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Original Article

Chelidonium majus L. (Papaveraceae) morphology, anatomy and traditional medicinal uses in Turkey

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ABSTRACT

Background and Aims: *Chelidonium majus* is known as "kırlangıç otu" in Turkey and the different plant parts, especially the latex and aerial parts have been used as folk medicines for different purposes such as digestion, hemorrhoids, jaundice, liver, eye, and skin diseases. Despite the traditional uses of *Chelidonium*, there have been no detailed anatomical studies related to this species.

Methods: The description and distribution map of *C. majus* was expended according to herbarium materials and an anatomical study was made using fresh materials. The information related to traditional uses and local names of this species was evaluated from ethnobotanical literature in Turkey. For anatomical studies freehand sections were prepared using razor blades and sections were double-stained with Astra blue and safranin.

Results: In the anatomical study, epidermal sections containing trichome and stomata characters were elucidated. The leaves are bifacial and hypostomatic. The stomata are anomocytic in the paradermal section. The cross-section of the stem showed multi-layered parenchymatous cells in the cortex and a single-layered endodermis with simple eglandular trichomes. The cross-section of the root showed that the epidermis was replaced with the periderm. Under the phloem, which had few layers, the xylem was composed of tracheary elements surrounded by sclerenchymatous cells.

Conclusion: Our results indicated that the morphological and anatomical characters alongside articulated laticifers and latex properties provide useful tools for the identification of this taxon from the other genera in the Papaveraceae family.

Keywords: Anatomy, *Chelidonium majus*, morphology, traditional uses, Turkey

INTRODUCTION

Papaveraceae Juss. is a medicinally important family comprising 23 genera and ca. 240 species found mainly in the Northern Hemisphere (Kadereit, 1993). All the family members are lactiferous with a well-developed duct system that produces a different kind of latex, from milky or watery white to yellow or red juice in all parts of the plant.

Chelidonium L. (greater celandine) from the Chelidonieae tribe is a world-wide distributed genus from temperate Eurasia to Northwest Africa and the Atlantic coasts of America (Cullen, 1965). Although this genus has been considered a monotypic genus for a long time, Krahulcová (1982) divided it into two separate species according to their different chromosome numbers and distribution areas: *Chelidonium majus* L. (2n=12) distributed in Europe, Siberia and China and *C. asiaticum* (H. Hara) Krahulc. (2n=10) distributed in East Asia and Japan. *C. majus* is one of the oldest medicinal plants, having been in use since ancient times, and Dioscorides and Pliny describe its uses to treat different diseases (Zielinska et al., 2018).

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Chelidonium, also known as greater celandine or devil's milk, has been used in various complementary and alternative medicine (CAM) systems including homeopathy and Traditional Chinese Medicine (TCM) to treat various skin disorders such as papillae, warts, condylomas, as well as ulcers, cancer, oral infection, liver disorders, chronic bronchitis, asthma, and general pain (EMA, 2010; Aljuraisy Mahdi & Al-Darraji, 2012; Maji & Pratim, 2015; Hao, Gu & Xiao, 2015; Nawrot et al., 2017).

The latex of this species has been used externally for the treatment of skin conditions such warts, calluses, wounds, herpes, and cons in Iran (Miraldi, Ferri & Mostaghimi, 2001) and in European countries including Croatia (Prieroni et al., 2003;Varga, Solic, Dujakovic, Luczaj& Grdisa, 2019), Georgia (Bussman et al. 2017), Portugal (Gaspar et al., 2002; Novais, Santos, Mendes & Pinto-Gomes, 2004; Neves, Matos, Moutinho, Queiroz & Gomes, 2009), Slovenia (Lumpert & Kreft, 2017), Albania (Pieroni, Dibra, Grishaj, Grishaj, Maçai, 2015), Romania (Papp, Birkas-Frendl, Farkas & Pieroni, 2013), Italy (Leporatti & Ivancheva, 2003; Bellia & Pieroni, 2015; Guarrera, Forti & Marignoli, 2005; Dei Cas et al., 2015; Menale et al., 2006; Passalacqua, Guarrera & De Fine, 2007; Cornara, La Rocca, Terrizzano, Dente, F. & Mariotti , 2014; Fortini, Marzio, Guarrera & Iorizzi, 2016), Bosnia and Herzegovina (Redzic, 2007; Saric-Kundalic, Dobes, Klatte-Asselmeyer & Saukel, 2010; 2011; Savic Macukanovic-Jocic & Jaric, 2019), Kosovo (Mustafa et al. 2012), Spain (Blanco, Macia & Morales, 1999; Gonzalez-Hernandez Romero, Rodriguez-Guitian & Rigueiro, 2004; Benitez, Gonzalez-Tejero & Molero-Mesa, 2010; Calvo, Akerreta & Cavero, 2011; Rigat et al., 2015;), and Montenegro (Menkovic et al., 2011) (Figure 1). However, the leaves, flowers or aerial parts of *C. majus* are used internally in liver and gallbladder complaints in several countries (Ivancheva & Statcheva, 2000; Leporatti & Ivancheva, 2003; Pieroni, Dibra, Grishaj, Grishaj & Maçai, 2005; Jaric et al., 2007; Menkovic et al., 2011; Savikin et al. 2013; Jaric et al., 2015). Besides these, it is used for the treatment of bronchitis, lithontriptic, stomach ulcers in Kosovo (Mustafa et al., 2012), for lung cancer in Bosnia and Herzegovina (Redzic, 2007), for diarrhea, asthma, and gastric disorders in Iran (Miraldi, Ferri & Mostaghimi, 2001), for cold, asthma, bronchitis, and pneumonia in Spain (Menendez-baceta et al. 2014), as abortifacient in Italy (Idolo, Motti & Mazzoleni, 2009), against cancer, for hemorrhoids and blood cleansing in Ukraine, as well as for kidney problems in Romania (Soukand & Pieroni, 2016) (Figure 1).

Figure 1. Distribution map of countries with traditional use of *Chelidonium*.

In Turkey, *C. majus* is called "kırlangıç otu" (Güner, Aslan, Ekim, Vural & Babaç, 2012) and it has been used as a traditional medicinal plant for 26 different purposes in ten provinces mainly located in the Northwestern parts of Turkey.

The aerial parts, leaves and flowers of the plant are used both externally and internally, while the latex is used only externally for the treatment of skin diseases. Applying the latex directly to remove warts is the most common medicinal use of the plant (Uzun et al., 2004; Kültür, 2007; Ünsal, Vural, Sarıyar, Özbek & Ötük 2010; Kızılarslan & Özhatay, 2012; Akbulut & Özkan, 2014; Sargın, Akçicek & Selvi, 2013; Saraç, Ozkan & Akbulut, 2013; Sargın, Selvi & Lopez, 2015; Polat, Cakilcioglu, Kaltalioğlu, Ulusan & Türkmen, 2015; Mumcu & Korkmaz, 2018). The traditional medicinal uses of *C. majus* in Turkey are presented in Table 1.

The greater celandine herb has been approved by both the European Pharmacopoeia and Turkish Pharmacopoeia. In addition, it has also been included in Commission E monographs for its use in spastic discomfort of the bile ducts and gastrointestinal tract, gall bladder and skin diseases (EMA, 2010; WHO, 2010; Görsöz, 2018). Pharmacological studies indicated *Chelidonium* extracts have anti-viral (Zuo, 2008; Gilca, Gamana, Panaita, Stoian & Atanasiu 2010), anti-microbial (Kokoska, 2002), anti-tumor, anti-inflammatory (Lee, 2007) and analgesic properties (Huang, 1999).

Chelidonium is a particularly well-known genus because of the presence of numerous therapeutically important alkaloids located in the different parts of the plant, especially in the latex. More than forty alkaloids including phenanthridine (3,4-benzylisoquinoline), protoberberine, protopine, quinolizidine, aporphine) have been isolated from *Chelidonium* (Kedzia, Łozykowska, & Gryszczynska, 2013; Hao, Gu & Xiao, 2015; Zielinska et al., 2018). Isoquinoline alkaloids are pharmacologically relevant substances of this taxon (Grosso et al., 2014; Zielinska et al., 2018).

According to the therapeutic potential and traditional uses of *C. majus* and its hepatotoxic effect in chronic administration (EMA, 2010; WHO, 2010; Pantano et al., 2017), it is important to conduct morphological and anatomical studies to provide reliable diagnostic characters for the identification of raw material and commercial samples to avoid any unwanted toxic harm.

Despite the medicinal uses of *Chelidonium* species, there has not been any detailed research on the anatomical and morphological properties of the genus in Turkey. In this study, we provide detailed anatomical properties of *C. majus*, expanded morphological information and a distribution map based on Turkish samples. In addition, the traditional uses of this plant in Turkey are discussed in detail.

MATERIAL AND METHODS

Fresh plant materials at the flowering period were collected from Ankara, Turkey in June 2019 by Golshan Zare (GZ1309). Voucher specimens were deposited in the Hacettepe University Faculty of Pharmacy Herbarium under the classification code HUEF20008. For morphological investigation, 44 speci-

Table 1. Traditional medicinal uses of *C. majus* in Turkey.

Province	Local name	Parts Used	Preparation	Administration*	Use	Literature
Afyonkarahisar	Kırlangıç otu	Aerial parts	Infusion	Int.	Digestion, hemorrhoids, jaundice, liver, eye disease, skin diseases	Arı et al., 2015
Bilecik	Kırlangıç otu	Latex	Raw	Ext.	Warts	Unsal et al., 2010
Giresun	Kına otu	Flowers	Decoction	Ext.	Warts	Polat et al., 2015
		Leaves				
Izmit	Temre otu	Aerial parts	Infusion	Int.	Diuretic	Kızılarslan and Özhatay, 2012
		Latex	Raw	Ext.	Wounds, eczema	
Kırklareli	Sarılık otu, Sultan otu, yara otu, temra otu, mayasıl otu	Herba	Decoction	Ext.	Hepatitis	Kültür, 2007
				Int.		
		Latex	Raw	Ext.	Inflamed wounds, wounds, warts, itching, hemostatic	
		Leaves	Decoction	Ext.	Rheumatism, sciatica	
Manisa	Siğil otu, Bostan otu	Aerial parts	Infusion	Int.	Spasm, dyspepsia, gastrointestinal diseases	Sargın et al., 2013; Sargın et al., 2015
			Raw	Ext.	Carminative, costiveness, warts, corns	
		Leaves	Mash	Ext.	Warts	Sargın et al., 2013;
Rize	Mecmenuk çayırı	Aerial parts	Raw	Ext.	Eczema, warts, acne	Saraç et al., 2013
Sakarya	---	Aerial parts	Infusion	Int.	Eczema	Uzun et al., 2004
Samsun	Kırlangıç otu	Aerial parts	---	Int.	Diuretic, purgative, caustic	Mumcu and, Korkmaz, 2018
		Latex	---	Ext.	Warts, ringworm	
Trabzon	Temre	Latex	Raw	Ext.	Skin diseases	Akbulut and Ozkan, 2014

*Int.: Internal; Ext: External

mens of *C. majus* from the Ankara University Faculty of Science Herbarium (ANK), Hacettepe University Faculty of Science Herbarium (HUB), Ankara University Faculty of Pharmacy Herbarium (AEF), Hacettepe University Faculty of Pharmacy Herbarium (HUEF) and Edinburgh (E) Virtual Herbarium were studied and Flora of Turkey and the East Aegean Islands (Cullen, 1965) were followed for terminology and description order. The distribution information related to herbarium samples, records of flora in Turkey and the East Aegean Islands and the collected fresh materials of *C. majus* were plotted on a map (Figure 2). Determination and measurement of microscopic characters were done by means of direct observation under Leica Stereo Microscopes (Model EZ4) and photographed.

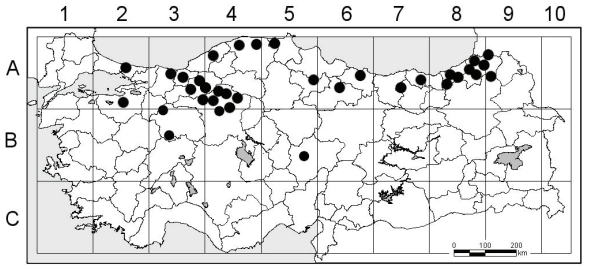

Figure 2. Distribution map of *C. majus* in Turkey.

Fresh specimens (GZ1309) were used for the anatomical investigations and cross-sections were prepared from leaves (at middle), stems (basal and top), pedicels and roots. Paradermal

sections were also performed for leaves. Freehand sections were prepared using razor blades and sections were cleared with sodium hypochlorite and then stained by double stain with Astra blue and safranin. Slides were observed with a Leica CME light microscope and photographed.

RESULTS AND DISCUSSION

Morphology

Chelidonium majus L., Sp. Pl. 505 (1753).

Kırlangıç otu (Güner, Aslan, Ekim, Vural & Babaç, 2012).

Type: Described from Europe (Hb. Linn. 668/1).

Synonyms: *C. laciniatum* Mill., Gard. Dict., ed. 8. n. 2 (1768). *C. majus* var. *grandiflorum* DC., Syst. Nat. 2: 99 (1821). *C. laciniatum* var. *fumariifolium* DC., Syst. Nat. 2: 100 (1821). *C. umbelliferum* Stokes, Bot. Mat. Med. 3: 180 (1812).

Perennial herb, 30–70(–100) cm, branched at the base. Rhizome thick, fleshy, reddish-brown. Stem erect, branched with bright orange sap, sparsely pubescent, especially on the nodes, woody stock covered by persistent leaf. Basal leaves petiole 2–14 (18) cm, blade glaucous abaxially with conspicuous veins, green adaxially, obovate-oblong or broadly obovate, 8–20 cm, abaxially sparsely pubescent especially on the veins, adaxially glabrous, bipinnatifid or pinnatisect, lobes 2–4 pairs, obovate-oblong, irregularly parted or lobed; lobe margin crenate. Cauline leaves alternate, petiole 5–18 mm; blade 2–12 (–15) x 1–8 cm, leaves pinnate with 5–7 broad leaflets, the terminal leaflet often 3-fid, ovate to oblong. Inflorescence nearly umbellate with flowers (2) –5–7 (8). Pedicel tenuous, 2–8 cm, pubescent when young, later glabrous. Flowers 2–2.5 cm across. Sepals 2, free, caducous, ovoid, 5–8 mm, glabrous or sparsely pubescent. Petals 4, yellow, obovate, 10 x 8–15 mm, entire. Stamens 8 mm numerous. Filaments yellow, anthers oblong. Style short, with 2 spreading stigma-lobes (Figure 3). Ovary linear, 1 cm, glabrous. Fruit slender siliqua-like capsule (2) 30–60 x 2–4 mm, torulose, glabrous, monolocular, without a septum, basipetal, opening from below by 2 valves, many seed, pedicel the same as or usually shorter than fruit. Seeds 1–2 mm, dark brown or black, shiny in fresh material, reticulate patterned, with a white appendage, ovoid, alveolate (Figure 4).

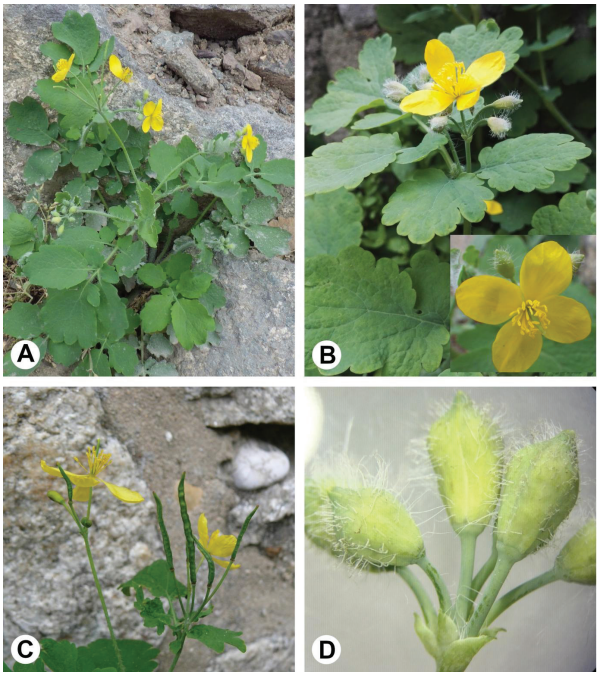

Figure 3. A, Habitus; B, flower and inflorescence; C, capsule fruit; D, flower buds with trichomes.

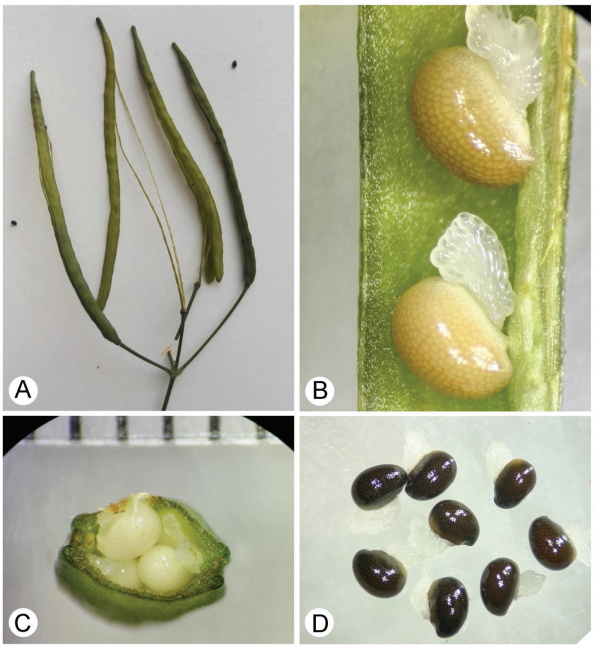

Figure 4. A, Fruit; B, fruit longitudinal sections; C, fruit Transverse sections; D, seed.

Flowering time: April-August.

Habitat: Shaded ground in woods and thickets, sea level-2000 m.

Phytogeographic region: Euro-Siberian element.

World distribution: Widespread in Asia, North America and whole Europe, Northwest Africa; it grows in forests and open shrubby areas, shady, ruderal sites.

Turkey distribution: West and Black Sea regions (Figure 2).

Examined specimens: A2(E) Istanbul: Kestanesou, 22.06.1895 *Aznavour* (E!); Bursa: Uludağ to Soğukpınar, 500-1000 m, 16.05.1962, *Dudley* 34741(E!). A3 Bolu: Karadere to Yedigöl, 650 m, 18.06.1962, *P.H.Davis & Coode,* 37688 (E!); Bolu to Abant lake, 800-900 m, 14.07.193, *S. Fehmi* (ANK!); Yedigöller National Park, 1000 m, 13.06.1977, *R. İlarslan* 102 (ANK!); Düzce: Aşağıkaraköy, Çilimli, 2000 m, 16.05.2009, *A. Mine Gençler Özkan, İ. Gürbüz, G. Akaydın, E. Miser* 26472 (AEF!); Akçakoca, Küpler village, 350-370 m, 22.07.2002, *A. Doğru Koca* 1864 (HUB!); Ankara: between Beypazarı and Kıbrısak, around Yiğenler village, 1050-1300 m 01.06.2001, *Ali A. Dönmez* 8953 (HUB!); Ankara: Çankaya, Bülbülderesi, by the road, 945 m, 20.06.2019, G. Zare 1309 (HUEF!); A4 Zonguldak: Amasra, 14.04.1985, *Venter* (HUB!); Ankara: Beypazarı, Dereli, 1300 m, 02.07.1978, *Y. Akman* 75 (ANK!); Ankara: Çubuk, Karagöl, around the lake, 1500 m, 23.05.1973,

S. Erik 423 (HUB!); Kızılcahamam, around Güven, 1200 m, 13.06.1992, *M. Koyuncu* 9792 (AEF!); ibid., 22.07.2002, *H. Duman* 2291 (AEF!); Seyhamamı, stone pit, 1000 m, 27.07.1975, *B. Kasaplıgil, S. Başaran* (AEF!); Maden suyu, 1000 m, 17.07.1977, *K. Karamanoğlu, M. Coşkun* 14513 (AEF!); Kızılcahamam, Çamları village, 02.07.1948, *K. Karamanoğlu* 522 (ANK!); Kastamonu: Azdavay to Cide, 800 m, 31.07.1962, *P.H.Davis* 38690 (E!); between Cide-Kızılca, 900 m, 12.06.1979, *O. Ketenoğlu* 1387 (ANK!); İnebolu, 18.04.1932, *W. Katte* (ANK!). A5 Kastamonu: Yağalar village, 1500 m, 12.06.1975, *M. Kılıç* 3324 (ANK!); Ayancık, Çangal, 1100 m, 11.08.1945, *Bakı Kasaplıgil* (ANK!); Amasya, 30.06.1893, *A. Manissadjian* 754 (E!). A6 Tokat: Artova, Aktaş, Çal Tepe, ca. 1300-1400 m, 16.07.19, *R. İlarslan* 588 (ANK!). A7 Giresun: Gengene village, 700 m, 24.06.1977, *Y. Akman* 702 (ANK!); Gümüşhane: Harava village, 1100 m, 17.08.1983, *Ş. Yıldırımlı* 5736 (HUB!). A8 Trabzon: Sürmene, around Köprübaşı, 700 m, 29.04.1982, *A. Güner* 4292, *B. Yıldız* (ANK! AEF!); Uzungöl castel, 28.07.1994, *N. Tanker, M. Koyuncu, M. Yıldız, S. Kuruas* (AEF!); Rize: Çamlıhemşin, near Zilkale, c. 700 m, 16.08.1980, *A. Güner* 3061 (HUB!); Salarha, Kömürcüler village, 200 m, 21.04.1985, *A. Güner* 6282, *M. Bilgin* (HUB!); 2. km from Güneyce to İkizdere, 320 m, 26.03.1983, *A. Güner* 4610, *B. Yıldız, M. Bilgin* (HUB!); Artvin: Arhavi, around Ortacalar, 750 m, 21.04.1984, *M. Koyuncu* 6782, *T. Ekim, A. Güner, M. Bilgin* (AEF!); Dikyamaç village, 750 m, 22.04.1997, *M. Coşkun* 19870 (AEF!); Alaca (Tiryal) southeast slope, 163 m, 14.06.1978, *A. Düzenli* 895 (ANK!); Artvin: Dikyamaç village, 05.06.1993, *M. Coşkun* 184 (AEF!); Borçka, 50 m, 18.05.1985, *Ş. Yıldırımlı* 7876 (HUB!); Çoruh, 1100 m, 28.04.1960, *Stainton* 8301(E!). A9 Artvin: Çoruh, Ardanuç to Kordevan mountain, 1450 m, 27.06.1957, D. 30140 (E!); Kars: Posof, 1600-1750 m, 29.06.1986, *N. Demirkuş* 3658 (HUB!). B3 Afyonkarahisar: Şuhut, Koçyatağı village, 28.05.2003, 1200 m, *Ahmet Sezgin* 03048 (HUEF!); Eskişehir: Türkmen mountain, 1400 m, 07.06.1985, *T. Ekim* 2550 (ANK!). B5 Kayseri: Hisarak, 14.06.1944, *H. Bağda* (ANK!).

Anatomy

The anatomical structures of the specimen were determined by examination of the root, stem, pedicel and leaf cross-sections. Additionally, the stomatal index of the species is presented in Figures 5-8.

Trichome: The surfaces of all parts of this species contain simple, uniseriate (4-6 cell) and eglandular trichomes whose density show variation in different parts of individuals and among the population (Figures 5 A-C). On the leaf surface, trichomes are dorsiventral and density is higher on the veins and nods.

Leaves: Cross-sections of the leaf blades in both surfaces contain epidermal cells with sinuous anticlinal walls covered by a thin layer of cuticula. The superior epidermis of the leaf consists of 4-6 angled, rectangular, anisodiametric cell layers and stomata are absent. Mature epidermis cell size is 79.16±16.35 x 26.66±5.77µm. Leaves are hypostomatous and stomata are confined to the lower surface (abaxial). Stomata type is ranunculaceous (anomocytic) and guard cells are surrounded with 4-6 cells which are not distinct from the remaining cells in the mature epidermis (Figure 5 D-E). Upper epidermis have slightly larger cells than lower epidermis. These cells are significantly wavy in anticlinal walls, with 21±4.0 µm width in narrow the

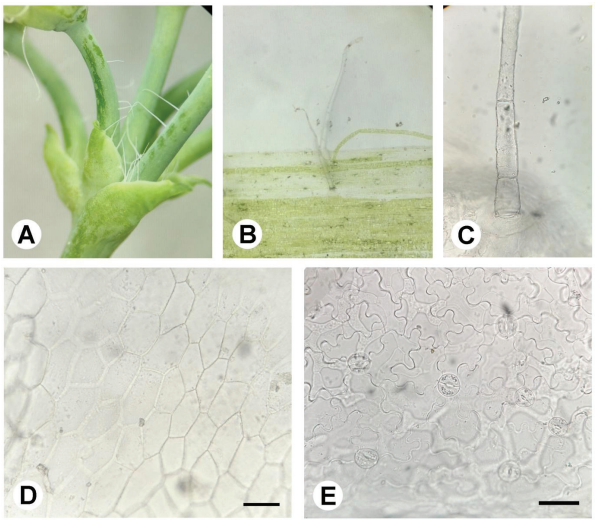

Figure 5. Transverse sections of the epidermis, A-C, uniseriate hairs; D, adaxial epidermis; E, abaxial epidermis with ranunculaceous type stomata. Scale bars: (D, E) 50 µ.

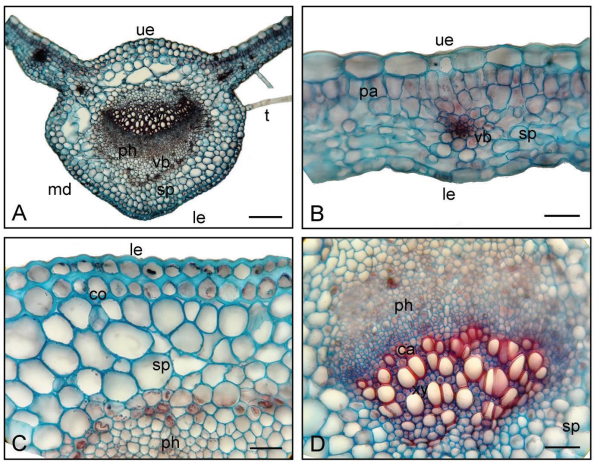

Figure 6. Transverse sections of Leaf. A, C, and D, midrib; B, blade; ca, cambium; ue, upper epidermis; le, lower epidermis; pa, palisade cell; sp, spongy parenchyma cell; ph, phloem; t, trichome; xy, xylem. Scale bars: (A), 200 µ, (B, C, D) 50 µ.

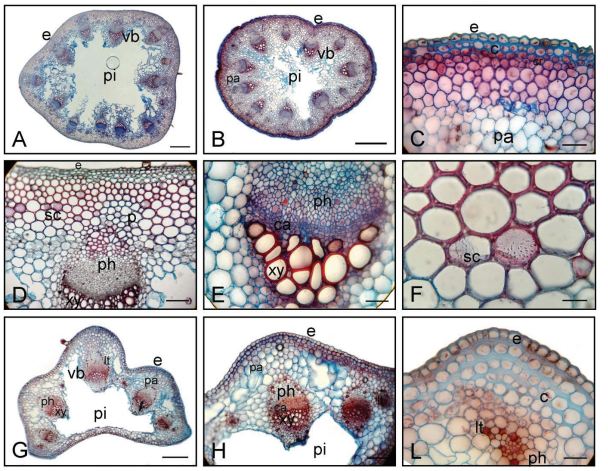

Figure 7. Transverse sections of stem and pedicel. A-F Stem; G-L, pedicel. ca, cambium; co, cortex; ue, upper epidermis; le, lower epidermis; pa, palisade cell; sp, spongy parenchyma cell; ph, phloem; pi, pith region; vb, vascular bundle; sc, secretery cell; xy, xylem. Scale bars: (A, B, G) 500 µ, (D, H), 200 µ, (C, E, F, L) 50 µ.

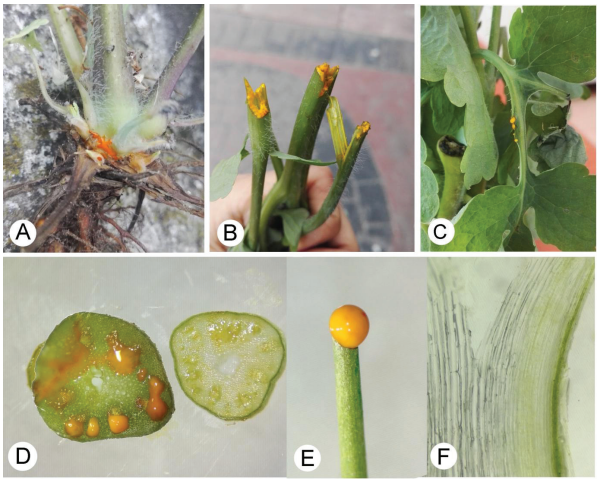

Figure 8. A-C, Orange latex in root, stem and leaves of the *Chelidonium*; D cross section of stem; E and F, Transverse and longitudinal section of stem and articulated laticiferous tubes.

part, 73.00±9.2 µm width in the large part of the cells and 42.36±3.98 µm length. The inferior epidermis consists of numerous stomata whose rounded shape and stomata index is 19.66±1.61 (mm^2). Stomata size is 21.5 ± 2.1. x 21.13±2.0 µm. In leaf cross-section slides indicated leaves have bifacial (dorsiventral) structure and the palisade layer is restricted to the upper side (Adaxial). Leaf thickness is between 180–200 µm and the mesophyll structure generally includes one or several layers of palisade parenchyma cells under the upper epidermis and thin-walled spongy parenchyma cells with wide intercellular spaces. However, the transverse region is sometimes not distinctly differentiated into palisade and spongy regions (Figures 6). The leaf main vein thickness is 800-1100 µm, contains 1-3 layers of collenchyma under the epidermis and 3-5 layers of thin-walled parenchyma cells with different sizes between the collenchyma layer and the arc-shaped vascular bundles. In this area, a few calcium oxalate crystals were seen in the cells. Veins contain numerous collateral vascular bundles, with the xylem located on the upper side and phloem located on the lower side, and in main vein latex cells found in the vascular region (Figure 6).

Stem: The stem transverse section in the young part is circular and in the old part tends to show a pentagonal shape with rounded corners. The outer part is covered with a single layer of epidermal cells with a thin cuticula. Multicellular simple trichomes are seen on the epidermis. Immediately under the epidermis single or multi-layered collenchymatous cells were detected. The cortex consists of multi-layered parenchymatous cells that have various shapes and sizes. Vascular bundles are collateral and 12-14 bundles are arranged in a single ring with concentric zones. The xylems generally tend to be V-shaped. In vascular bundles, 2-6 cambium layers between phloem and xylem are distinguishable. The xylem part is larger than the phloem part. The pith consists of parenchymatous cells that are large and polygonal in shape. This tissue is torn in the lower part of the stem and these tears form a pith cavity (Figure 7A-B). Latex is generally present throughout all parts of the plant and is found in articulated laticiferous tubes. Laticiferous tubes are placed in vascular bundles close to the phloem. In some of the cross-section slides, sieve plates related to the transverse or lateral walls of these tube cells were found (Figures 8). Calcium oxalate crystals occur in the parenchymatous cells.

Petiole: The petiole cross-section is triangular and its anatomical structure is similar to the stem structure. It contains a single layer of epidermis, one to several layers of collenchyma in the corners, and commonly exhibits an arc of vascular bundles without sclerenchyma. Also, there are articulated laticiferous latex tubes and cells and crystals of calcium oxalate in the cortex cells (Figures 7 G-L).

Root: The root structure indicates that this plant is annual. The periderm is generally scratched from the cortex and the cortex is multi-layered with 20-35 layers. Endodermis cannot be distinguished and borders are not clear. The primary structure in the central vascular bundle is diarch and xylem places under phloem (Figures 9).

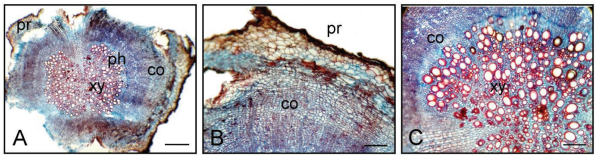

Figure 9. Transverse sections of root. a, cambium; co, cortex; pr, periderm; ph, phloem; pi, pith region; vb, vascular bundle; xy, xylem. Scale bars: (A) 500 µ, (B, C), 200 µ.

DISCUSSION

In this study, we investigated the distribution area, morphological and anatomical properties of *C. majus* as one of the traditional medicinal plants in Turkey. There are lots of studies on the phytochemical and therapeutic perspective of the genus *Chelidonium* (Kedzia Łozykowska & Gryszczynska, 2013; Grosso et al. 2014; Zielinska et al. 2018) but the distribution area, morphological and anatomical features of this species have not been taken into consideration, especially in Turkey.

The distribution area of *Chelidonium* in Flora of Turkey (Cullen 1965) is restricted to the Black Sea region and this taxon is known as the Euro-Siberian element. Our findings indicated this species grows abundantly in the transition area from Euro-Siberian to Irano-Turanian phytogeographic area. There are two records from Afyonkarahisar and Kayseri that are far from the natural distribution area of this species (Figure 2). This can be caused by anthropogenic impact or seeds being carried by animals. The habitats of this plant are forests and shady rural areas. We also found lots of individual plants in parks and roadsides in the cities.

Our results on morphological features are in agreement with the description of the taxon in the Flora of Turkey (Cullen, 1965). We also expended morphological characters according to 44 examined samples from fresh material and herbarium mentioned specimens. The shape of the leaves, umbellate inflorescence, small, yellow flowers, basipetal dehiscence capsule shaped fruits with deciduous valves and arillate seeds can be used to differentiate this species from other members of the family.

Although latex secretion in many unrelated families decreases its diagnostic value, whatever the chemical nature of its contents, it can be helpful in the taxonomy of taxa (Metcalfe & Chalk, 1957). In the Papaveraceae family, the presence of latex is a predominant character among members that shows the variation in colour and chemical component (Metcalfe & Chalk, 1957; Kadereit, 1993). The shiny orange latex found in all organs of the plant is peculiar to *C. majus* and is placed in articulated non anastomosing laticifers (Figure 8). Also, in agreement with Kadereit (1993), this tube significantly associated with the phloem of the vascular bundle and these structures can easily be distinguished even in broken or powdered herbal drugs (Pallag, Pasca, Taichiş, Honiges & Moisa, 2015; İşcan, Köse & Demirci, 2019). Kadereit (1993) indicated latex tends to disappear from the older parts of the plant; however, we found it in the old parts but the amount was low.

While the trichome types provided an important diagnostic character among the species of Papaveraceae family, the results indicated that uniseriate trichomes are diagnostic for the whole tribe Chelidonieae. In addition, considering the diagnostic value of epidermal cell shape, the presence of stomata just in the adaxial side of leaves, in contrast with other genera such as *Papaver* and *Roemeria* (Metcalfe & Chalk, 1957) and the stomata index can provide confirmatory evidence in the identification of this taxon.

These results can help to facilitate the identification of material for use by people, detecting contamination of this taxon with other herbal drugs and providing identified raw material for scientific research in the medicinal field.

C. majus is one of the oldest medicinal species, having been in use since ancient times. This plant was cited by Dioscorides to treat jaundice and dermatologic disorders and Pliny the Elder for the preparation of eye lotion (Jones, 1966; Dioscorides, Osbaldeston & Wood, 2000). *C. majus* has been extensively used to treateye diseases, ulcers and skin disorders as well as against colic and jaundice in Europe (Mayer, Uehleke & Saum, 2003). In Turkey, especially in the Black Sea region, a distribution area of *Chelidonium*, the different parts of this plant, commonly latex and the aerial parts of the plant have been used as folk medicines for the treatment of different diseases (Table 2). The latex is externally as hemostatic and for the treatment of skin diseases such as wounds, eczema, warts, ringworm, and itching (Kültür, 2007; Ünsal Vural, Sarıyar, Özbek & Ötük, 2010; Kızılarslan & Özhatay, 2012; Akbulut & Özkan, 2014; Mumcu & Korkmaz, 2018). The infusions of aerial parts are used internally to treat hepatitis (Kültür, 2007), hemorrhoids, jaundice, liver, eye and skin diseases (Arı et al. 2015). In addition, it is used for gallbladder, (Mumcu & Korkmaz, 2018), and gastrointestinal diseases such as digestion, spasm, dyspepsia (Sargın, Akçicek & Selvi, 2013; Sargın, Selvi & Lopez, 2015; Mumcu & Korkmaz, 2018) and used as purgative and diuretic (Kızılarslan & Özhatay, 2012; Mumcu & Korkmaz, 2018). It is also used externally to treat warts, corns, acne (Sargın, Akçicek & Selvi, 2013; Saraç, Ozkan & Akbulut, 2013; Sargın, Selvi & Lopez, 2015), eczema (Uzun et al., 2004; Saraç, Ozkan & Akbulut, 2013; Polat, Cakilcioglu, Kaltalioğlu, Ulusan & Türkmen, 2015), and rheumatism (Kültür, 2007).

In traditional medicine different parts of the plant are used for several therapeutic purposes. Nawrot et al (2017) suggest protein content of the *Chelidonium* can be affected by the biological activity of this taxa. They calm changes in the plant's needs at different developmental life stages from intense biosynthetic processes to defence against different environmental factors such as pathogens can affect latex composition. These changes in phytochemical composition could explain the biological activity alteration and subsequently divergent medicinal use of the plant extracts in the different developmental stages. The skin treatment properties of *C. majus* might be related to antibacterial, antifungal, antiviral and anti-inflammation activities of these taxa. It seems that these activities are attributed mostly to the alkaloids and flavonoids present in *Chelidonium* (Zuo et al., 2008; Zeileska et al. 2018). Stickl (1928) proved that the bactericidal properties are related to chelerythrine (Taborska Bochorakova, Dostal & Paulova, 1995) and sanguinarine (Hadaruga & Hadaruga, 2009). Also, the glycosaminoglycan present in the latex beside alkaloids containing chelidonine (Monavari, Shahrabadi, Keyvani, Bokharaei-Salim, 2012), chelerythrine (Taborska, Bochorakova, Dostal & Paulova, 1995), sanguinarine (Hadaruga & Hadaruga, 2009), coptisine (Bodalski, Pelezarskaund & Ujec, 1958) and berberine is able to inhibit the development of human immunodeficiency virus (HIV)(Gerencer et al., 2006) and human papilloma virus (HPV) (Etxenagusia et al., 2000). The antifungal activity of *Chelidonium* is attributed to alkaloidal compounds such as dihydrochelerythrine and dihydrosanguinarine which inhibit spore germination and the growth of mycelium in fungi (Maji & Pratim, 2015).

The other most reported indications of *C. majus*, both in European/Mediterranean and East Asian (TCM) traditions were for various liver complaints (Zielinska et al., 2018). Some of the hepatoprotective and choleretic/cholagogue activities might be explained by the presence of hydroxycinnamic (caffeic) acids' esters and dihydrochelerythrine (Weiskirchen, 2016). The *in vivo* research indicated that the phenolic components and alkaloids contain chelidonine, berberine and theprotopine showed choleretic activity and caused an increase in the bile acid flow. It seems this effect is responsible for their hepatoprotective activity (Vahlensieck et al., 1995).

The main concern in *Chelidonium* is a possible hepatotoxicity of the plant because of the presence of alkaloids (Maji & Pratim, 2015; Zeileska et al. 2018). Research points out dose-dependent toxicity and according to EMA the toxicity of using dried parts of *Chelidonium* in a normal dose is low but severe and irreversible hepatotoxicity can happen in a high dose or chronic uptake (EMA, 2010). Nevertheless, further investigation is needed to determine possible toxic effects in daily administration and term of use.

CONCLUSION

C. majus is most commonly used for the treatment of skin diseases and liver disorders in Turkey and other countries. Considering the toxicity of this species alongside its traditional uses and common commercial materials, detailed morphological and anatomical structures can provide a useful tool to avoid contamination of this taxon with other drugs.

Our results indicated that the morphological characters such as leaf and flower shape, seed-specific morphology provided useful tools for the identification of this taxon from the other genera in the Papaveraceae family. Also, the presence of orange latex in all parts of the fresh materials or articulated laticifers with remaining latex content can be used as authentication diagnostic characters in powdered herbal drugs or broken plant materials. The other anatomical structures such as the stem and root cross-section, trichomes and stomata type share common structures across all taxa of the family and provided a limited opportunity to support the identification of this taxon.

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