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*Full Length Research Paper*

# Anatomical and Morphological Profiling of *Salvia tchihatcheffii*: A Turkish Endemic Species

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**In this study, the morphological and anatomical properties of *SALVIA TCHIHATCHEFFII* (Fisch. & Mey.) Boiss. (Lamiaceae) which is endemic to Turkey was investigated. *S. TCHIHATCHEFFII* has a perennial taproot. In contrast to the other *SALVIA* species that was investigated before the plant has two different stem as fertile and sterile stem with round in shape. Sterile stem is prostrate, leafy, fertile stem is procumbent-ascending, unbranched. The stamen type of the plant is A. We observed that in cross-section sterile stem three different cortex layer, with one of them is formed as crescent shape. In addition, the glandular hairs of the investigated species are classified. Other anatomical features are discussed too. The results are presented with photographs, drawings and tables.**

**Key words:** Anatomy, Lamiaceae, morphology, *Salvia tchihatcheffii.*

## INTRODUCTĐON

Many species of Lamiaceae are aromatic and often used as herbs, spices, folk medicines and a source of fra-grance (Werker et al., 1985). *Salvia,* the largest genus of the family Lamiaceae, represents an enormous and cos-mopolitan assemblage of nearly 1000 species displaying a remarkable range of variation. The genus comprises 500 specie. in Central and South America, 250 species in Central Asia/Mediterranean and 90 species in Eastern Asia (Walker et al., 2004). Turkey is a major diversity centre for *Salvia* in Asia (Vural and Adıguzel, 1996). Since the most recent works of the genus in Turkey, four new species have been described; the total has now reached 90. Forty seven of these *Salvia* species in Turkey are endemic (Hedge, 1982; Davis et al., 1988; Dönmez, 2001; Hamzaoglu et al., 2005).

*Salvia* species are important group of useful plants which have not lose their importance since ancient times.

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The genus is named “Salvia” derived from “Salveo” which means “to save, to recover” in Latin (Hamlyn, 1969). *Salvia*, commonly known as sage, has multiple uses such as condiment, food additive, seasoning, spice and herbal tea (Demirci et al., 2005). The seeds of *Salvia* species often produce mucilage on wetting (Hedge, 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 (Estilai et al., 1990). In the Eastern countries, that mucilage is used for the treatment of eye diseases (Baytop, 1999). In addition to *Salvia* species (sage) were reported to be used for memory-enhancing purposes in European folk medicine (Perry et al., 2003; Orhan et al., 2007). Beside *Salvia* species have medicinal value, they are also grown in parks and gardens as ornamental plants (Nakipoglu, 1993). The appearance of the young leaves, which are very hairy, may have played a role in the folk ‘perception’ of the external medical properties of the species (Pieroni et al., 2004). Most of *Salvia* species have not been investigated in point of morphological and anatomical characters, except a few species (Cobanoglu, 1988; Nakipoglu and Oguz, 1990; Cobanoglu et al., 1992, Ozdemir and Senel, 1999;

Ozdemir and Senel, 2001; Ceja-Romeo et al., 2005; Novoa et al., 2005, Baran and Ozdemir, 2006; Kaya et al., 2007). In addition there are the papers dealing with glandular hairs and essential oil characteristics of *Salvia* species (Venkatachalam et al., 1984; Chakalov et al., 1993; Serrato-Valenti et al., 1997; Bisio et al., 1999; Corsi and Bottega, 1999; Kaya et al., 2003; Avato et al., 2005; Krstic et al., 2006). Any morphological and anatomical study has not been found in the literature, except the main morphological knowledge (Hedge, 1982) and caryological properties (Ozkan, 2006) of *Salvia tchihatcheffii.* In this study, we aimed to introduce the morphological and anatomical characters of endemic *S. tchihatcheffii* in detail.

## MATERIALS AND METHODS

The plant samples were collected from natural populations. Some samples were used for morphological and anatomical studies, some were dried as herbarium sample and stored in Celal Bayar University Herbarium (CBUH 15276). Investigated species was collected from the following location:

Ankara: between Ankara and Polatlı, Polatlı roadside, 50.km, Limestone slopes, 1000 m, 05.vi.2004.

The taxonomical description of the species follows Hedge (1982). Anatomical studies were carried out on the samples kept in alcohol 70%. The cross-sections of root, stem, leave, petiole, calyx and corolla were prepared according to Ozkan et al. (2008). The classification of glandular hairs was made according to Werker et al., (1985) and Ozdemir and Senel (2001).

## RESULTS

### Morphological properties (Figure 1 and Table 1)

The root of the taxon is 18 - 33 cm in length and taproot in shape. There is brown and hard bark on the root. The plant has two different stem. One of them has flowers; it is named as fertile stem. The another stem has no flo-wers; it is named as sterile stem. Sterile stem is pro-strate, leafy, fertile stem is procumbent-ascending, un-branched. Leaves are trisect or pinnatisect with two pairs of lateral segments. Terminal segments are linear oblong. Leaves are 1.4-2.5 x 0.9-2 cm in size. Petiole is 0.3-0.8 cm in length. The flowers are at the base of bracts, arranged verticillately on the plant and the verticillasters are 2-6 (-8) flowered. The calyx shape is tubular-cam-panulate, 0.7-1.1 x 0.3-0.5 cm in size and is colored as pale green to yellow. The upper lip of calyx is tridentate and the lower lip is bidentate and its size is 0.4-0.7 cm. The corolla is pale violete to white. The stamen type of the plant is A. Filaments are 0.2 - 0.4 cm and style is 1-1.5 cm long. The nutlets are pale-brown and rounded to trigonus, ovoid in shape and its size 1-2.3 x 2.5-3 mm.

The species is distributed at the 400-1200 m height, limestone slopes and wineyard.

### Anatomical properties

### Root (Figure 2A and Table 2)

The surface of root is covered, by multilayered, phellem cells, outer most cells dark crushed and sometimes exfaliated. Cambium is not distinguishable. Xylem elements are located in large region of root. The pith consists of paranchymatical ovoidal cells.

### Fertile stem (Figure 2B and Table 2)

Epidermis is single layered, thin walled and consists of flat ovaidal cell. Cortex is 4-8 layered, 1-2 row of cortex cells flattened. Sclerenchymatical sheats present on the phloem elements. Cambium cells are not distinguishable. The pith is large and consist of parenchymatic ovaidal cells.

### Sterile stem (Figure 2C and Table 2)

There are a thick cuticle on the epidermis. Epidermis 1 - 2 layered on the outher surface of the stem and consists of flat ovoidal cells. There are glandular and aglandular hairs on epidermis. Most of them are glandular. Cortex have three different layers as shown. The first layer con-sist of thick-walled, flattened, colenchyma cells. Second layer is 3-5 rowed and formed as crescent. The cells of this layer are ovaidal. Third layer cells are nearly the same lenght and breadth, regular without intercellular space.

### Leaf (Figure 3 and Table 2)

There is a single layered epidermis having flat-ovaidal cells on abaxial and adaxial surface of leaf. Epidermis cells are bigger and more on the abaxial surface than adaxial surface. Palisade parenchyma cells are 2-4 layered. There are 3-5 layered spongy cells. Glandular and eglandular hairs are present on both adaxial and abaxial epidermis.

### Petiole (Figure 4 and Table 2)

Petiole is covered by cuticle and regular layered ovaidal epidermal cells. There is single-layered collenchyma cells under the epidermis. Epidermal cells are 36-85 x 18-54 m in abaxial surface and 18-54 x 12-48 m in adaxial

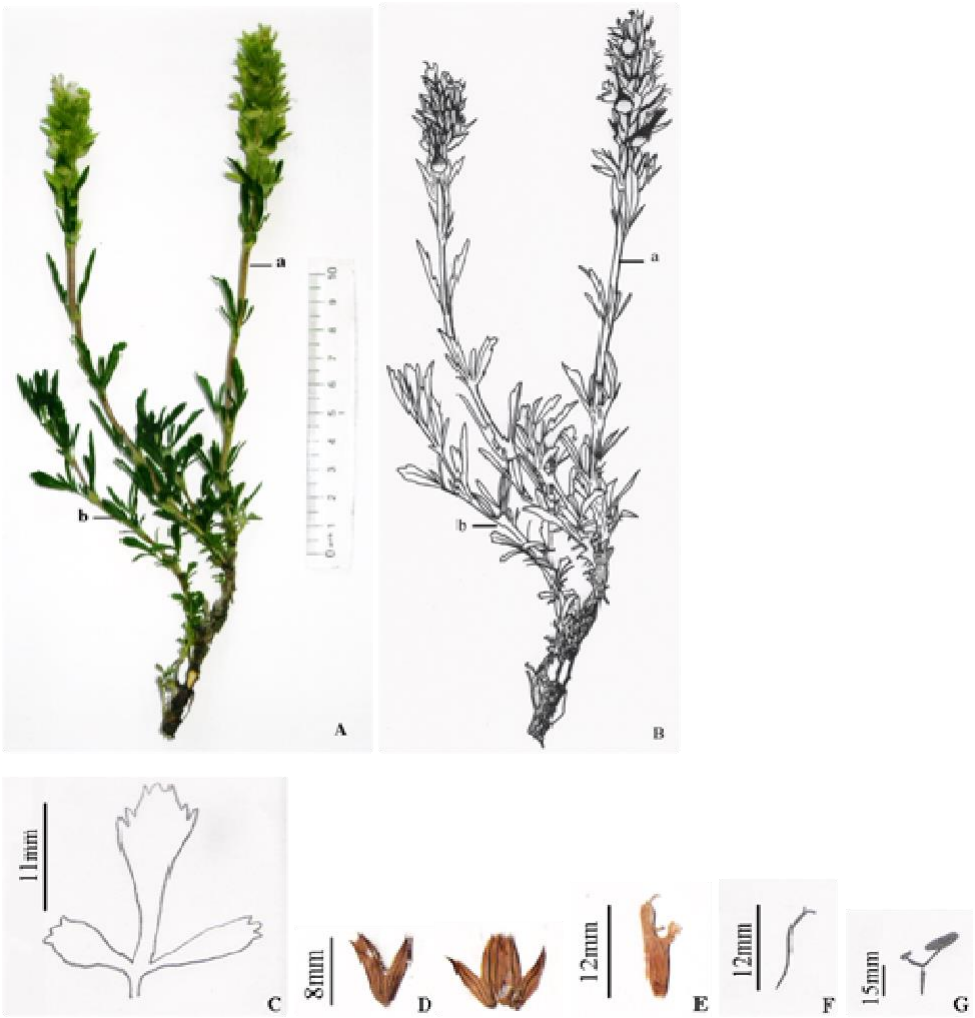


**Figure 1.** General appearence and some parts of *Salvıa tchihatcheffii*. A-B. General Appearence; a. fertile stem, and b. sterile stem. C. Leaf. D. Calyx. E. Corolla. F. Pistil. G. Stamen.

surface. Parenchymatic cortex is present under epidermis cells are 6-12 layered. These cells are 36 - 120 m in dia-meter and ovoidal in shape. There is large vascular bundle on median region petiole and small vascular bundles are located on the end part of petiole cross-section. The large vascular bundle are surrounded by sclerenchymatic cells. Type of vascular bundle is colla-teral. There are a lot of glandular and eglandular hair on epidermal cells. Most of them are glandular hair.

**Calyx (Figure 5A and Table 2)**

Adaxial epidermis cells are smaller than the abaxial epidermis. Cuticle on the abaxial epidermis is thicker than the adaxial epidermis. Parenchyma consists of flat ovoi-dal cells. Vascular bundle is surrounded by a scleren-chymatic sheat. There are hairs on epidermis and most of them are glandular. The glandular hairs are type I capi-tate with head cell.

**Corolla (Figure 5B and Table 2)**

In the cross-section, cuticle is present on both the outer and inner epidermis. The abaxial and adaxial epidermis cells are nearly the same size. Parenchyma cells are dif-ferent from each other in size and with intercellular space cells. There are hairs on epidermis and most of them eglandular hairs.

**Hair properties (Figure 6 and Table 3)**

As shown in Figure 6, *S. tchihatcheffii* has the various glandular and eglandular hairs at stem, leaf, petiol, calyx

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

| Parameter | Min. - Max. (cm) | Mean ± S.D* (cm) |
|---|---|---|
| **Root** | | |
| Root length | 18.6 - 32.50 | 24.8 ± 4.84 |
| **Stem** | | |
| Fertile stem length | 16 - 34.30 | 27.28 ± 5.74 |
| Sterile stem length | 2.50 - 10 | 6.25 ± 3.75 |
| **Leaf** | | |
| Leaf length | 1.4 - 2.50 | 2.04 ± 0.39 |
| Leaf width | 0.90 - 2 | 1.50 ± 0.38 |
| **Petiole** | | |
| Petiole length | 0.30 - 0.80 | 0.55 ± 0.15 |
| **Flower** | | |
| Calyx length | 0.70 - 1.10 | 0.91 ± 0.11 |
| Calyx width | 0.30 - 0.50 | 0.41 ± 0.06 |
| Calyx teeth length | 0.40 - 0.70 | 0.52 ± 0.09 |
| Pedicel length | 0.30 - 0.50 | 0.40 ± 0.07 |
| Corolla length | 1.0 - 1.50 | 1.21 ± 1.54 |
| Filament length | 0.20 - 0.40 | 0.26 ± 0.61 |
| Style length | 1 - 1.50 | 1.26 ± 0.14 |
| **Bract** | | |
| Bract length | 0.60 - 2 | 1.22 ± 0.43 |
| Bract width | 0.50 - 0.80 | 0.61 ± 0.01 |
| **Bracteol** | | |
| Bracteol length | 0.30 - 0.90 | 0.61 ± 0.19 |
| Bracteol width | 0.10 - 0.30 | 0.23 ± 0.07 |
| **Seed** | | |
| Seed length | 2,50 - 3.00 | 2.75 ± 0.25 |
| Seed width | 1.00 - 2,30 | 1.65 ± 0.65 |

M: Mean; SD: Standard deviation.

and corolla. There are the capitate hairs which has head cells. The capitate hairs vary greatly in structure, size, proportions, occurance on plant organs and manner of secretion.

## DISCUSSION

No information on *Salvıa tchihatcheffii* (Fisch. & Mey.) Boiss. has been found in the literature except general taxonomical properties of the taxon (Hedge, 1982; Dönmez, 2001) and caryological properties (Ozkan, 2006). The anatomical characters *S. tchihatcheffii* (Fisch. & Mey.) Boiss. are reported for the first time in the present paper. The findings of *S. tchihatcheffii* were compared with anatomical studies made on the genus *Salvia* in literature. The present findings of investigated species were compared with the anatomical studies made on the genus *Salvia* in literature.

The morphological properties of investigated species show some differences from findings of Flora of Turkey (Hedge, 1982). Our samples of *S. tchihatcheffii* were fertile stem 16-34 cm tall, bract 0.6-2 x 0.5 x 0.8 cm, pedicel 0.30-0.50 cm, and calyx 0.7-1.1 x 0.3-0.5 cm. According to Flora of Turkey (Hedge, 1982) the fertile stem 10 - 20 cm tall, bract 0.1 - 1.6 x 0.4 - 0.7 cm, pedicel 0.30 - 0.40 cm, calyx 0.8 - 1.1 x 0.9 - 1.2 cm. The others morphological finding (leaves, petiole, corolla and seed) in our study nearly the same as finding of Flora Turkey (Hedge, 1982). In addition to the size of sterile stem, fila-ment, style and bracteole of investigated species are given in this study.

Accoding to Metcalfe and Chalk (1972), the characteristic feature of Lamiaceae family is a quadrangular stem and a well developed collenchyma, supporting tis-sue at the corners of stem On the contrary, in our anato-

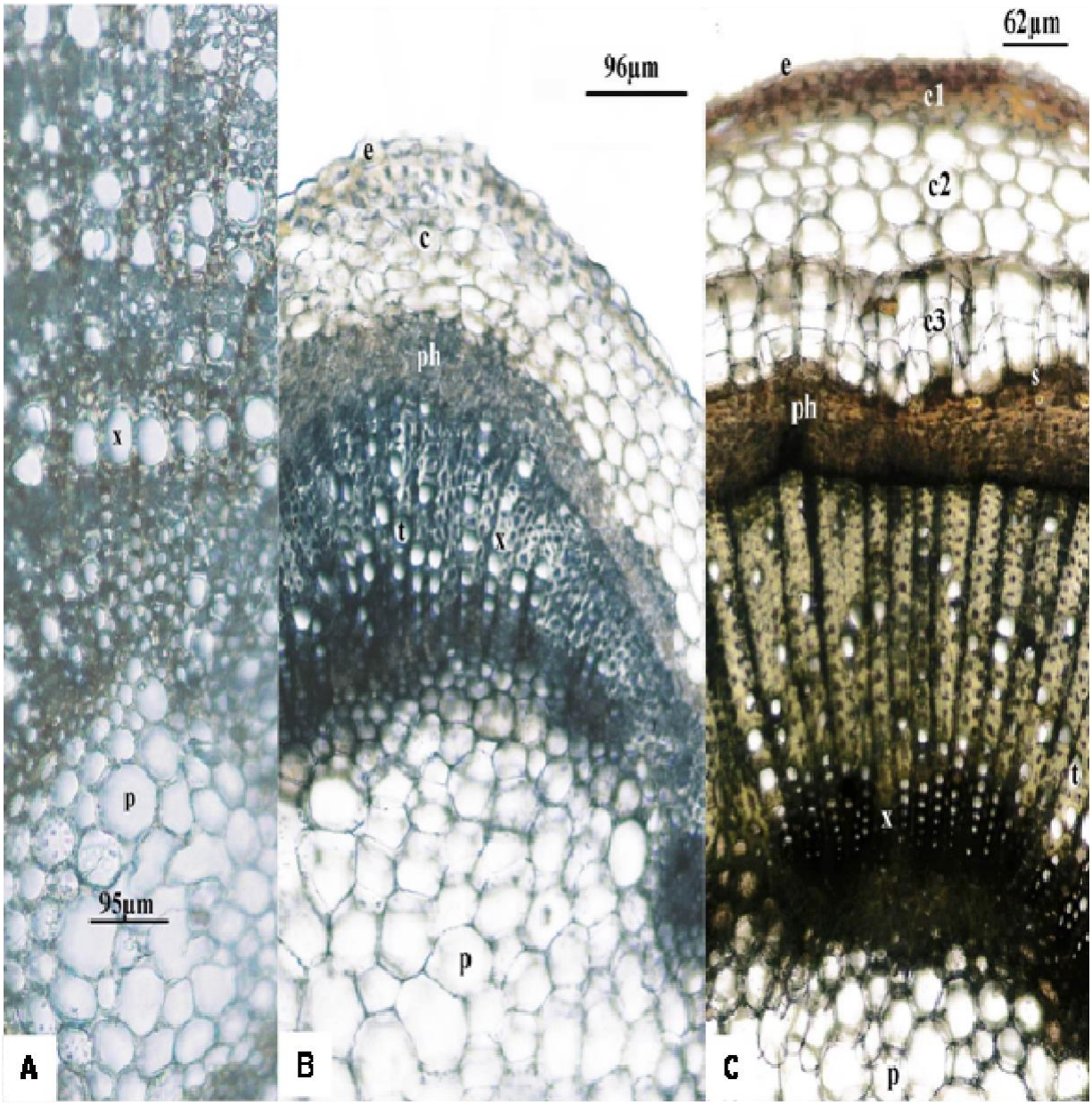


**Figure 2.** The root (A), The fertile (B) and sterile (C) stem sections of *Salvia tchihatcheffii*. e: Epidermis, c: cortex (c1, 2, 3 three different layer), s: sclerenchyma, ph: phloem, t: trachea, x: xylem, p: pith.

mical study the stem of *S. tchihatcheffii* that has different two stem, as sterile and fertile is not quandrangular and has not collenchyma at the corner. Both of them has rounded in shape. The cortex of the sterile stem consisting of three different layer. The second layer (Figure 2 and c2) is formed as crescent cortex. But fertile stem has only the cortex consists of usual paranchymatic cells.

Pithrays of Lamiaceae family are 2 - 12 or more rowed and quite heterogenous in structure (Metcalfe and Chalk, 1972). In *Salvia* species examined in the literature pith rays are 1 - 10 rowed and root center is filled with primary xylem (Cobanoglu, 1988; Cobanoglu et al., 1992; Ozdemır and Senel, 1999). The root of *Salvia forskahlei* has a large pith consisting of parenchymatic cells and pith rays are 2-40 rowed (Ozdemır and Senel, 2001). The root center of *S. tchihatcheffii* was filled with xylem and the pith rays were 2-8 rowed. Number of rows in pith rays can be used as a species distinguishing feature, because it differ in every species.

Leaf mesophyll of *Salvia* species is entirely paren-

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

| Parameter | Width (µm) Min. - Max. | Height (µm) Min. - Max. |
|---|---|---|
| **Root** | | |
| Vessel | 15.25 - 61 | |
| Pith cell | 25 - 95 | |
| **Fertile Stem** | | |
| Cuticle | 2.62 -10.48 | |
| Epidermis cell | 7.86 - 26.2 | 5.24 - 15.72 |
| Cortex cell | 15.72 - 41.92 | 10.48 - 31.44 |
| Trachea cell | 5.24 -15.72 | |
| Pith cell | 20.96 - 94.32 | |
| **Sterile Stem** | | |
| Cuticle | 2.62 - 5.24 | |
| Epidermis cell | 5.24 -20.96 | 2.62 - 10.48 |
| Cortex cell | 7.86 -31.44 | 10.48 - 36.68 |
| Crescent parenchyma | 15.72 - 62.88 | |
| Trachea cell | 5.24 - 26.2 | |
| Pith cell | 26.2 -94.32 | |
| **Leaf** | | |
| Adaxial cuticle | 2.62 - 7.86 | |
| Adaxial epidermis cell | 5.24 -15.72 | 5.24 - 10.48 |
| Abaxial cuticle | 2.62 - 5.24 | |
| Abaxial epidermis cell | 5.24 - 13.1 | 13.1 - 15.72 |
| Palisade cell | 38.4 - 76.8 | 19.2 - 28.8 |
| **Calyx** | | |
| Adaxial cuticle | 4.3 - 9.5 | |
| Adaxial epidermis cell | 75 -115 | 45-70 |
| Abaxial cuticle | 4.3 - 9.5 | |
| Abaxial epidermis cell | 75 -180 | 76 - 130 |
| Parenchyma cell | 48 -130 | |
| **Corolla** | | |
| Adaxial cuticle | 1.31 - 5.24 | |
| Adaxial epidermis cell | 25 - 75 | 23-62 |
| Abaxial cuticle | 1.31 - 2.62 | |
| Abaxial epidermis cell | 20 - 42 | 23-34 |
| Parenchyma cell | 14.4 - 45 | |

hymatic and the median vein of leaf is surrounded by collenchyma (Metcalfe and Chalk, 1972). Lacuner collenchyma forming around intercellular spaces is present in *Salvia* genus (Yentur, 1995). The same characteristics were found in the investigated species in this study. The arrangement of vascular bundels in the petiole of Lamiaceae species is important from taxonomic point of view (Metcalfe and Chalk, 1972). Nakipoglu and Oguz (1990) separed the vascular bundles of seven *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 three pieces, while that of the species without is single, large and undivided. In *S. tchihatcheffii* a plant without basal leaves, we observed one central vascular bundles and two small bundles at each and of petiole. These find-ings suggest that *S. tchihatcheffii* is a plant without basal leaves.

In conclusion, it can be inferred that there some differences besides the similarities between *S. tchihatcheffii* and other *Salvia* species in literature *S. tchihatcheffii* are covered with glandular hairs which produce essential oil

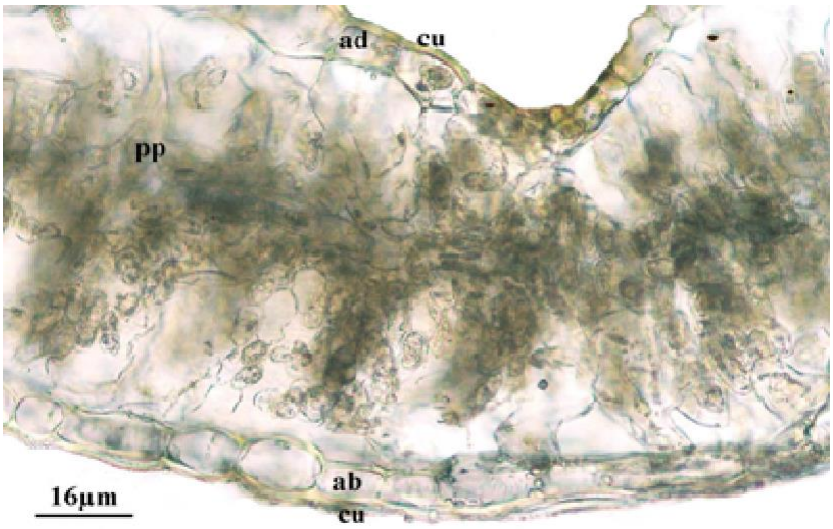


**Figure 3.** The leaf of *Salvia tchihatcheffii*. ab: Abaxial epidermis, ad: adaxial epidermis, cu: cuticle, pp: palisade parenchyma.

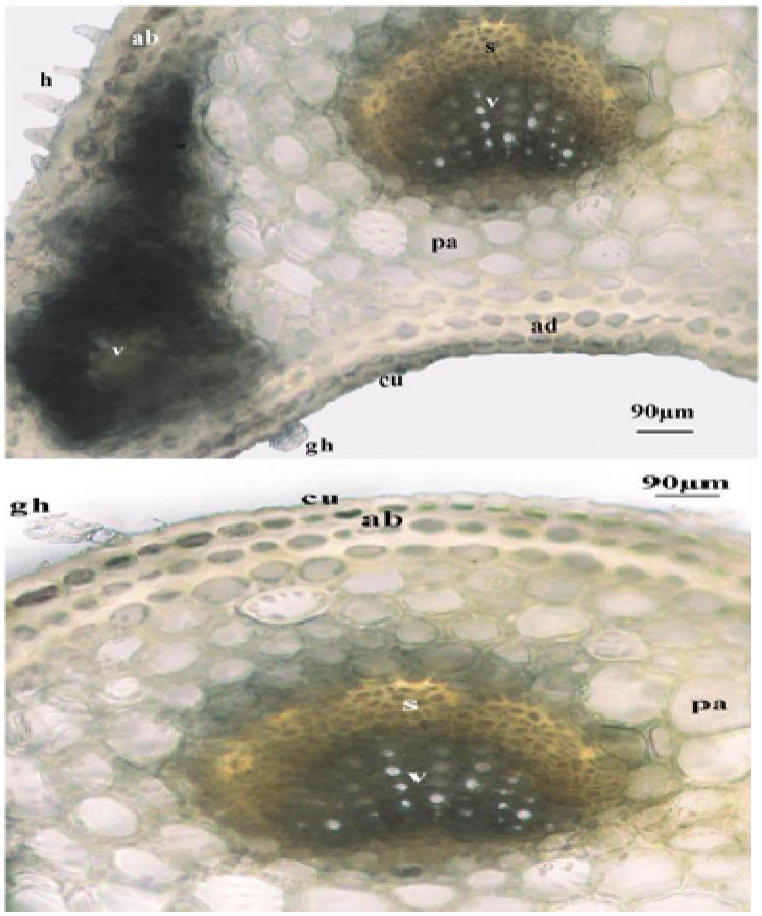


**Figure 4.** The petiole of *Salvia tchihatcheffii*. ab: Abaxial epidermis, ad: adaxial epidermis, cu: cuticle, pa: parenchyma, s: sclerenchyma, v: vascular bundle, gh: glandular hair, h: eglandular hair.

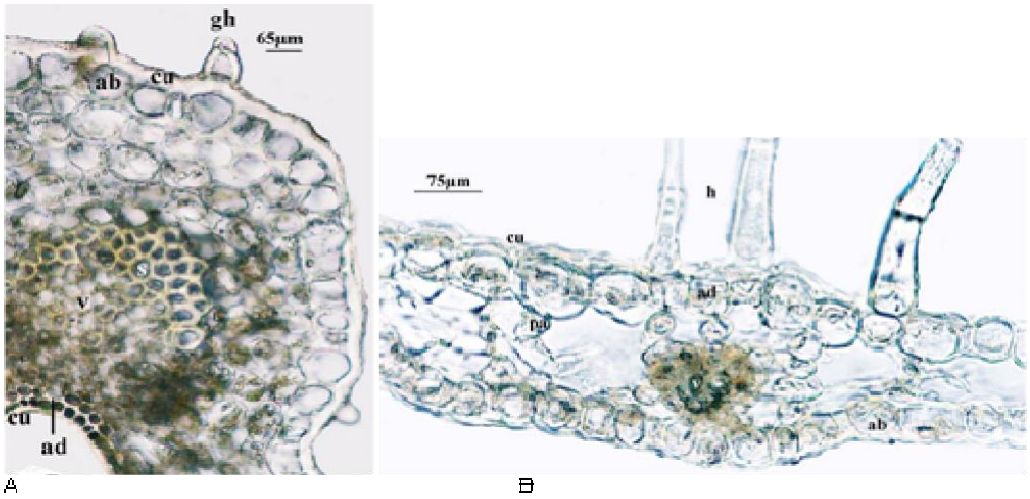


**Figure 5.** The calyx (A), corolla (B) of *Salvia tchihatcheffii*. ab: Abaxial epidermis, ad: adaxial epidermis, pa: parenchyma, gh: glandular hair, cu: cuticle, s: sclerenchyma, v: vascular bundle.

**Table 3.** Glandular hair type of various organs of *Salvia tchihatcheffii.*

| Organ | Capitate hairs | | | | | | | | | Peltate hairs | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Type I | | | Type II | | | Type III | | | | |
| | Head cell | Stalk cell | Base cell | Head cell | Stalk cell | Base cell | Head cell | Stalk cell | Base cell | Centre cell | Periphery cell |
| **Stem** | 1 | - | 1 | 1 | 1 | 1 | | | | 2 | 6 |
| | 1 | 1 | 1 | 2 | - | 1 | | | | 4 | 10 |
| | 2 | 1 | 1 | 1 | 3 | 1 | | | | | |
| | | | | 1 | 2 | 1 | | | | | |
| | | | | 1 | - | 1 | | | | | |
| | | | | 2 | 1 | 2 | | | | | |
| | | | | 1 | 2 | 2 | | | | | |
| **Petiole** | 1 | 1 | 1 | 1 | 1 | 1 | | | | 8 | 3 |
| | 1 | - | 1 | | | | | | | 6 | 2 |
| | | | | 1 | - | 1 | | | | | |
| | | | | 1 | 2 | 1 | | | | | |
| | | | | 1 | 1 | 2 | | | | | |
| **Leaf** | 1 | 2 | 1 | 1 | 2 | 1 | | | | | |
| | | | | 1 | 1 | 1 | | | | | |
| | | | | 1 | 3 | 1 | | | | | |
| | | | | 1 | 3 | 2 | | | | | |
| **Calyx** | 1 | 2 | 1 | 1 | 2 | 1 | | | | 6 | 2 |
| | | | | 1 | - | 1 | | | | 8 | 3 |
| **Corolla** | 1 | 1 | 1 | 1 | 3 | 1 | 1 | 3 | 1 | | |
| | 2 | 1 | 1 | | | | | | | | |
| | 1 | 2 | 1 | | | | | | | | |
| | 1 | 2 | 2 | | | | | | | | |
| | 1 | - | 1 | | | | | | | | |
| | 1 | 2 | 3 | | | | | | | | |

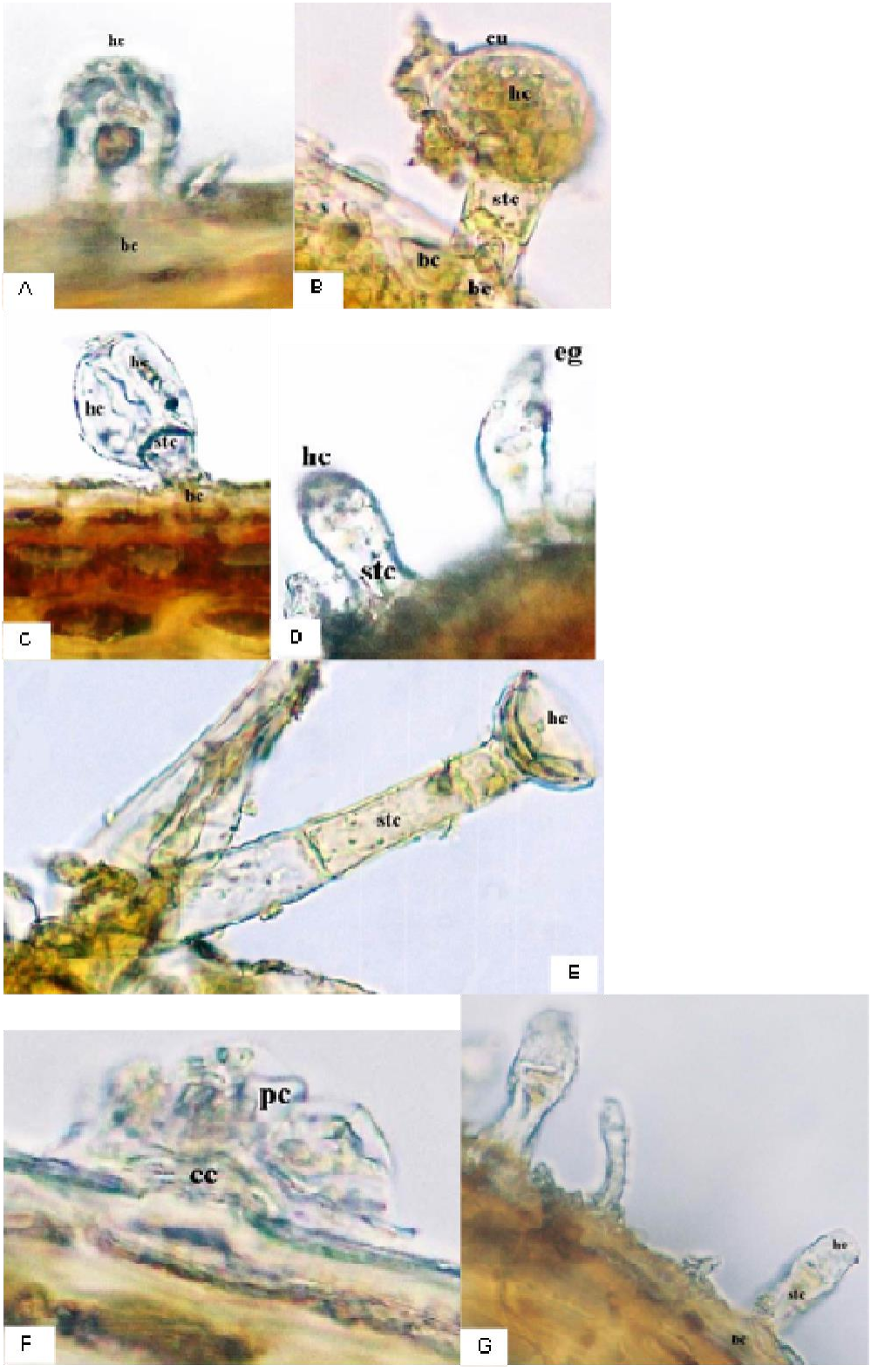


**Figure 6.** Photographs of glandular and eglandular hairs of *Salvia tchihatcheffii* A - C: Type 1 capitate hairs. D: Type 2 capitate hair and eglandular hair E : Type 3 capitate hair, F: Peltate hair. G : glandular hairs. hc. head cell stc. stalk cell bc. base cell, cc: central cells, pc: periphery cells.

having a pleasant smell. This plant may be important in medicine and economy because of its fragrant essential oil.

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