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Morphological and anatomical study of the endemic species *Phlomis monocephala* (*Lamiaceae*)

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Abstract. Morphological and anatomical properties of the endemic species *Phlomis monocephala* are investigated in this study. Cross sections of root, stem and leaf parts of the plant are examined and demonstrated by photographs. Most of the anatomical properties are similar to the other members of *Lamiaceae* family. Raphide crystals are observed in the leaf cross section. Sclerenchyma groups are noted above the stem phloem. The morphological structure, cell numbers and distribution of glandular and eglandular hairs on the aerial organs of *Phlomis monocephala* have been determined. The cell numbers of head, stalk and base of capitate glandular hairs are identified.

Key words: Anatomy, glandular hairs, *Lamiaceae*, morphology, *Phlomis monocephala*

Introduction

The *Lamiaceae* family has about 3200 species which mostly grow in the Mediterranean area. Approximately 45 genera and 550 species of the family are distributed naturally in Turkey (Davis 1988; Güner & al. 2000). Many species of the *Lamiaceae* are aromatic and often used as herbs, spices, fragrances and in folk medicine (Werker & al. 1985). The genus *Phlomis* L. is represented by 34 species, six varieties and 10 hybrids in the *Flora of Turkey* (Huber-Morath 1982; Dadandı & Duman 2003). Aromatic herbs and shrubs which have flowers resembling the lips of a mouth and four-lobed ovary, where each lobe yields a seed, are grown primarily for their dense whorls of lipped flowers and attractive foliage. Some *Phlomis* species are used in folk medicine for their analgesic and antidiarrheal properties, and for treatment of ulcers and hemorrhoids. There are few reports about the pharmacological and biological effects of *Phlomis*. Some studies have shown various effects, such as anti-inflammatory, immunosuppressive, antimutagenic, anti-nociceptive, antifibriel, free radical scavenging, anti-malarial, and anti-microbial (Sarkhail & al. 2006). Different classes of glycosides comprising diterpenoids, iridoids, phenylpropanoids, phenylethanoids, and flavonoids have been identified from the genus *Phlomis*. Many of these phenylpropanoids showed significant biological activities: cytotoxic, cytostatic, anti-inflammatory, immunosuppressant, and anti-microbial (Kamel & al. 2000). To our knowledge, there has been no morphological and anatomical study on *Phlomis monocephala* prior to this study, except for the general notes in the *Flora of Turkey* (Davis 1982). The aim of this article is to provide detailed information about the plant that can have economical importance.

Material and methods

Material was collected from a natural population in Mersin, Silifke (Turkey C5 square), in May, during flowering in 2012. Specimens were kept in the herbarium at Celal Bayar University. Morphological illustration of the plant taxon was made from fresh and dry specimens following *Flora of Turkey*, vol. 7 (Davis 1984). Morphological measurements were taken from the root, stem and leaf of fresh plant material. For anatomical studies, the plant specimens were fixed in 70 % ethanol. The paraffin method (Algan 1981) was used for preparing cross sections of root, stem and leaves of *P. monocephala*. A sliding microtome was used to make 15–20 μm transverse sections, subsequently stained with safranin-fast green. The slides were photographed with motorized Leica DM 300 microscope. The mesaurements of root, stem and leaf cell size of the species were taken with ocular micrometer. Minimum, maximum, mean and standard deviation was determined.

Results

Morphological description

Shrub, nearly 150 cm high. Leaves densely covered with whitish or mostly yellowish stellate-tomentose hairs. Especially on the dorsal side, no longer undivided hairs are present. Lower cauline leaves oblong to oblong-ovate, obtuse. Leaves 2–6.5 × 1–3.5 cm, cuneate at base, denticulate or entire. Petioles up to 3 cm. Floral leaves shortly petiolate, oblong, as long as, or up to 2x long as verticillasters. Verticillasters 1–2 in number and 6–12 flowered. Bracteoles 5–8 × 1.5–2 mm, lanceolate and densely white-ianate. Calyx 10–14 mm, densely white-ianate and stellate-hairy, teeth broadly triangular, scarcely apparent, with mucro 0.5 mm. Corolla yellow and 20–30 mm in size. Nutlets glabrous (Fig. 1).

Anatomical description

Root: The outer surface of the root with multiple thin peridermis. The secondary xylem and phloem have ring shape. Cortex 6–7 layered below the peridermis. Trachea cells irregularly located in the xylem tissue that is below the phloem. Cambium indistinguishable. Pith rays 1–2 layered. No pith area in the root.

Fig. 1. General aspect and flower of *P. monocephala.*

Stem: Cross section quadrangular. The wall of epidermis sells cutinised. Four collenchyma bundles (angular type) observed in the stem corners. The cortex 4–6 cells layered. Cortex cells oval and rectangular in shape. A phloem layer present under the cortex. The xylem with thick and strongly lignified cells. Parenchymatous pith cells with small intercellular spaces in the middle of the stem. Pith cells with small intercellular spaces.

Leaf: A thick cuticle on the adaxial epidermis of the leaf. A single layered epidermis of ovoid and rectangular cells on the abaxial and adaxial surface.

Epidermis cells bigger on the adaxial than on the abaxial surface. The palisade parenchyma usually consisting of 1–2 layers of elongated cells. The spongy parenchchyma with small intercellular spaces. Various in size vascular bundles and raphide crystals are present in the mesophile. Stoma cells located on both surfaces too. Also glandular and eglandular hairs are present on both surfaces of the leaf (Fig. 2; Table 1).

Hair description

The stem, leaf, petiole, corolla, calyx, and bract of *P. monocephala* are covered with various glandular hairs. Glandular hairs on the petiole and bract are more varied and greater in number than elsewhere. There are capitate glandular hairs of Type I, Type II and Type III. Type I capitate hairs have 1–2 head, 1–3 stalk and 1–2 base cells. Type II capitate hairs have 1–2 head, 1–4 stalk and 1–2 base cells. Type III capitate hairs have 1 head, 1–2 stalk and 1–2 base cells. Furthermore, stalk cells are absent in some Type I capitate hairs. Also, there are glandular Type I, II, III and eglandular dendroid hairs in *P. monocephala* (Figs 3, 4; Tables 2, 3).

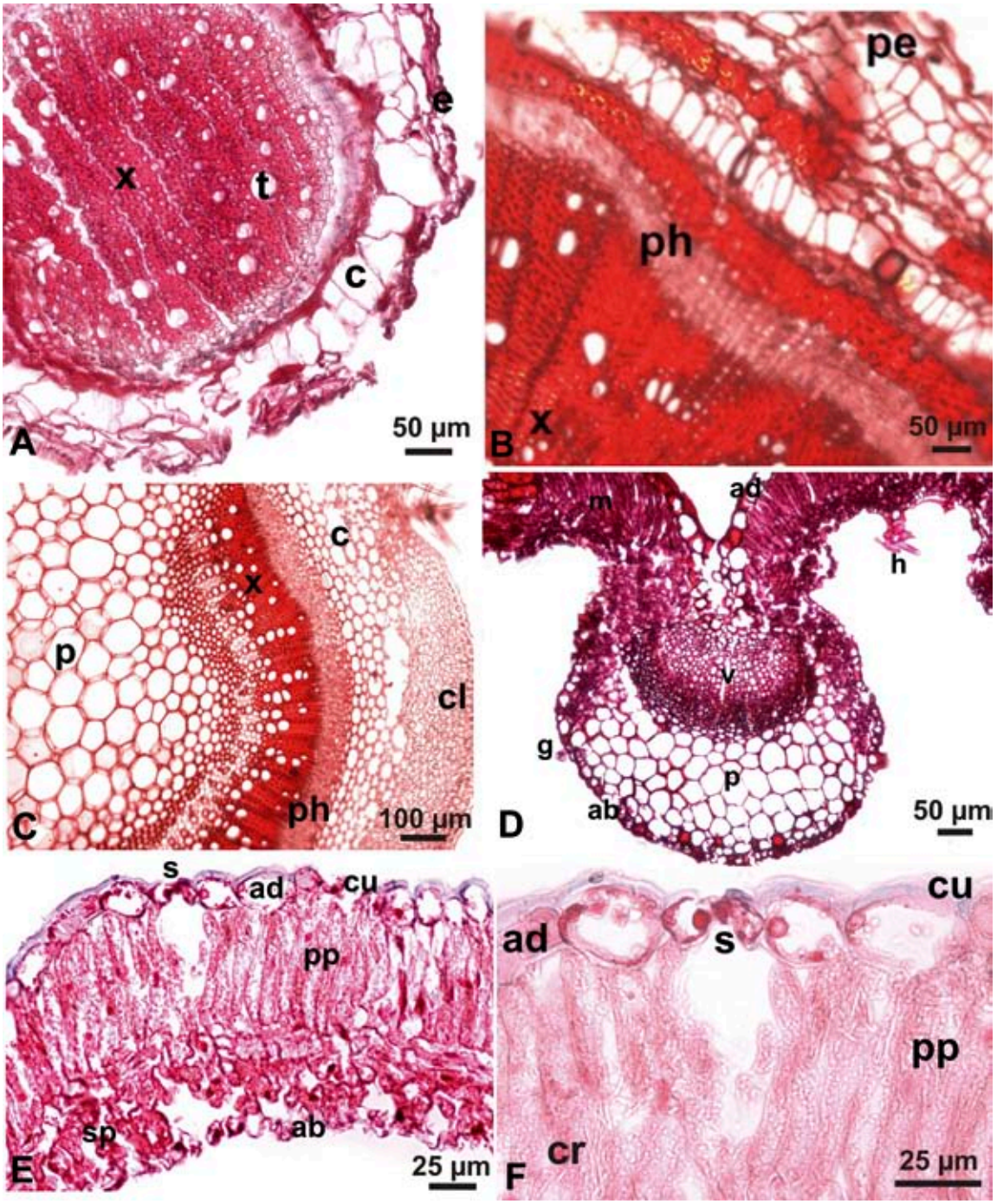

Fig. 2. **A**, **B**: transverse section of root; **C**: transverse section of stem; **D**, **E**, **F**: transverse section of leaf of *P. monocephala*; **ab**: abaxial epidermis, ad: adaxial epidermis; **c**: cortex; **cl**: collenchyma; **cr**: crystals; **cu**: cuticle; **e**: epidermis; **g**: glandular hair; **h**: hair; **m**: mesophile; **p**: pith; **pe**: peridermis; **ph**: phloem; **pp**: palisade parenchyma; **s**: stoma; **sp**: spongy parenchyma; **t**: trachea; **x**: xylem; **v**: vascular bundle.

Fig. 3. **A**, **B**, **M**, **R**, **U**: glandular hairs of stem; **K**, **V**: glandular hairs of leaf; **F**, **G**, **H**, **L**, **P**, **Q**, **S**, **T**, **W**, **Y**: glandular hairs of petiole; **D**, **I**, **J**, **N**, **O**, **P**: glandular hairs of bract; **C**: glandular hairs of calix; **E**: glandular hairs of corolla; **A-J**: Type I; **K-T**: Type II; **U-Y**: Type III; **bc**: base cell; **hc**: head cell; **sc**: stalk cell: X 63.

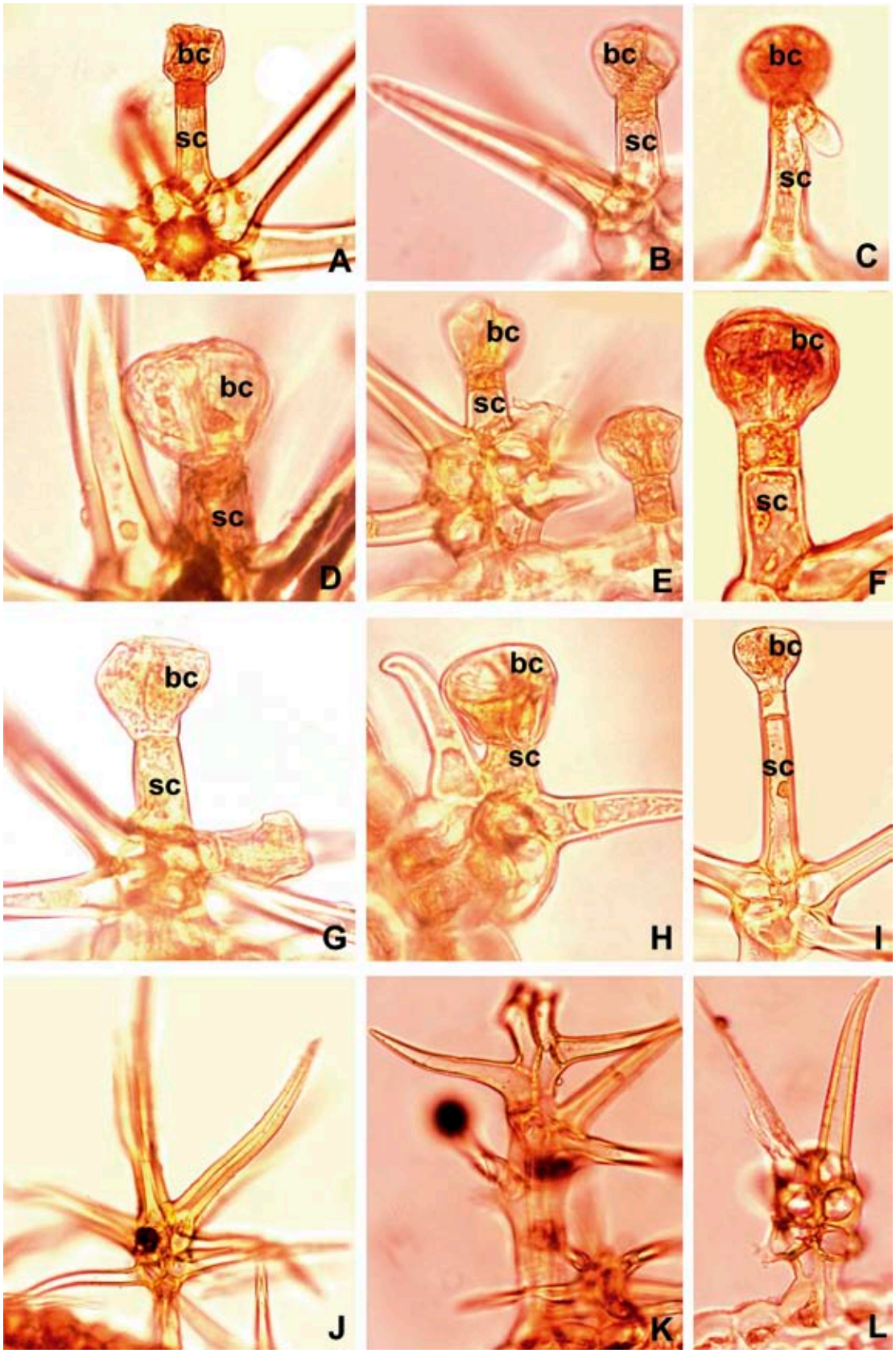

Fig. 4. **A**, **F**: dendroid glandular hairs of petiole; **B**, **D**, **E**, **H**: dendroid glandular hairs of stem; **C**, **I**: dendroid glandular hairs of leaf; **G**: dendroid glandular hairs of bract; **J**, **K**, **L**: dendroid eglandular hairs of stem; **bc**: base cell; **hc**:head cell; **sc**:stalk cell: X63.

Table 1. Anatomical Measurements of *P. monocephala*.

	Width (µm)		Lenght (µm)	
	Min–Max	Mean±SD	Min–Max	Mean±SD
Root				
Periderm cell	22 -38	29 ±1.14	10-16	14±2.04
Cortex cell (D.)	22 -63	42±8.18		
Trachea(D.)	12-45	27±6.57		
Stem				
Epidermis cell	12-23	19±2.51	7-15	10.5±1.55
Cortex cell (D.)	15-58	29±14		
Trachea (D.)	10-33	21±6.4		
Pith cell (D.)	40-105	62±21.4		
Leaf				
Adaxial Epidermis	20-33	26±4.3	15-20	18±2.18
Abaxial Epidermis	12-40	22±5.2	12-22	15.5±2.3
Palisade	7-18	13±2.4	35-60	45±4.5
Spongy	12-18	14±1.8	15-28	20±3.2

Table 2. Capitate Hairs of *P. monocephala*.

	TYPE I			TYPE II			TYPE III		
	Head	Stalk	Base	Head	Stalk	Base	Head	Stalk	Base
Stem	1	1	1	1	1	1	1	1	1
				1	2	1			
Leaf	1	2	1				1	1	1
Petiole	2	0	1	1	2	1	1	2	1
	2	1	1	1	3	2	1	2	2
	2	3	2	2	4	2			
Bract	1	1	1	1	1	1	1	2	1
	2	1	1	2	1	1			
Calix	1	1	1						
Corolla	1	1	1						

Table 3. Dendroid glandular hairs of *P. monocephala*.

	TYPE I			TYPE II			TYPE III		
	Head	Stalk	Base	Head	Stalk	Base	Head	Stalk	Base
Stem	1	2		1	2		1	1	
				2	2				
Leaf	1	2							
Petiole	1	2		2	2				
Bract				2	1				

Discussion

In the course of the study, it has been found that the general anatomical structure of *P. monocephala* is in concordance with the *Lamiaceae* pattern, as given in the scientific literature. In *P. monocephala,* root vessels are wider than stem vessels, which agrees with reports on the other species (e.g. Carlquist 1975; Ewers & al. 1997; Psaras & Sofroniou 1999). *P. monocephala* stem vessel elements are narrower than the average values given for the evergreen sclerophylls (Fahn & al. 1986). By contrast, the narrow vessels of the stem wood provide safety against cavitations, as the conduit diameter has been positively correlated to drought-induced cavitations (Hargrave & al. 1994). Recent data have shown that vulnerability to cavitations may limit the distribution of the species by defining its tolerance across habitats (Pockman & Sperry 2000). This may affect the geographical distribution of *P. monocephala*, which is found in the Mediterranean climate. Crystal shape and location is distinctive characters in plants and very important for taxonomic studies (Metcalfe & Chalk 1983; Yentür 1995; Fahn 1990).

Therefore, raphide crystals in the leaf can contribute to illuminating the phylogenetic relationship between the *Phlomis* species. Capitate glandular trichomes are taxonomically significant and form part of the floral specialized properties for pollination in the *Lamiaceae* (Navarro & El Oualidi 2000). In our study, glandular hairs have varied greatly in structure and produce essential oil applicable in medical treatment. Similar capitate glandular trichomes were observed in *Lamium lycium, Leonotis leonurus* (L.) R.Br., *Salvia blepharophylla* Brandegee ex Epling and *Salvia chrysophylla* (Ascensão & al., 1995; Ascensão & Pais 1998; Bisio & al. 1999; Baran & Özdemir 2009; Kahraman & al. 2010b). Hopefully, our findings will contribute to further phylogenetic, taxonomic and chemical studies into the endemic species *P. monocephala.*

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