

THE MORPHOLOGICAL AND ANATOMICAL CHARACTERS OF *SALVIA NAPIFOLIA* JACQ. IN TURKEY

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Abstract

The morphological and anatomical characters of *Salvia napifolia* Jacq. of the family Lamiaceae have been investigated. The plant has a perennial taproot, the stem is erect and quadrangular. Leaves are simple, occasionally lyrate, inflorescence is its verticillate cyme, corolla is lilac-white. Stems, leaves, petioles and flowers have glandular and eglandular hairs. In the anatomical research, cross-sections of root, stem, leaf and petiole have been examined. Roots with thick periderms, cortex multilayered sclerenchyma groups above phloam, cambium not clear, no pith as center of root filled with xylem, distinct pith rays. Stem with collenchymatous hypodermis, sclerenchyma group above vascular bundles, vascular bundles at corners large and lobed, large pith with interrupted pith rays. Leaves with diacytic stomata both on abaxial and adaxial epidermis. Anatomy of petiole, calyx, corolla has also been investigated.

Introduction

The genus *Salvia* L. with over 900 species is probably the largest member of the family Lamiaceae and is found in both subtropical and temperate parts of the world (Özdemir and Şenel 1999). The two largest centres of the genus are in America and in South-West Asia. Anatolia is a major centre for *Salvia* in Asia (Vural and Adigüzel 1996). Since the most recent revision of the genus in Turkey, three new species have been described and the total number has now reached 89 (Davis 1982, Davis *et al.* 1988, Güner *et al.* 2000, Dönmez 2001). Forty three of these *Salvia* species in Turkey are endemic (Davis 1982). *Salvia* species are an important group of useful plants which have been known to have importance since ancient times. The genus is named “*Salvia*”, derived from Latin “*Salveo*”, which means “to save, to recover” (Özdemir and Şenel 2001). The antibacterial, antituberculous and antiphlogistic activities of the constituents of *Salvia* species are well-established (Ulubelen *et al.* 2001). Besides medicinal value, *Salvia* species are also grown in parks and gardens as ornamental plants (Nakipoğlu 1993).

Morphological and anatomical characters of most of *Salvia* species have not been investigated in the past. No anatomical study in detail on *Salvia napifolia*, the subject of this paper, has been found in existing literature. There is just some information on the morphological aspect of the species (Davis 1982).

Materials and Methods

Plant samples of *Salvia napifolia* Jacq. were collected from natural populations in 2005 from Manisa-Gölmarmara at the following altitude and date : B1 Manisa : Gölmarmara 79 m, April, 2005. Some samples were used for morphological and anatomical observations and some were dried as herbarium sample. Taxonomic description of the plant was prepared according to Davis (1982). Anatomical studies were carried out by hand using razor on the samples preserved in 70% alcohol.

Results and Discussion

Morphological characters: The tap roots of *S. napifolia* is thick with dark brown outer covering. Stem erect, quadrangular, pilose below and villous above. Leaves petiolate, petiole pilose; simple, ovate-broadly ovate, occasionally lyrate, crenate to crenose, unicostate-reticulate, faintly hairy. Inflorescence verticillate-cyme, 5-6 flowers in a verticel. Flowers bracteate, bracts broadly ovate, acuminate, or sometime \pm circular, Zygomorphic, bright red in colour.

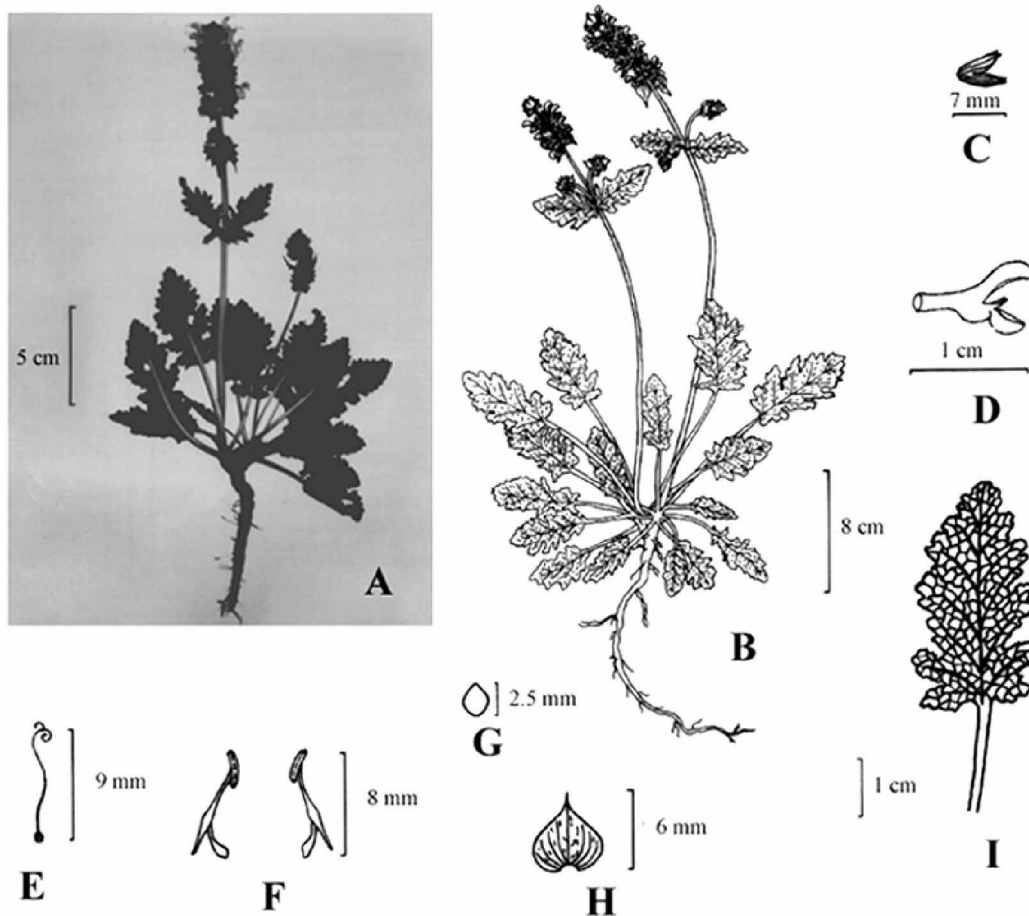


Fig. 1. General appearance and some parts of *Salvia napifolia*. A-B. General appearance, C. calyx, D. corolla, E. pistil, F. stamens, G. seed, H. bract and I. leaf.

Calyx bilabiate, campanulate, upper lip tridentate, lower lip bidentate, villous. Corolla bilabiate, upper lip of two lobes slightly falcate and lilae and lower of three lobes white in colour. The median lobe of lower lip biggest and concave. The lower part of corolla tube ventricose. Fertile stamens two; stigma unequally bifurcated. Nutlets-4, trigonous, dark brown.

Stem, leaf, petiole, pedicel, calyx and corolla covered with glandular and eglandular hairs. (Fig. 1, Table 1).

Table 1. Morphological measurements of plant organs of *Salvia napifolia*.

Platn part	Parameter	Min. - Max. (cm)	Mean \pm S.D. (cm)
Root	Root length	11 - 30	18.4 \pm 7.3
Stem	Stem length	18 - 35	26.9 \pm 7.3
Leaf	Leaf length	1.6 - 6.6	3.88 \pm 1.63
	Leaf width	0.7 - 3.5	2.03 \pm 0.85
Petiole	Petiole length	0.4 - 9.8	5.31 \pm 2.69
Flower	Pedicel length	0.1 - 0.4	0.3 \pm 0.10
	Calyx length	0.45 - 1.0	0.68 \pm 0.18
	Length of calyx teeth	0.05 - 0.60	0.24 \pm 0.20
	Corolla length	0.70 - 1.25	1.03 \pm 0.13
	Filament length	0.15 - 0.30	0.22 \pm 0.06
	Anther length	0.15 - 0.25	0.21 \pm 0.02
	Pistil length	0.8 - 1.20	0.70 \pm 0.24
Bract	Bract length	0.25 - 1.30	0.65 \pm 0.35
	Bract width	0.45 - 1.20	0.70 \pm 0.24
Seed	Seed length	0.22 - 0.25	0.24 \pm 0.01
	Seed width	0.16 - 0.20	0.18 \pm 0.01

S.D. = Standard deviation.

Anatomical charracters

Root : There was a thick peridermis. Cortex was multilayered and parenchymatic under the peridermis. Many sclerenchyma groups, 2 - 6 or more celled, were present among flattened cortex parenchyma cells. Sclerenchyma groups were also present above phloem. Clear and large phloem was interrupted by pith rays as to form groups. Cambium was not clear. Center of root was entirely filled with xylem. There were 2 - 6 rowed, thin or thick pith rays (Fig. 2 A, Table 2).

Stem: The cross-section of stem was quadrangular. Epidermis was single layered. Collenchyma was 12 - 16 layered under epidermis, projecting at the corners of stem, becoming thin towards edges. Cortex parenchyma under epidermis was 5 - 10 layered and under collenchyma 3 - 5 layered. Thick sclerenchyma groups were present above vascular bundles at the corners. Phloem was located under sclerenchyma. Cambium was not very clear. Thickness of xylem part was as much as sclerenchyma plus phloem. Vascular bundles at the corners were large and sometimes lobed (Fig. 2 B). Vascular bundles at the edges were very small and 4 - 5 in number (Fig. 2 C). Pith rays interrupted, 1 - 3 rowed. A large pith under vascular bundles was present at the center of stem. Trachea cells were arranged at the same line (Fig. 2 B-C, Table 2).

Leaf : There was a single layered epidermis on both adaxial and abaxial surface of leaf. Epidermal cells were oval, squarish or nearly rectangular in the cross-section. Palisade parenchyma was 2 - 4 layered and spongy parenchyma 3 - 4 layered. Palisade and spongy parenchyma cells had a lot of chloroplast. Stomata were present on both adaxial and abaxial epidermis. Stoma type was diacytic. The median vein of leaf was surrounded by lacunar collenchyma, 2 - 3 layered collenchyma was present under the adaxial epidermis while 2 layers of

parenchyma cells adjacent to the abaxial epidermis were thick walled in respect the inner parenchyma cells in leaf (Fig. 3 G, Table 2).

Petiole : The outermost layer of petiole in cross-section consisted of oval, squarish or nearly rectangular epidermal cells. Collenchyma was 2 - 5 layered under abaxial epidermis, gradually becoming thin towards both ends. Parenchyma was 11 - 15 layered. Parenchyma cells were nearly

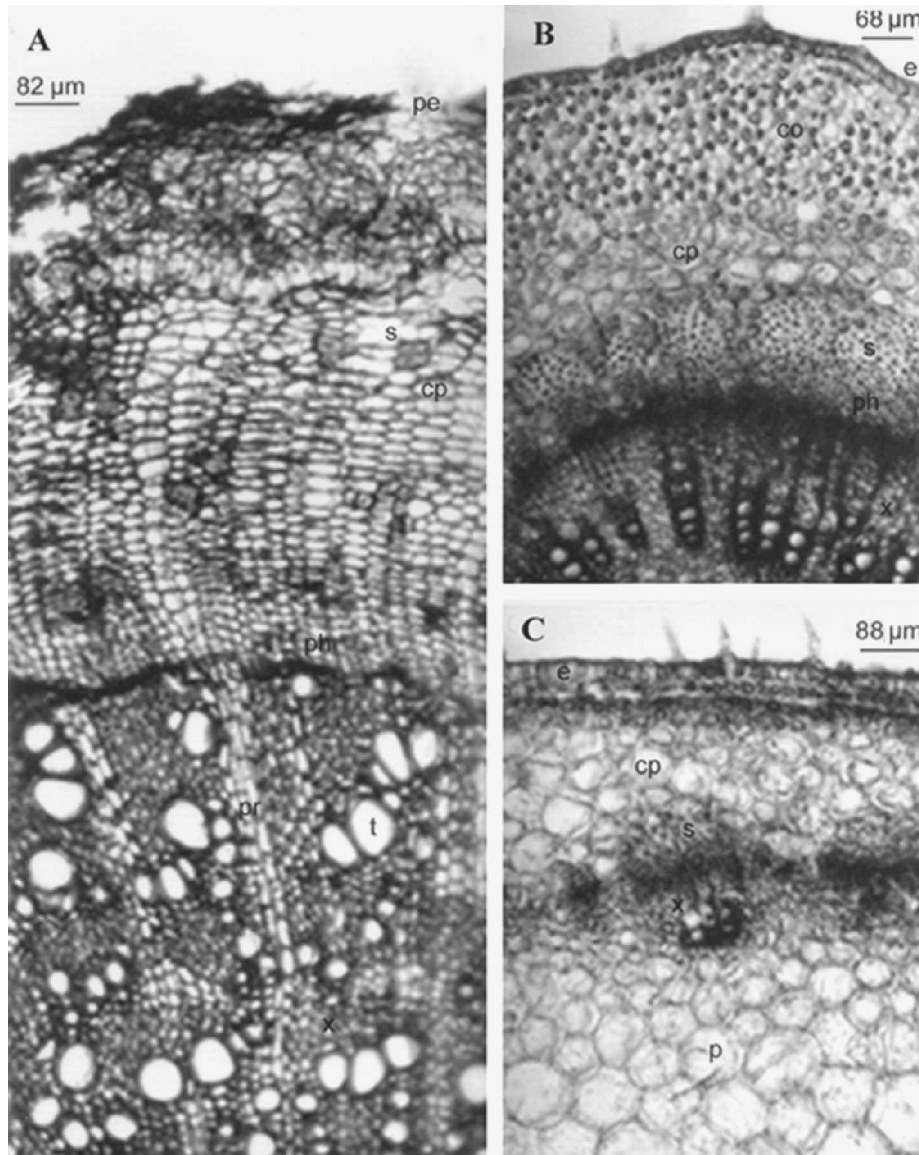


Fig. 2. The root (A) and stem (B, C) sections of *Salvia napifolia*, e = exepidermis, pe = peridermis, ph = phloem, t = trachea, p = pith, cp = cortex parenchyma, pr = pith ray, s = sclerenchyma, t = xylem.

circular. Type of vascular bundle was collateral. At the cross-sections taken from median level of petiole, it has been observed that the number of vascular bundle in the center differed. There were 1, 2 or 3 vascular bundles in the center and 1 - 3 small vascular bundles at the ends. The central vascular bundles were sometimes single and lobed or divided into 2 - 3 pieces. The 2 pieced central vascular bundles had lobe while 3 pieced ones had no lobe. Sclerenchyma upon the central vascular bundles was thick. Phloem was located between sclerenchyma and xylem. The central vascular bundles had 32 - 33 xylem rays (Fig. 3 A - F, Table 2).

Table 2. Anatomical measurements of various tissues of *Salvia napifolia*.

Parameters	Width (μm)		Length (μm)	
	Min. - Max.	Mean \pm S.D.	Min. - Max.	Mean \pm S.D.
Root				
Peridermis cell	10.7 - 32.1	21.42 \pm 8.46	5.4 - 21.4	13.4 \pm 6.9
Parenchyma cell	21.4 - 79.4	51.0 \pm 21.3	16.1 - 42.9	32.0 \pm 11.0
Pith ray	6.8 - 524.8	95.3 \pm 126		
Trachea cell	15.9 - 100.6	51.5 \pm 31.4		
Stem				
Cuticle	5.3 - 13.2	9.3 \pm 3.4		
Epidermis cell	7.9 - 37.1	21.2 \pm 12.6	5.3 - 15.9	10.6 \pm 4.2
Parenchyma	26.8 - 85.7	50.4 \pm 24.4		
Trachea cell	5.3 - 52.9	26.8 \pm 19.9		
Pith cell	10.7 - 32.1	21.4 \pm 8.5		
Leaf				
Cuticle	3.4 - 20.4	12.3 \pm 5.4		
Adaxial epidermis cell	8.2 - 81.8	36.2 \pm 24.7	16.4 - 95.5	39.7 \pm 21.6
Abaxial epidermis cell	10.9 - 46.4	25.7 \pm 13.1	10.9 - 54.5	26.3 \pm 13.6
Mesophyll region	129.9 - 523.6	335.6 \pm 126.8		
Palisade region	61.2 - 278.8	176.2 \pm 68.7		
Spongy region	54.4 - 264	129.8 \pm 73.8		
Palisade cell	10.9 - 29.9	21.1 \pm 6.1	24.5 - 95.5	53.4 \pm 22.9
Spongy cell	13.6 - 32.7	23.2 \pm 6.6		
Petiole				
Adaxial epidermis cell	10.9 - 40.9	22.5 \pm 9.2	16.4 - 35.5	26.0 \pm 6.4
Abaxial epidermis cell	5.5 - 27.3	15.0 \pm 7.9	13.6 - 32.7	23.0 \pm 7.5
Parenchyma cell	26.8 - 150.0	84.6 \pm 49.0		
Trachea cell	10.6 - 37.1	24.4 \pm 9.7		
Calyx				
Adaxial epidermis cell, sinuous walled	9.6 - 54.5	31.1 \pm 21.0	13.6 - 51.8	28.6 \pm 17.4
Abaxial epidermis cell, sinuous walled	19.1 - 54.5	39.8 \pm 13.2	27.3 - 54.5	36.5 \pm 10.8
Parenchyma cell	10.9 - 32.7	20.6 \pm 9.0	8.2 - 19.1	13.2 \pm 3.3
Corolla				

Adaxial epidermis cell	12.3 - 38.2	22.7 ± 8.1	13.6 - 32.7	22.0 ± 6.0
Abaxial epidermis cell	16.4 - 29.9	24.7 ± 5.1	16.4 - 35.5	30.6 ± 7.4
Parenchyma cell	10.9 - 35.5	21.8 ± 11.3	8.2 - 27.3	15.0 ± 7.8

S.D. = Standard deviation.

Calyx : Adaxial and abaxial epidermis were single layered. Abaxial epidermal cells were usually larger than the adaxial ones. Parenchyma was 3 - 5 layered. Parenchyma cells were flattened or nearly rectangular and filled with a lot of chloroplasts. Epidermis had stoma. Epidermal cells were sinuous walled in the superficial sections (Table 2).

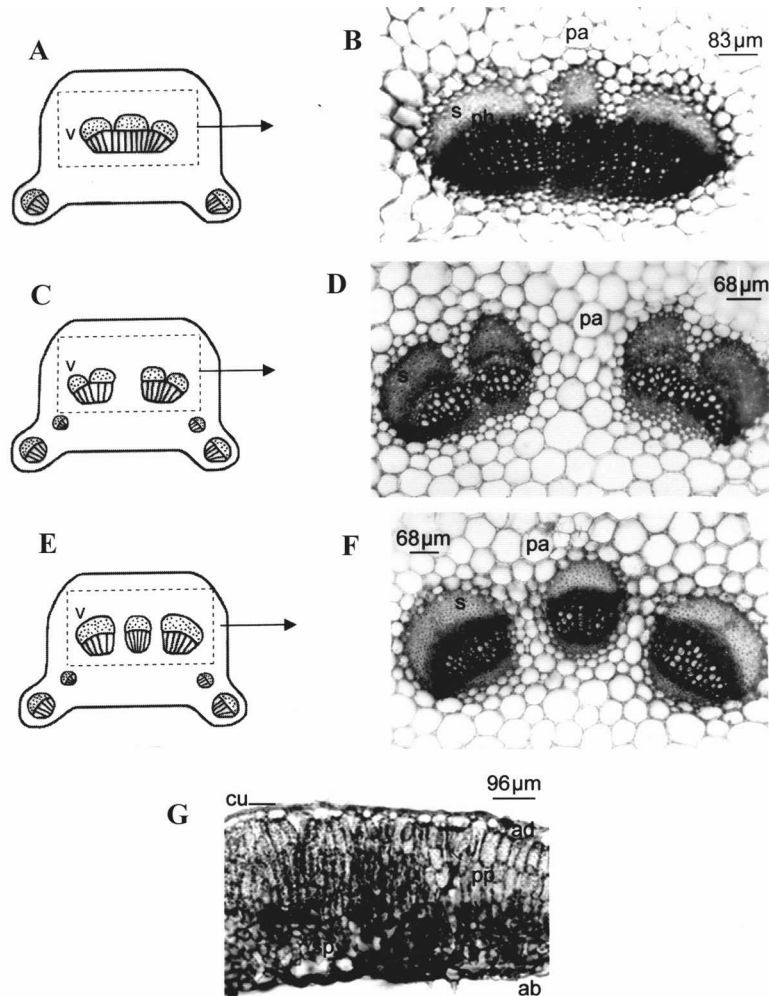


Fig. 3. The (A - F) petiole and leaf (G) sections of *Salvia napifolia*, pa = parenchyma, s = sclerenchyma, ph = phloem, x = xylem, cu = cuticle, ad = adaxial epidermis, pp = palisade parenchyma, v = vascular bundle, sp = spongy parenchyma, ab = abaxial epidermis.

Corolla : A thin cuticle surrounded epidermal cells. The outer surfaces of abaxial epidermal cells were sometimes with papilla. Abaxial epidermal cells are usually larger than adaxial epidermal cells. Parenchyma was 3 - 4 layered and had intercellular spaces (Table 2).

The genus *Salvia* comprises of about 89 species, some of which are of economic value. The authors aimed to introduce *S. napifolia* morphologically and anatomically in detail in this paper. It is stated that there is mucilage on the seed coat of Lamiaceae family, including *Salvia* seeds, which may help to germinate easily, keeping the seeds wet (Fahn 1977, Davis 1982). This clear mucilage that the seeds give off on wetting is used for lacquerware and is mixed with fruit juices to produce pleasant drinks in Mexico (Estilai *et al.* 1990). In the Eastern Turkey the mucilage is used for the treatment of eye diseases (Baytop 1999). The leaf venation of *S. napifolia* was pinnate reticulate.

The present findings of *S. napifolia* were compared with the anatomical studies made on the genus *Salvia* in literature. Few researchers observed sclerenchyma groups in the root cortex of some *Salvia* species (Çobanoğlu 1988, Çobanoğlu *et al.* 1992). The root of *S. forskahlei* L. has a sclerenchymatic ring in addition to sclerenchyma groups at the cortex (Özdemir and Şenel 2001). The root cortex of *S. napifolia* had clear sclerenchyma groups of 2 - 6 or more celled both upon phloem and in cortex parenchyma. No sclerenchymatic ring was seen.

Pith rays of Lamiaceae family are 2 - 12 or more rowed and quite heterogeneous in structure (Metcalf and Chalk 1972). In *Salvia* species examined in the literature, pith rays are 1 - 10 rowed and root center is filled with primary xylem (Çobanoğlu 1988, Çobanoğlu *et al.* 1992, Özdemir and Şenel 1999). The root center of *S. forskahlei* has a large pith consisting of parenchymatic cells and the pith rays are 2 - 40 rowed (Özdemir and Şenel 2001). The root center of *S. napifolia* was filled with xylem and the pith rays were 2 - 6 rowed. Number of rows in pith rays can be used as a species-distinguishing feature, because it differs in every species.

The characteristic feature of Lamiaceae family is a quadrangular stem and a well-developed collenchyma, supporting tissue at the corners of stem (Metcalf and Chalk 1972). The stem of *S. napifolia* was quadrangular and had a well-developed collenchyma at the corners. Woody stem of *S. forskahlei* has sclerenchyma groups upon the phloem and also a sclerenchymatic ring upon the sclerenchyma groups, but the herbaceous stem has only a sclerenchymatic ring (Özdemir and Şenel 2001). The stem of *S. napifolia* had large sclerenchyma groups upon the phloem and did not have any sclerenchymatic ring. Cambium in some *Salvia* species examined is 2 - 3 layered or sometimes unclear (Çobanoğlu 1988, Özdemir and Şenel 1999, 2001). The cambium of *S. napifolia* was not clear. Leaf mesophyll of *Salvia* species is entirely parenchymatic and the median vein of leaf is surrounded by collenchyma (Metcalf and Chalk 1972). Lacunar collenchyma forming around intercellular spaces is present in *Salvia* genus (Yentür 1995). The authors found the same characteristics in *S. napifolia*. The arrangement of vascular bundles in the petiole of Lamiaceae species is important from the taxonomic point of view (Metcalf and Chalk 1972). Nakipoğlu and Oğuz (1990) separated the vascular bundles of 7 *Salvia* species into two groups such as those species with basal leaves and those without basal leaves. According to this separation, the central vascular bundle of the species with basal leaves is divided into 3 pieces, while that of the species without basal leaves is single, large and undivided. In *S. napifolia*, a plant with basal leaves, the authors observed 1, 2 or 3 central vascular bundles and 1 - 3 small bundles at each end of petiole. These findings suggest that although *S. napifolia* is a plant with basal leaves, the number of central vascular bundle of petiole shows variation, being sometimes divided into 2-3 pieces or sometimes single, large and lobed in contrast to that of Nakipoğlu and Oğuz (1990). Epidermis cells of the calyx and corolla of *S. sclarea* L. have

sometimes papilla on their outer surfaces (Özdemir and Şenel 1999). In *S. napifolia*, sometimes epidermal cells of the corolla had papilla.

In conclusion, it can be inferred that there were some differences besides the similarities between *S. napifolia* and the other *Salvia* species in literature. *S. napifolia* was covered with glandular hairs which produce essential oil having a pleasant smell. We suggest that *S. napifolia* may be important in medicine and economy because of its fragrant essential oil. In addition, *S. napifolia* with lilac flowers and the leaves forming a rosette at the base can be also used as an ornamental plant in parks and gardens.

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