescent-tomentose indumentum (Table 1). It can be distinguished from *Campanula hagielia* by its more cylindrical flowers and more robust stem (Table 1). In 2022, *Campanula lyrata* subsp. *icarica* was mentioned as a new record for the flora of Türkiye (Özdöl et al. 2022c). In addition, there are some morphological studies (Alçıtepe 2011) about *C. lyrata* subsp. *icarica* but there is no detailed study since it was first published. However, in this study, especially information about flower features characteristics was expanded.

The genus *Erysimum* shows considerable morphological variability. Most *Erysimum* species are biennial or perennial herbs with yellow flowers. Rarely, they have a shrubby habit and white,

pink, purple or orange flowers. The fruits are dehiscent siliques with many uniseriate or biseriate (rarely) seeds which generally become mucilaginous when wet. The fruit indumentum consists of medifixed bifid and/or three- to five-rayed, sessile stellate trichomes. *Erysimum aureum* grows in shady habitats in forests and forest margins, near rivers, shrubs and undergrowths. It is primarily distributed in Russia, as well as in the west of the Caspian Sea, in the northeast of the Black Sea and in Western Europe. The specimens of *Erysimum aureum* collected in Türkiye were obtained from natural populations discovered in Bayburt province during flowering and fruiting periods. *Erysimum aureum* is closely related to *E. cheiranthoides* L. and *E. odoratum* Baumg. worldwide. *Erysimum cheiranthoides* is distributed in mostly temperate regions of Northern hemisphere. *E. odoratum*'s native range is from Central Europe to Ukraine (POWO 2022). It can be easily distinguished from *Erysimum cheiranthoides* with its biennial life cycle, longer style and bigger petals (Table 2) and from *E. odoratum* by its much shorter elliptic or oblong leaves and mostly 3- to 4-fid inner siliqua hairs. In 2022, *Erysimum aureum* was mentioned as a new record for the flora of Türkiye (Özdöl et al. 2022c). Additionally, in this study, especially information on siliqua indumentum and flower characteristics was expanded compared to other studies (Vasilchenko 1939; Ball 1964; Polatschek 2010), and the stem length was upgraded 130 cm to 170 cm.

Table 1. Morphological comparison of *Campanula lyrata subsp. icarica*, *C. lyrata subsp. lyrata* and *C. hagielia*.

	C. lyrata* subsp. *icarica	***C. lyrata* subsp. *lyrata***	***C. hagielia***
Stem	erect or slightly ascending, robust	erect	erect or flexuous
Rosette leaves	terminal lobe cordate	terminal lobe oblong-ovate	terminal lobe cordate or ovate-cordate
Indumentum	pubescent to pubescent-tomentose	subhispid, scabrid	softly hirsute or pubescent
Inflorescence	spike, panicle, sometimes raceme, rarely compound heads on axil, sometimes dense facile	pedicellate or subsessile, in racemes or panicles.	terminal and axillary, pedicellate
Corolla	cylindrical to narrowly infundibular	cylindrical to narrowly infundibular	large, broadly cylindrical to infundibular

Table 2. Morphological comparison of *Erysimum aureum*, *E. odoratum* and *E. cheiranthoides*.

	E. aureum	***E. odoratum***	***E. cheiranthoides***
Life form	biennial (rarely annual)	biennial	annual
Rosette leaves	elliptic to oblong	elliptical to obovate	leaves oblong-lanceolate or lanceolate
Petal	8–11 mm long	13–16 mm long	up to 5 mm
Style	1–2 mm long	1–2 mm long	0.8–1 mm
Siliqua hairs (outer)	2–3 fid	mostly 2 fid	3–4 fid
Siliqua hairs (inner)	3–4 fid	mostly 2 fid	3–5 fid

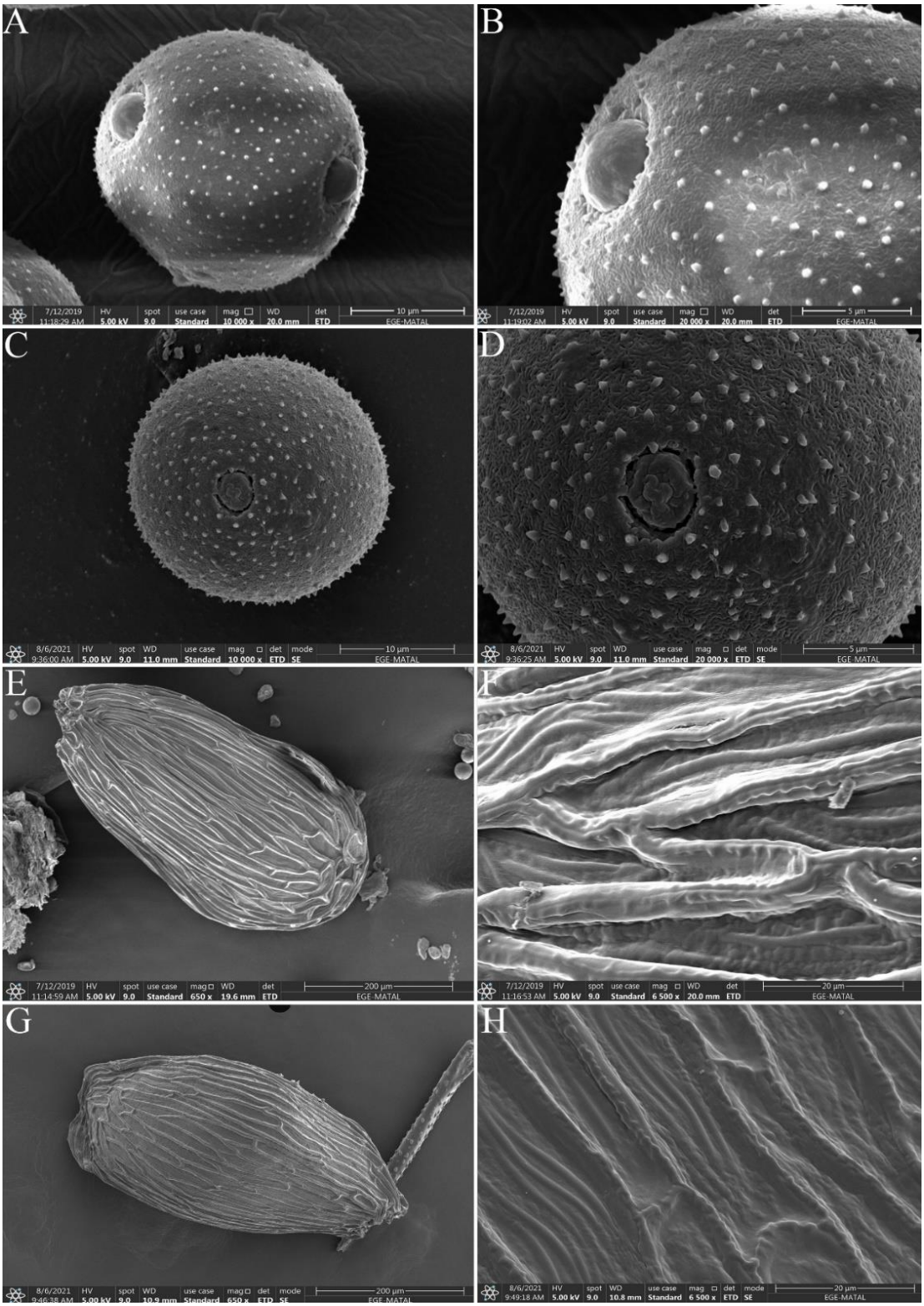

Figure 9. Pollen and seed micromorphology comparison between *Campanula lyrata* subsp. *icarica* and C. *lyrata* subsp. *lyrata*. Pollen micro morphology of *C. lyrata* subsp. *icarica* (A: general review, B: close review), pollen micromorphology of *C. lyrata* subsp. *lyrata* (C: general review, D: close review), seed micromorphology of *C. lyrata* subsp. *icarica* (E: general review, FD: close review), and seed micromorphology of *C. lyrata* subsp. *lyrata* (G: general review, H: close review).

Micro-morphological Notes

Between the seed surfaces of *Campanula lyrata* subsp. *icarica* and *C. lyrata* subsp. *lyrata* have no considerable differences but pollen surfaces show some differences. Spinules of *Campanula lyrata* subsp. *lyrata* pollens surfaces are more dens and longer than *C. lyrata* subsp. *icarica* (Figures 7 and 9). When this study was compared with the previous study on seed micromorphology of *Campanula lyrata* subsp. *icarica*, there were differences. According to Liveri et al. (2020), the seed size is about "0.65 × 0.3", but in this study, seeds were measured as "0.5 × 0.2". As a result of this study, it was observed that the seed sizes could be smaller. Additionally, this is the first study on pollen micromorphology of *Campanula lyrata* subsp. *icarica*.

There are some morphological differences between pollen grains of *Erysimum aureum* and *E. odoratum*. Although *Erysimum aureum* pollen grain shape is spheroidal to prolate-spheroidal and polar axis length is 19.3-23.1 μm, *E. odoratum* shape is prolate and polar axis length is 26-50 μm (Halbritter 2016). On the other hand, the seed surface of *Erysimum aureum* is micropitted but *E. cheiranthoides* seed surface is reticulate-tuberculate (Song et al. 2018). Also, this study is the first detailed micro-morphological study on *Erysimum aureum*.

ACKNOWLEDGEMENTS

The author is grateful to Prof. Dr. Dimitrios Phitos and Prof. Dr. Georgia Kamari (experts in the genus *Campanula*) for taxonomical comments on *Campanula lyrata* subsp. *icarica*; Dr. Özal Güner for the information on the Muğla location of *C. lyrata* subsp. *icarica*; Prof. Dr. Birol Mutlu, Assoc. Prof. Dr. Barış Özüdoğru and Dr. Dimitry A. German (experts in the family Brassicaceae) for their useful taxonomical comments on *Erysimum aureum*. We appreciate the approval and help provided by the curators of AMD, B, EGE, GAZI, MW, L, LD, U and UPA. In addition, we would like to thank Ege University Scientific Research Projects Coordination Unit, which provided financial support to the FYL-2018-20184 MSc Thesis project named "Flora of the region between Menderes, Özdere and Seferihisar".

AUTHOR CONTRIBUTION STATEMENT

In this study; study idea and design, data collection, analysis and interpretation of results, writing the article draft were done jointly by the authors.

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Appendix 1. Informations of comprised specimens of related taxa.

Campanula hagielia. TÜRKİYE. **Aydın**: Kuşadası, Samsundağı, Tekçam, c. 600 m, 29.05.1969, N.Başaran & M.Çetindağ (EGE 16855!); **İzmir**: Kemalpaşa, 04.05.1962, C.Regel 37 (EGE 16854!); Kemalpaşa, Nifdağı, on Ovacık peak road, c. 610 m, 08.05.1972, Ö.Seçmen, Tekeşoğlu & E. Leblebici (EGE 9966!); **Muğla**: Fethiye, Hisarönü, Belceğiz, c. 1450 m, 11.05.1967, H.Peşmen, G.Oğuz & E.Leblebici (EGE 4903!); Marmaris, Datça road, 23.04.1969, K.Walther (EGE 16853!); Çine road, rocky place, Ö.Seçmen 1804, E.Leblebici & L.Bekat (EGE 17463!). GREECE. Rhodos: Lindos, Acropolis, tegen de rotsen aankleve; Nomos Dodekanisou, Eparchia, Rodou, Embonas-Siana, verkrautete, gedüngte Weinkultur auf N-exp, mittel saurer, Shiefer-Ranker-Braunerde, 361253 N, 274934 E, 380 m, 08.05.1999, N.Böhling 9879e (B, B100151116!).

***Campanula lyrata* subsp. *lyrata*.** TÜRKİYE. **Bursa**: Along the road Uludağ, c. 8 km S. of Bursa, waste, calcareous roadside, 800 m, 21.06.1989, W.J.M.Vader & W.J.J.O.De Wilde (L, L102760!); **Denizli**: Babadağ, Babadağ villige, Roadside, c. 1400 m, 08.05.1996, Ö.Seçmen, Y.Gemici & S.Oluk (EGE 35374!); Babadağ, Süzek, c. 1250 m, 02.07.1985, Y.Gemici (EGE 32365!); Sarayköy, Babadağ, Hisarköy to Tekçam, c. 950 m, 22.05.1972, Ö.Seçmen, G.Oğuz, E.Leblebici & S.Oflas (EGE 16862!); **Eskişehir**: Gökçekaya dam, rocky places, 330 m, 27.04.1989, A.Ocak (EGE 33809!); **İzmir**: Menderes, Değirmendere, Karacadağ road, 38 06.313 N, 027 06.105 E, 250 m, 30.05.2018, T.Özdöl 1138 (EGE!); Bergama, between Kozak and Kıranlı village, roadside, 22.05.1986, Ö.Seçmen 3337 (EGE 19745!); Bornova, calcerous places, 100–600 m, ??.05.1932, O.Schwarz (EGE!); Bergama, between Kozak-Nebiler-Kaplan, c. 400 m, 03.06.1987, Ç.Yılmazer 482 (EGE 19744!); Karagöl, c. 800 m, 04.05.1996, Ö.Seçmen 4634 (EGE 18771!); Ödemiş, Bozdağ, 23.05.2001, S.Kırmızıgöl & S.G.Şenol (EGE 35859!); Ödemiş, Bozdağ, Bozdağ-Herseroluk, c. 1350 m, 16.06.1972, Ö.Seçmen, Ahmet & E.Leblebici (EGE 10059!); Kozak, Kıranlı villagei Mardan watercourse, 15.05.1966, H.Peşmen 537 (EGE 2881!); Gümüldür, Kaplan, 22.03.1979, Ö.Seçmen & E.Leblebici (EGE 21227!); Dikili-Çağlayan village, 24.06.1965, H.Peşmen 39 (EGE 8653!); Selçuk-Belevi, 23.04.1970, S.Oflas 12 (EGE 5516!); Kemalpaşa, Nifdağı, c. 1300 m, 16.07.1975, Ö.Seçmen 382a (EGE 23942!); N. of Bornova, 16.04.1969, K.Pitz (EGE 7875!); Kemalpaşa, Nifdağı, c. 900 m, 06.06.1973, Ö.Seçmen 454 (EGE 23506!); Selçuk, Ayasuluk hill, c. 40 m, A.Nasuhoğlu (EGE 41736!); **Kütahya**: Emet, between Gültepe and Tahtalı hill, 1350 m, 09.06.1981, Y.Gemici & G.Görk (EGE 37852!); Emet, Yenice village, 700 m, 20.06.1980, Ö.Seçmen, G.Görk & E.Leblebici (EGE 18452!); Yağcık villige to Eğrigöz villige, 840 m, 17.05.1978, Ö.Seçmen, A.Yayıntaş & G.Görk (EGE 18168!); Emet, Asarlık, Samrık stream, 1240 m, 10.10.1978, G.Görk 220 (EGE 18260!); between Simav and Sındır, Pinmurt, c. 400 m, 05.06.1972, Ö.Seçmen, G.Oğuz, S.Oflas & E.Leblebici (EGE 16885!); Gediz, Murat Dağı, 21 km to Karaağaç village, c. 800 m, 03.06.1972, S.Oflas, G.Oğuz, Ö.Seçmen & E.Leblebici (EGE 10205!); **Isparta**: Garip village, *Cedrus* forest, c. 1250 m, 09.06.1983, L.Bekat (EGE 35992!); Eğirder vil., c. 940 m, 20.05.1966, C.Regel & H.Peşmen (EGE 177!); Gelendost vil., 22.05.1966,

C.Regel, H.Peşmen & G.Oğuz (EGE 185!); Manisa, Spil Dağ, StraBenrand, offener, P.Hein (B, B100089290!); **Manisa**: Ilıca, 27.04.1975, Ö.Seçmen 158 (EGE 23940!); Soma, coal business, 2 km to Daniş village, c. 460 m, 13.05.1977, Ö.Seçmen 1057 (EGE 23638!); Soma, roadside, c. 600 m, 12.05.1977, Ö.Seçmen, E.Leblebici & G.Görk (EGE 17151!); Salihli, Bozdağ road, c. 900 m, 10.05.1975, Ö.Seçmen, M.Öztürk & T.Kesercioğlu (EGE 23941!); 90 km from Manisa to Demirci, roadside, 16.05.1978, Ö.Seçmen, E.Leblebici & G.Görk (EGE 17148!); Salihli, Çamurbayan, *Pinus*, *Quercus* forest, 17.06.1965, H.Peşmen 38 (EGE 8651!): Akhisar-Gölmarmara, 29.04.1966, H.Peşmen 691 (EGE 5422!); Yeniköy-Demirci, *Pinus nigra* forest, 18.06.1965, H.Peşmen 37 (EGE 8656!); **Muğla**: Sandras Dağı, above Ağla, eastern slope of Altınsivrisi, *Pinus brutia, P. nigra* subsp. *pallasiana* forests, 1900 m, 20.06.1999, M.Döring, G.Parolly & D.Tolimir (B, B100274522!).

***Erysimum cheiranthoides*.** Polona septentrionalis, Torun-Bielany, in graminoso prope Institutum Boilogiae, 30.07.1974, W.Gugnacka (AMD 38402!); Amersfoort, de Uithof braafliggend terrain, 27.07.1971, (L, L3246764!).

***Erysimum odoratum*.** C. Europa tot N. Italie, N. Griekenland en W. Rusland, 28.06.1972, (U, U1159212!).