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MORPHOLOGY, ANATOMY AND ECOLOGY OF CRITICALLY ENDANGERED ENDEMIC *CROCUS PESTALOZZAE* BOISS. (IRIDACEAE) IN NORTH-WEST TURKEY

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Abstract

Morphology, anatomy and ecology of endemic species *Crocus pestalozzae* Boiss. (Iridaceae), have been investigated during flowering period in early spring. The bulbous plant grows in moist heath, meadowland and rocky areas in the North-West of Turkey. Morphological properties of plant parts have been described in detail. Transverse sections of roots, stems and leaves have been illustrated and the anatomical characters of arms, keel, papillae, mesophyll and vascular bundles of leaf have been described. Population status of the plant has also been determined.

Introduction

The genus *Crocus* L. (Iridaceae) is distributed mainly in the Mediterranean region and comprises 80 species world-wide (Mabberley 1997). It is represented by 63 taxa (including subspecies and varieties) in Turkey of which thirty one are endemic to Turkey (Davis 1984, Davis *et al.* 1988, Kerndorff and Pasche 1997). Many species of the family Iridaceae are popular because of their bright, colourful, pretty flowers, and also because they grow and bloom faster than many other ornamental plants (Kandemir and Engin 2000, Baytop 1984). In addition, some *Crocus* species have been used for making dye, perfume and medicaments. It has been reported by Abdullaev (2003) that saffron could be effective in cancer chemoprevention in the future.

The Umraniye *Crocus* is one of the plants flowered in the early spring with white or lilac-blue flowers in moist heath, meadowland and rocky areas. It is distributed only in the North-West of Turkey (especially in Umraniye-Istanbul). Highest population are found in Maltepe-Omerli-Pendik triangular areas in Istanbul. Although it was densely distributed in the Anatolian Part of Istanbul, nowadays it is critically endangered relating to the uncontrolled, unplanned and rapid development of the city. The species has been included in the Red Data Book of Turkey in the VU (Vulnerable) category by Ekim *et al*. (2000).

Very recently Satıl and Selvi (2007) described the anatomy and ecology of some *Crocus* taxa from the west part of Turkey. In the present paper, a detailed knowledge about morphological, anatomical and ecological properties of *C. pestalozzae* have been provided. It is compared with other species of the genus *Crocus*.

Material and Methods

The specimens of *Crocus pestalozzae* Boiss. and soil samples were collected from five localities of North-west Turkey during flowering periods and these are: A2: Istanbul-Umraniye, moist heath and meadowland areas of Çekmeköy District, 80 m, 20 February 2006 - 2007, Kandemir 410. A2: İstanbul-Çataltepe moist health and meadowland areas 90 m, 23 January 2006-2007, Kandemir 411. A2: İstanbul-Taşdelen, moist heath, meadowland and rocky areas, 90-100 m, 17 February 2006 - 2007, Kandemir 412. A2: Kırklareli-Kıyıköy to Saray, meadowland areas near

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culture areas and rocky slopes, 100-130 m, 22 February 2006 - 2007, Kandemir 413. A2: Kocaeli-Ballıkayalar Valley, Pınarlık place, Kanyon entry, rocky and moist meadowland areas, 80 m, 28 February 2006-2007, Kandemir 414.

The taxonomic characters were studied and described according to Davis (1984). The plants flower during January to March. Fresh samples were stored in 70% alcohol. Anatomical studies were carried out using transverse sections of roots, stems and leaves of the stored and paraffin-infiltrated tissues (Algan 1981).

The soil pH, Calcium carbonate, soil texture, water holding capacity, total soluble salts have been determined according to the standard methods (Bayraklı 1987). Nitrogen, phosphorus, potassium and organic matter contents of the soils have beeen analyzed by micro-Kjeldahl, ammonium molybdate-tin chloride, flame photometer and the Walkley-Black methods, respectively (Kaçar 1996).

Results and Discussion

Plants are 10 - 25 cm tall. The corm is about 1.5 - 2.5 × 1.2 - 2.5 cm in size, corm tunics are membranous or coriaceous, brown, separating (splitting) at the base into horizontal rings of tissues. Leaves 3 - 6, synanthous, about 10 - 28 cm × 1.0 - 1.5 mm in size. They are erect, green and with a distinct white median stripe. Bracteole is subequal to bract. Scape is 3-10 cm in size, 1-flowered (Fig. 1a) during Janurary to March. Throat of perianth is yellow, sparsely pubescent. The perianth segments are 2 - 3.5 × 0.5 - 1.2 cm, obtuse or subacute, lilac-blue or white, yellow at inside base (Fig. 1b). Stamens 3, filaments 3 - 6 mm, yellow stained blackish at base, scabrid-pubescent in lower half. Anthers are 6 - 10 mm long, yellow (Fig. 1d). Style is dividing into three slender orange branches and 9 - 16 mm long (Fig. 1e) and is usually equal to stamens. Fruit is capsule shaped, 12 - 16 × 7 - 9 mm (Fig. 1f). Seeds are brownish, 2 - 4 mm in diameter (Fig. 1g).

Perianth size is 2.0 - 3.5 × 0.5 - 1.2 cm and most of the morphological findings are generally in agreement with those reported in the Flora of Turkey. The *C. pestalozzae* is a distinct taxon and need not be merged with *C. biflorus* aggregate. The sheathing leaves (cataphylls) are wholly green in *C. pestalozzae*, but scarious in *C. biflorus*. The small black stain at the base of each filament is an additional differentiating character of *C. pestalozzae.*

Epidermis of roots single layered with isodiametric cells, thin walled, 14 - 18 × 16 - 20 µm in size (Fig. 2). Cortex is 5 - 7 layered consisting of ovoidal parenchyma cells, 40 - 60 µm in diameter (Table 1). Single layered endodermis is 12 - 16 µm diameter with thicker wall on the cortex side. Pericycle parechymatous, cells are 8 - 12 µm diameter. Metaxylem is located on the centre while 5 - 6 protoxylem are on the periphery of vascular bundles (Fig. 2). It has been observed that the roots have 5 - 6 xylem strands. The thickening on the walls of the endodermal cells on the cortex side of root is clear. The same properties have been reported on the root of *C. leichtlinii* (D. Dewar) Bowles (Akan *et al*. 2007).

Epidermis of stem is also composed of isodiametric cells, 12 - 14 × 12 - 16 µm and without hair (Fig. 3 a, b). The cortex cells are 8 - 10 layered ovoidal in shape, 25 - 40 µm diameter (Table 1). Vascular bundles 8-10 in the periphery and 4 in the centre.

Leaves consist of two long lateral arms and a rectangular keel in the middle (Fig. 4a). The arms are recurved towards the keel. Micropapillae are conspicuous on the cuticle (Fig. 4b). Both adaxial and abaxial epidermis cells are rectangular. Anticinal walls of epidermis cells in stomatal region are slightly sinuous. Stomata are anomocytic (Fig. 5b). The stomata are present in the abaxial epidermis and on the groove parts. Mesophyll consists of palisade and spongy parenchyma (Fig. 4b). The central part of the keel consists of large thin walled parenchyma cells, called lacuna. Vascular bundles are located in a row in the abaxial surface of the leaf and extend along the arms.

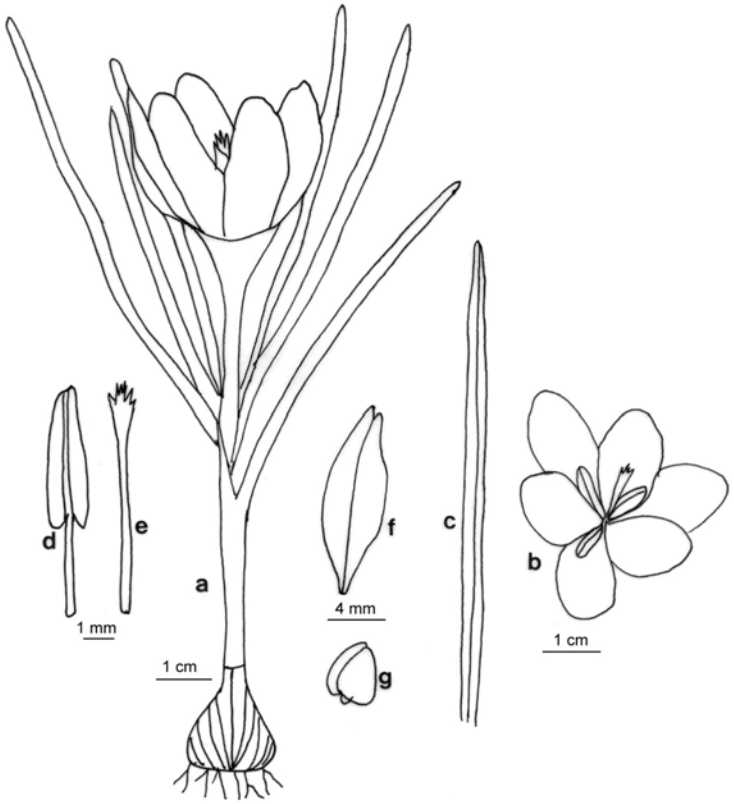
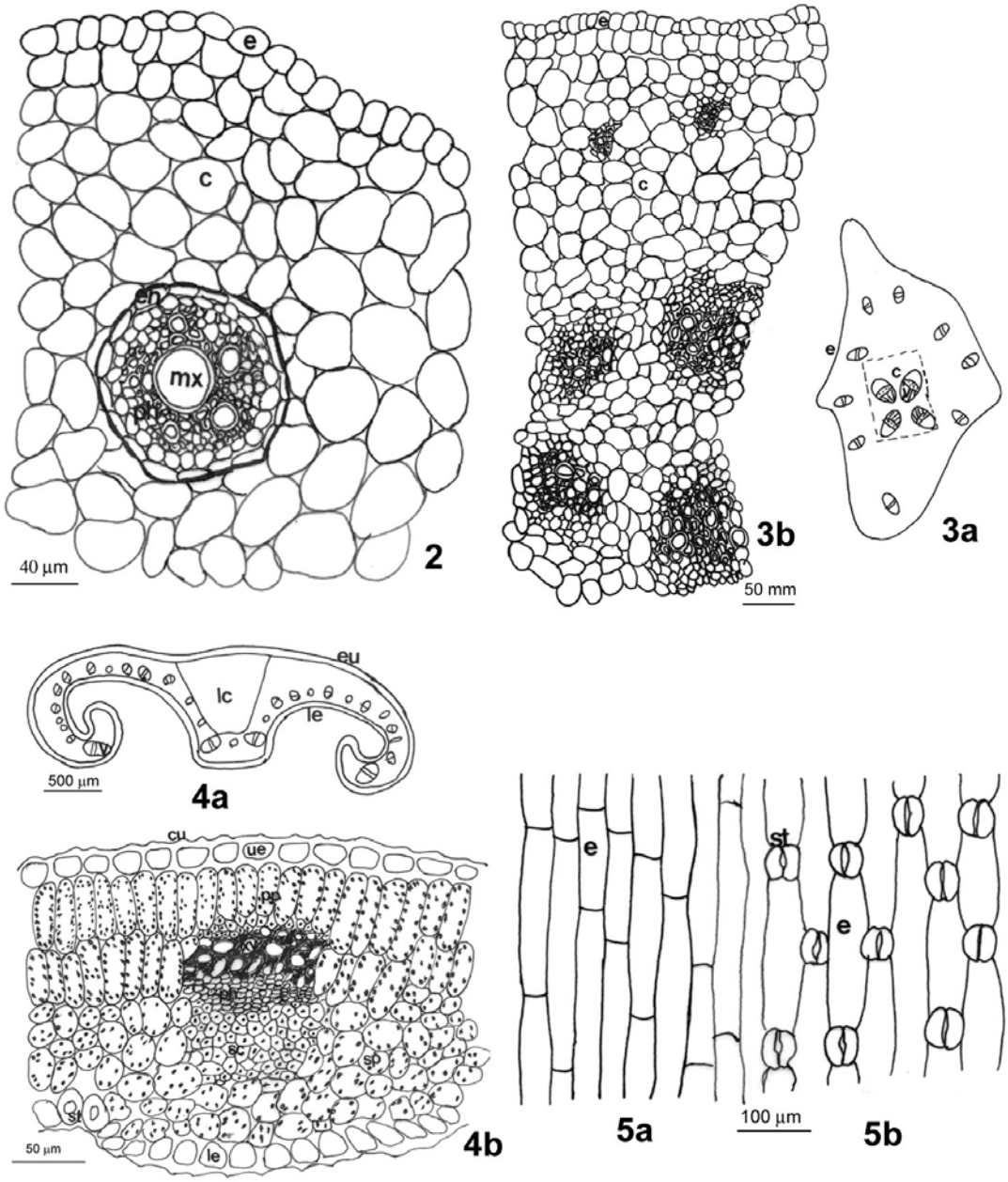


Fig. 1. General appearance and various parts of flowers of *C. pestalozzae.*
a. plant, b. flower, c. leaf, d. stamen, e. style, f. fruit, g. seed.

Table 1. Dimensions of various tissues in transverse section of *C. pestalozzae.*

		Width		Length	
		Minimum	Maximum	Minimum	Maximum
Root	Epidermis cell	16	20	14	18
	Parenchyma cell	40	50	-	-
	Endodermis cell	12	16	4	7
	Pericyle cell	8	12	5	7
	Tracheary element	14	20	-	-
Stem	Epidermis cell	12	16	12	14
	Parenchyma cell	25	40	-	-
	Tracheary element	16	20	-	-
	Phloem element	8	10	-	-
	Pith parenchyma	20	30	-	-
Leaf	Cuticle	8	12	-	-
	Upper epidermis cell	20	25	22	25
	Pailsade parenchyma cell	20	25	45	50
	Spongy parenchyma cell	25	30	-	-
	Lower epidermis cell	20	25	20	25



Figs 2-5. Anatomy of *C. pestalozzae*. 2. Cross section of a root. 3a. General appearance of a part of t.s. of a stem, b. A part of the cross section of a stem. 4a. General appearance of cross section of a leaf. b. Cross section of a portion of the leaf. 5a. Upper epidermis in surface view, b. Lower epidermis of the leaf in surface view. (c = cortex, cu = cuticle, e = epidermis, en = endodermis, lc = lacuna, le = lower epidermis, mx = metaxylem, ph = phloem, pp = palisade parenchyma, sc = schlerenchyma, sp = spongy parenchyma, st = stomata, ue = upper epidermis, v = vascular bundle, xy = xylem).

There are four large vascular bundles two at the corners of the keel and the other two are at the end of arms. Vascular bundles are collateral type with sclerenchyma cells at the poles of longer bundles (Fig. 4b).

Rudall and Mathew (1990) pointed out that the leaves of most species of *Crocus* have a distinctive cross sectional outline with a central square or rectangular "keel" and two lateral recurved "arms", which may be taxonomically significant. These properties found in *C. pestalozzae* have been observed in the leaves of *C. fleischeri* Gay (Erol and Küçüker 2007), *C. gargaricus* subsp. *gargaricus, C. oliveri* subsp. *istanbulensis, C. pulchellus* Herbert, *C. flavus* subsp. *dissectus* (Satıl and Selvi 2007), *C. leichtlinii* (Akan *et al* 2007), *C. pallasii* subsp. *turcicus* Mathew (Akan and Eker 2004) and *C. ancyrensis* (Herbert) Maw (Özkan *et al*. 1999). The leaves of the present species have a white stripe running axillary along the centre of the leaf. This is a common character in *Crocus* genus (Rudall and Mathew 1990, Erol and Küçüker 2007). The presence of micropapillae are important taxonomical structure of *Crocus* leaf anatomy and are conspicuous on the cuticle in *C. pestalozzae*. The anticlinal walls of epidermis cell are sinuous, the feature is also observed *C. candidus* (Erol and Küçüker 2007), *C. oliveri* subsp. *istanbulensis, C. biblorus* subsp. *nubigena, C. pulchellus, C. chrysanthus* Herbert (Satıl and Selvi 2007) and *C. leichtlinii* (Akan *et al*. 2007).

The leaves look like bifacial with two types of parenchyma but it is homologous to unifacial leaves (Rudall 1990, Rudall and Mathew 1990). Results of this study show that there are 1 - 2 layered palisade parenchyma and 3 - 4 layered spongy parenchyma in mesophyll of *C. pestalozzae*. These features have been observed in *C. gargaricus* subsp. *gargaricus, C. biflorus* subsp. *nubigena* (Herbert) Mathew, *C. flavus* subsp. *dissectus* Baytop and Mathew, *C. candidus* E.D. Clarke, *C. pallasii* subsp. *pallasii* and *C. pulchellus* (Satıl and Selvi 2007), whereas it has not been observed in the leaves of *C. leichtlinii* (Akan *et al.* 2007), *C. oliveri* subsp. *istanbulensis* Mathew, *C. cancellatus* subsp. *mazziaricus* (Herbert) Mathew (Satıl and Selvi 2007). Presence of sclerenchyma cells observed in *C. pestalozzae* has also been observed for *C. gargaricus* subsp. *gargaricus, C. chrysanthus, C. biblorus* subsp. *nubigena, C. oliveri* subsp. *istanbulensis, C. pulchellus* (Satıl and Selvi 2007), *C. leichtlinii* (Akan *et al*. 2007), *C. fleischeri, C. wattiorum* Mathew (Erol and Küçüker 2007) and *C. ancyrensis* (Özkan *et al.* 1999).

Physical and chemical properties of soils where *C. pestalozzae* is distributed are shown in Table 2. It is revealed that the plant grows better in soils with no salinity, medium calcareous, neutral to slightly acidic pH and clayey-loamy soils. The species generally prefers to grow in soils with rich organic matter, nitrogen, phosphorus and potassium. It has been observed that *Iris taochia* Woronow *ex* Grossh. (Kandemir 2006), *Iris histroides* Foster (Kandemir and Engin 2000), *Iris pseudacorus* L. (Engin *et al*. 1998), *C. pulchellus, C. oliveri* subsp. *istanbulensis, C. biflorus* subsp. *nubigena* and *C. pallasii* subsp. *pallasii* (Satıl and Selvi 2007) also prefer to grow in the same type of soils.

Table 2. Chemical properties of the Argillaceous loamy soils sampled from growing sites of *C. pestalozzae.*

Locality	pH	Total soluble salts (%)	$CaCO_3$ (%)	Organic matter (%)	N (%)	P (%)	K (%)
İstanbul-Ümraniye-Çekmeköy	6.28	0.097	3.6	5.8	87.1	42.3	96.2
İstanbul-Çataltepe	6.55	0.061	2.9	4.7	82.0	26.5	57.8
İstanbul-Taşdelen	6.90	0.108	3.4	3.0	69.6	30.6	35.1
Kırklareli-Kıyıköy-Saray	7.20	0.070	2.5	3.9	40.7	25.7	72.5
Kocaeli-Ballıkayalar-Valley	7.32	0.088	4.2	4.6	53.8	17.4	68.4
Mean	6.85	0.085	3.32	4.40	66.6	28.5	66.0
Standard deviation	1.75	1.69	1.78	2.12	2.30	2.90	1.99

When the population density of *C. pestatozzae* in 2007 and 2008 was compared, it was observed that the number is decreasing because of the rapid development of the city and applying

agro-chemicals in the culture areas (Table 3). Therefore, *Crocus pestalozzae* has been proposed to include in the CR (Critically endangered) rather than VU (vulnerable) category.

Table 3. The population density of *C. pestalozzae* for two years in localities from where samples were collected.

Localities	Number of plants/100 m^2	
	2007	2008
İstanbul-Çekmeköy	13	0
İstanbul-Çataltepe	8	4
İstanbul-Taşdelen	7	0
Kırklareli-Kıyıköy-Saray	10	5
Kocaeli- Ballıkayalar Valley	9	3

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