

## The anatomical properties of *Salvia* section (Lamiaceae) in central district of Mardin (Turkey) and their taxonomic implications

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### Research Article

**Abstract** – In this study, 4 *Salvia* species found in the *Salvia* section distributed in the Artuklu district of Mardin province were analyzed comparatively in terms of anatomy. Plant specimens of *Salvia* section were collected from 11 localities. Anatomical studies were performed on specimens preserved in 70% alcohol. Transverse sections taken from the roots, stems, leaves, and petioles of the species were examined under a light microscope for anatomical examination. The anatomy of *S. bracteata*, *S. macrochlamys*, *S. suffruticosa*, *S. trichoclada* species were examined. The *S. suffruticosa* species was examined in detail for the first time anatomically. The data obtained as a result of the researches were compared with the previous studies on the *Salvia* section. In anatomical examinations, it was observed that the root, stem, leaf, and petiole structures of the taxa were similar but shapes and measurements in addition to this the number of tissue layers and pith rows are different. Also anatomically analyses, it has been seen that hairiness formed a difference between some species. As a result of all these discussed data, the anatomical characters such as number of ray rows in root, number of collenchyma layers in stem, mesophyll structures in leaves, shape of midrib and number of vascular bundles in petiole, provide important taxonomic information.

**Keywords** – Anatomy, Artuklu, *Salvia*, Taxonomy, Turkey

## 1. Introduction

The Lamiaceae family is a very large family that includes 245 genus and 7,886 species in the world (Anonymous, 2013). *Salvia* L., the most extensive genus of the Lamiaceae family, consists of close to 1,000 taxa and shows a remarkable diversity, meaning a very large and cosmopolitan mixed community (Walker & Systma, 2007). It is found in Central and South America (500 taxa), North and West Asia (especially in Turkey, Iran and Russia) (about 200-220 taxa), East Asia (90 taxa), Africa (about 60 taxa), and Europe (about 36 taxa) (Harley et al., 2004). Turkey is one of the important gene centers of the Lamiaceae family. This family is represented in 45 genera and approximately 574 taxa in our country. This family, which has an endemism rate of approximately 44.5% in our country, is the third richest family in Turkey in terms of the number of taxa it contains (Davis, 1965-1985; Güner et al., 2012). The genus *Salvia* L. (Sage) belonging to this family has specified as 87 species in the flora of the country, half of which are endemic (Davis, 1982; Güner et al., 2000). According to the latest studies conducted in our country, 106 taxa of the genus *Salvia*, 58 of them are endemic, and the rate of endemism is 51% (Güner et al., 2012).

Bentham (1833) made the first subgenus classification of the genus. Boissier (1875) accepted Bentham's classification, in *Flora Orientalis* and divided the *Salvia* species distributed in Turkey into seven sections. Later Hedge (1972) altered the sect. *Eusphace* to sect. *Salvia*.

*Salvia* L. taxa, which means health in Latin; its annual or perennial plants in herb, shrub or suffruticose form. It usually has a distinctive aromatic odor and glandular hairs. Its flowers are white, yellow, pink, blue or purple, with two lips. It spreads in different habitats and elevations (Davis, 1965-1985). *Salvia* L. species are of economic importance due to their use both medicinally and as a spice. Some of the *Salvia* L. species

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are grown as decorative plants in gardens and parks due to their medicinal value as well as beautiful-looking flowers (Albayrak et al., 2008).

Anatomy which is greatly important as a means of connecting several important branches of modern plant science and as one of the oldest disciplines of plant science has accumulated an enormous amount of data (Povilus et al., 2020). In this respect, anatomical studies are important.

This investigation seeks to provide a clear understanding of anatomical features of the *S. bracteata* Banks & Sol., *S. macrochlamys* Boiss. & Kotschy, *S. suffruticosa* Montbret & Aucher ex Benth., and *S. trichoclada* Benth. species spreading in the Artuklu district of Mardin. Also, the anatomical characters of the *S. suffruticosa* species belonging to the *Salvia* section on which we studied have not been studied in detail until now. The anatomical value of the data obtained as a result of the study is also compared with previous studies on the *Salvia* section.

## 2. Materials and Methods

Plant specimens of the *Salvia* section were collected from 11 localities in Artuklu-Mardin (Figure 1, Table 1). Plant samples were preserved in the herbarium of Mardin Artuklu University, Vocational Higher School of Kızıltepe. Diagnoses were prepared according to Davis (1965-1985) and Güner et al. (2012). Anatomical analyses were performed on samples kept in 70% alcohol. Anatomical characters of root, stem, leaf, and petiole were examined by a light microscope (Isolab). Root, stem, leaf, and petiole cross-sections were stained with safranin-fast green solutions (Bozdağ et al. 2016). Sample sections were made manually with the help of a razor blade. The biometric measurements of the plant parts whose anatomical structures were examined are given in the Table 2, 3, 4, 5.

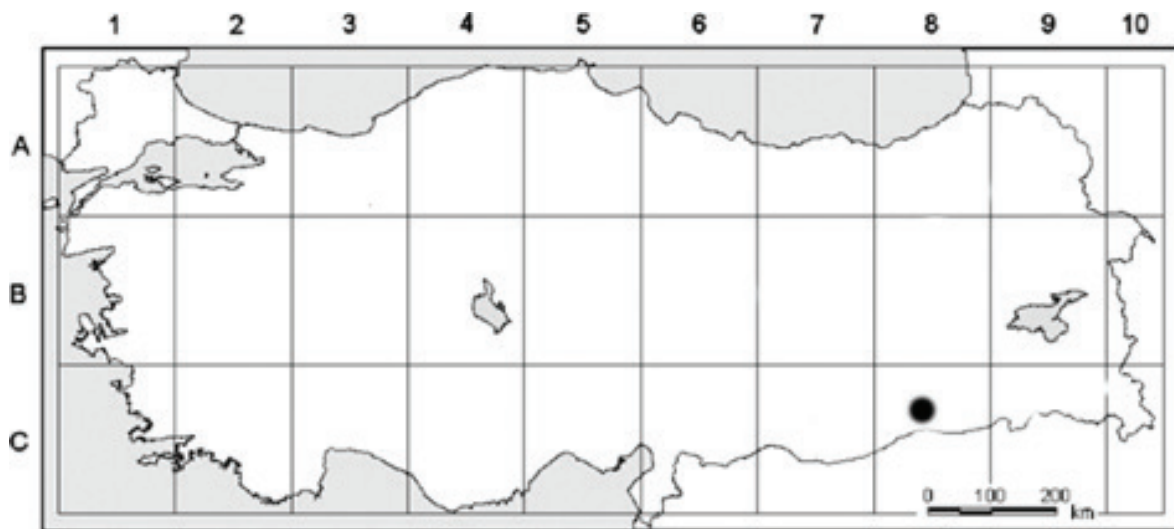


Figure 1. Distribution map of *Salvia* species

Table 1

*Salvia* section used for anatomical studies and collected localities

Species	Localities	Collector's number
<i>S. bracteata</i>	Turkey, C8 Mardin: Artuklu, Eskikale Village, Sultanköy Village, Hamzabey Village	M.Kılıç 204, 219, 224
<i>S. macrochlamys</i>	Turkey, C8 Mardin: Artuklu, Eskikale Village	M.Kılıç 218, 220, 221
<i>S. suffruticosa</i>	Turkey, C8 Mardin: Artuklu, Sultanköy Village, Hamzabey Village	M.Kılıç 208, 226
<i>S. trichoclada</i>	Turkey, C8 Mardin: Artuklu, Hamzabey Village	M.Kılıç 222, 229, 232

### 3. Results and Discussion

Sections taken from parts of plants (root, stem, leaf, petiole) were investigated in detail and the results are summarized below. The taxa are given in alphabetical order.

#### 3.1. Root anatomical characteristics

*Salvia bracteata*: Peridermis was a thick layer, crushed, and fragmented in cross-section. Parenchymatous cells under the peridermis were 5-6 rows and under it, there are 6-7 rows of phloem. Cambium was unclear. In the xylem, besides the large tracheas, tracheids and xylem parenchyma have lignified walls. Pith ray has 1-2 cells. The xylem is very narrow (Figure 2, Table 2).

*Salvia macrochlamys*: Peridermis was a thick layer, crushed, and fragmented in cross-section. Beneath the periderm is the multi-layered parenchymal cells, and below the parenchyma, several layered sclerenchyma groups are usually angular and contain 6-10 or more cells. There are 3-4 rows of phloem under sclerenchyma groups. Cambium was unclear. In the xylem, besides the large tracheas, tracheids and xylem parenchyma have lignified walls. Pith ray has 1-2 cells. The xylem is very narrow (Figure 2, Table 2).

*Salvia suffruticosa*: Peridermis was a thick layer, crushed, and fragmented in cross-section. Beneath the periderm is the multi-layered parenchymal cells, and below the parenchyma, several layered sclerenchyma groups in places. There are multi-layer of phloem under sclerenchyma groups. Cambium was unclear. In the xylem, besides the large tracheas, tracheids and xylem parenchyma have lignified walls. Pith ray has 1-2 cells. The xylem is very narrow (Figure 2, Table 2).

*Salvia trichoclada*: Peridermis was a thick layer, crushed, and fragmented in cross-section. Beneath the periderm is the multi-layered parenchymal cells, and below the parenchyma, several layered sclerenchyma groups in places. There are multi-layer of phloem under sclerenchyma groups. Cambium was unclear. In the xylem, besides the large tracheas, tracheid and xylem parenchyma have lignified walls. Pith ray has 2-4 cells. The xylem is very narrow (Figure 2, Table 2).

Table 2

Comparative anatomy of root of *Salvia* section

Species	Tissue	Width ( $\mu$ )		Length ( $\mu$ )	
		Min.–Max.	Mean $\pm$ S.D.	Min.–Max.	Mean $\pm$ S.D.
<i>S. bracteata</i>	Peridermis cell	13,46–56,27	35,52 $\pm$ 12,91	9,30–28,35	17,70 $\pm$ 4,87
	Parenchyma cell	21,85–47,45	32,64 $\pm$ 8,44	9,96–28,87	19,12 $\pm$ 5,24
	Trachea cell	15,93–65,91	42,55 $\pm$ 16,21	15,28–65,34	45,07 $\pm$ 16,11
	Pith cell	7,24–39,98	35,52 $\pm$ 12,91	6,47–22,36	17,70 $\pm$ 4,87
<i>S. macrochlamys</i>	Peridermis cell	17,00–36,03	26,69 $\pm$ 6,34	12,33–39,98	24,84 $\pm$ 8,10
	Parenchyma cell	13,12–44,73	26,98 $\pm$ 9,63	9,10–38,93	20,03 $\pm$ 10,15
	Trachea cell	17,62–70,09	38,60 $\pm$ 14,52	17,44–74,34	38,88 $\pm$ 14,78
	Pith cell	7,73–21,89	14,45 $\pm$ 4,13	11,68–32,61	21,81 $\pm$ 5,60
<i>S. suffruticosa</i>	Peridermis cell	7,94–29,63	20,58 $\pm$ 6,37	8,67–31,14	20,21 $\pm$ 6,79
	Parenchyma cell	10,20–28,44	20,13 $\pm$ 5,57	6,80–23,29	14,11 $\pm$ 4,73
	Trachea cell	14,96–59,63	32,29 $\pm$ 11,98	17,40–62,62	37,49 $\pm$ 13,47
	Pith cell	4,63–21,23	9,64 $\pm$ 4,46	6,42–16,33	10,31 $\pm$ 2,54
<i>S. trichoclada</i>	Peridermis cell	7,83–43,65	28,21 $\pm$ 9,47	5,03–21,49	12,37 $\pm$ 3,80
	Parenchyma cell	7,79–35,45	17,03 $\pm$ 6,65	6,70–21,22	13,49 $\pm$ 4,03
	Trachea cell	11,90–45,75	29,29 $\pm$ 10,15	9,41–53,31	30,67 $\pm$ 13,96
	Pith cell	3,35–7,61	5,68 $\pm$ 1,26	3,97–11,87	7,63 $\pm$ 2,48

S.D.: Standard Deviation

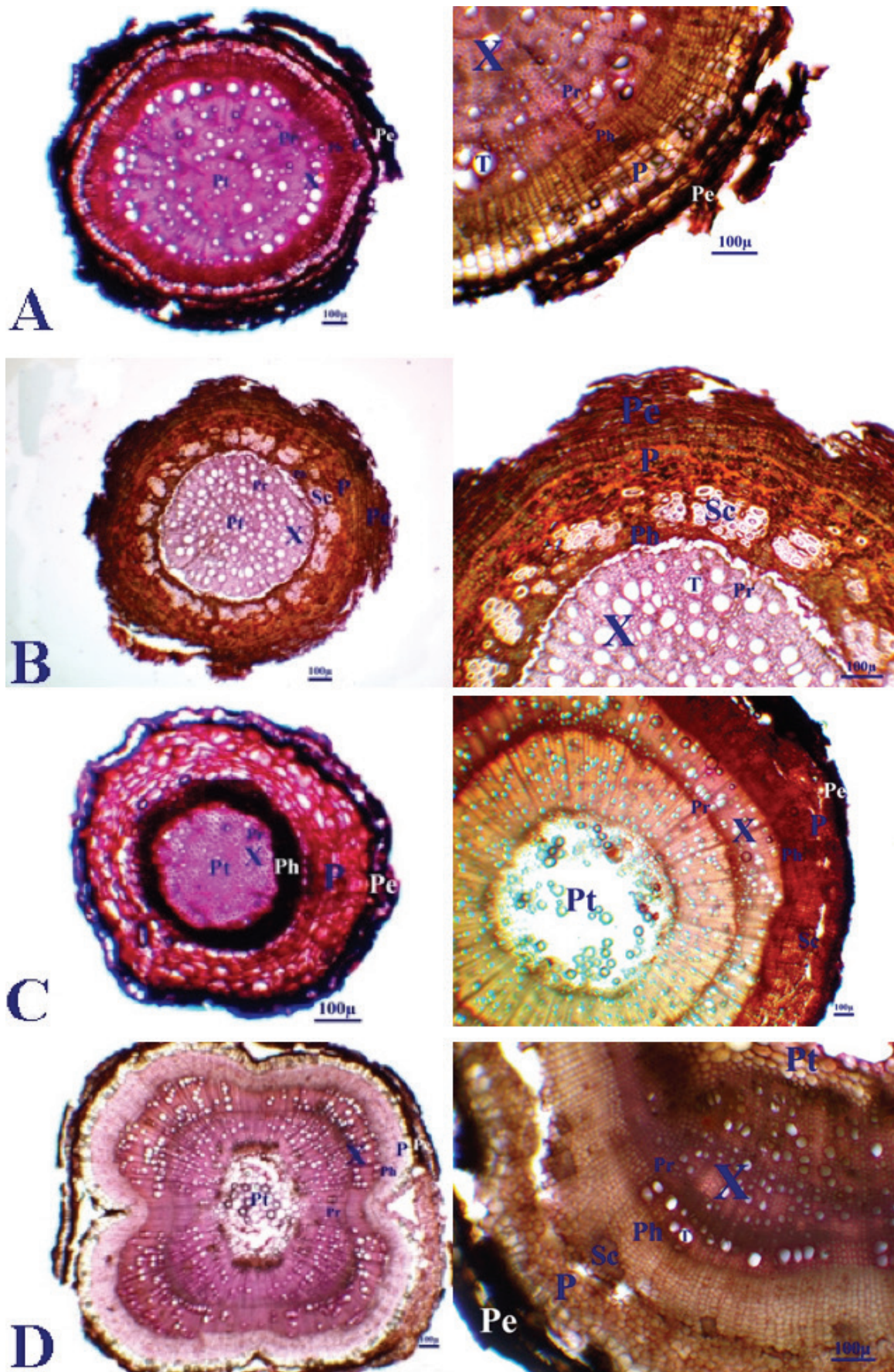


Figure 2. Cross-section of root. **A**, *S. bracteata*. **B**, *S. macrochlamys*. **C**, *S. suffruticosa*. **D**, *S. trichoclada*. Pe: Periderm, P: Parenchyma, Sc: Sclerenchyma, Ph: Phloem, X: Xylem, Pr: Pith ray, T: Trachea, Pt: Pith region

### 3.2. Stem anatomical characteristics

In all taxa were stem quadrangular in the cross-section. The epidermis is comprised of a uniseriate of oval, nearly rectangular cells covered by a thin cuticle layer.

*Salvia bracteata*: The epidermis contains single or multicellular glandular and eglandular hairs. There are 5-7 rows of collenchyma cells at the corners and 3-4 rows of these cells between the corners. Collenchyma is oval and quadrangular in shape. Parenchyma, formed by parenchymatous, cubic, and oval cells was 5-7 rowed at the sides and 4-6 rowed at the corners. There are crushed parenchymal cells between the parenchyma layer. 4-5 rows of sclerenchyma were located on the vascular bundles. The phloem is of 5-7 rows. Cambium indistinct. Xylem was larger than phloem. The pith region occurs of polygonal or orbicular parenchyma cells (Figure 3, Table 3).

*Salvia macrochlamys*: The epidermis contains glandular and eglandular hairs. There are 6-9 rows of collenchyma cells at the corners and 1-3 rows of these cells between the corners. Collenchyma is oval and quadrangular in shape. Parenchyma, formed by parenchymatous, cubic, and oval cells was 6-10 rowed at the edges and 4-8 rowed at the corners. 3-5 rows of sclerenchyma were located on the vascular bundles. The phloem is of several rows. Cambium indistinct. Xylem was larger than phloem. The pith region occurs of polygonal or orbicular parenchyma cells (Figure 3, Table 3).

*Salvia suffruticosa*: The epidermis contains glandular and eglandular hairs. There are 8-10 rows of collenchyma cells at the corners and 3-4 rows of these cells between the corners. Collenchyma is oval and rectangular in shape. Parenchyma, formed by parenchymatous, cubic, formless, and oval cells was 3-4 rowed at the edges and 4-5 rowed at the corners. 1-2 rows of sclerenchyma were located on the vascular bundles. The phloem is of several layers. Cambium indistinct. Xylem was larger than phloem. The pith region occurs of polygonal or orbicular parenchyma cells (Figure 3, Table 3).

*Salvia trichoclada*: The epidermis contains glandular and eglandular hairs. There are 6-7 rows of collenchyma cells at the corners and 1-4 rows of these cells between the corners. Collenchyma is oval, square, and rectangular in shape. Parenchyma, formed by parenchymatous, cubic and oval cells was 3-4 rowed at the edges and 4-6 rowed at the corners. 2-4 rows of sclerenchyma were located on the vascular bundles. The phloem is of several layers. Cambium indistinct. Xylem was larger than phloem. The pith region occurs of polygonal or orbicular parenchyma cells (Figure 3, Table 3).

### 3.3. Leaf anatomical characteristics

In all taxa were stomata present on both surfaces of the leaf (amphistomatic type) and stomata are diacytic type.

*Salvia bracteata*: The epidermis is square, oval, and almost rectangular covered with a thin cuticle. There are copious amounts of glandular and eglandular hairs of uni- or multi-cellular on the epidermis. Below the upper and lower epidermis layers is the hypodermis. Palisade parenchyma cells were 2-3 rowed and cylindrical, whereas spongy parenchyma cells were 2-3 rowed and circular or polygonal in shape. Mesophyll type is bifacial. The adaxial surface is concave around the median vein area. Collenchyma is below adaxial, and 2-3 rows. The vascular bundles are collateral. The arcuate vascular bundle is surrounded by parenchyma cells. Under the parenchyma is the xylem. The phloem is 3-4 rows and is located below the xylem. The abaxial surface is convex and located below it there are 4-5 rows of collenchyma (Figure 4, Table 4).

*Salvia macrochlamys*: The epidermis is oval and almost rectangular covered with a thin cuticle. There are copious amounts of glandular and eglandular hairs on the epidermis. Below the upper and lower epidermis layers are the hypodermis. Palisade parenchyma cells are elongated rectangular, 2-3 rowed above and 1-2 rowed below. The spongy parenchyma cells are 2-3 rowed with large intercellular spaces. Mesophyll type is equifacial. The adaxial surface is convex around the median vein area. Collenchyma is below adaxial, and 1-2 rows. The vascular bundles are collateral. The arcuate vascular bundle is surrounded by parenchyma cells. Under the parenchyma is the xylem. The phloem is several layers and is located

Table 3  
Comparative anatomy of stem *Salvia* section

Species	Tissue	Width ( $\mu$ )		Length ( $\mu$ )	
		Min.–Max.	Mean $\pm$ S.D.	Min.–Max.	Mean $\pm$ S.D.
<i>S. bracteata</i>	Cuticle	–	–	1,41–6,08	3,30 $\pm$ 1,24
	Epidermis cell	8,10–24,83	16,06 $\pm$ 3,59	6,70–16,51	11,23 $\pm$ 2,12
	Collenchyma cell	6,95–37,12	19,20 $\pm$ 7,15	7,82–27,11	15,25 $\pm$ 5,31
	Parenchyma cell	11,86–54,36	33,38 $\pm$ 12,61	12,20–47,18	28,50 $\pm$ 10,51
	Phloem cell	8,46–22,44	14,76 $\pm$ 3,78	5,64–17,16	9,08 $\pm$ 3,051
	Trachea cell	14,57–43,80	26,03 $\pm$ 8,76	13,25–44,08	26,69 $\pm$ 10,50
	Pith cell	24,15–90,58	56,98 $\pm$ 21,95	29,23–94,71	58,31 $\pm$ 22,77
<i>S. macrochlamys</i>	Cuticle	–	–	2,57–8,98	5,60 $\pm$ 1,67
	Epidermis cell	10,47–28,26	17,59 $\pm$ 5,38	8,97–14,66	11,52 $\pm$ 1,69
	Collenchyma cell	15,88–35,30	24,73 $\pm$ 6,45	13,72–32,81	21,71 $\pm$ 5,97
	Parenchyma cell	28,28–79,94	52,54 $\pm$ 14,67	23,12–61,51	37,90 $\pm$ 11,29
	Phloem cell	8,61–16,22	11,33 $\pm$ 2,12	2,93–10,60	6,27 $\pm$ 2,08
	Trachea cell	17,57–43,37	32,28 $\pm$ 8,04	18,11–60,86	35,23 $\pm$ 13,16
	Pith cell	59,00–206,41	117,77 $\pm$ 45,73	57,59–208,99	121,91 $\pm$ 46,26
<i>S. suffruticosa</i>	Cuticle	–	–	3,18–7,68	5,80 $\pm$ 1,27
	Epidermis cell	12,36–26,39	18,37 $\pm$ 4,28	10,30–22,25	16,24 $\pm$ 3,65
	Collenchyma cell	10,71–33,38	24,61 $\pm$ 6,52	9,79–32,08	23,03 $\pm$ 5,95
	Parenchyma cell	19,16–60,66	39,52 $\pm$ 12,80	10,36–56,91	32,90 $\pm$ 12,84
	Phloem cell	4,53–12,26	7,47 $\pm$ 1,94	2,41–8,23	5,43 $\pm$ 1,74
	Trachea cell	10,98–28,64	19,29 $\pm$ 5,30	8,98–29,12	19,42 $\pm$ 6,25
	Pith cell	20,19–105,02	51,90 $\pm$ 26,69	18,95–109,34	49,89 $\pm$ 27,00
<i>S. trichoclada</i>	Cuticle	–	–	2,45–6,26	3,76 $\pm$ 0,96
	Epidermis cell	6,99–23,26	15,67 $\pm$ 4,25	7,16–16,36	11,61 $\pm$ 2,39
	Collenchyma cell	7,91–25,10	15,04 $\pm$ 4,49	6,98–20,70	12,35 $\pm$ 3,88
	Parenchyma cell	16,71–58,63	31,97 $\pm$ 11,21	13,61–57,68	27,75 $\pm$ 10,92
	Phloem cell	3,96–15,49	8,81 $\pm$ 3,52	2,89–8,65	5,54 $\pm$ 1,64
	Trachea cell	9,62–24,81	17,47 $\pm$ 4,97	9,48–30,08	18,12 $\pm$ 5,72
	Pith cell	29,31–78,66	47,27 $\pm$ 14,30	23,44–73,04	45,76 $\pm$ 14,32

below the xylem. The abaxial surface is convex and located below it there are 2-3 rows of collenchyma (Figure 4, Table 4).

*Salvia suffruticosa*: The epidermis is oval and almost rectangular covered with a thin cuticle. There are copious amounts of glandular and eglandular hairs on the epidermis. Below the upper and lower epidermis layers are the hypodermis. Palisade parenchyma cells were 2-3 rowed and cylindrical or broad cylindrical, whereas spongy parenchyma cells were 1-2 rowed oval or elongated oval in shape. Mesophyll type is bifacial. The adaxial surface is slightly concave around the median vein area. Collenchyma is below adaxial, and 1-2 rows. The vascular bundles are collateral. The arcuate vascular bundle is surrounded by parenchyma cells. Under the parenchyma is the xylem. The phloem is several layers and is located below the xylem. The abaxial surface is slightly convex and located below it there are 2-3 rows of collenchyma (Figure 4, Table 4).

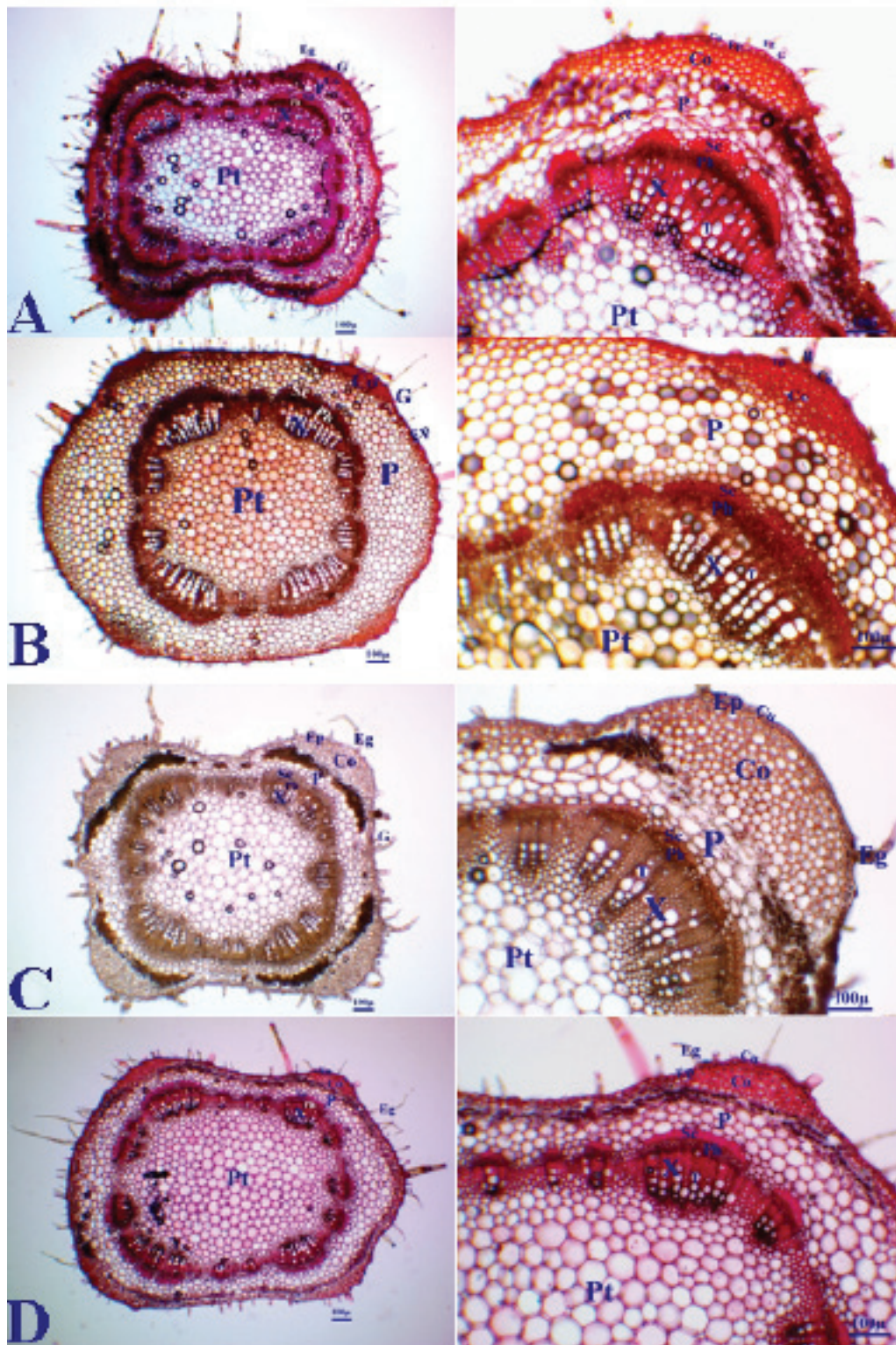


Figure 3. Cross-section of stem. **A**, *S. bracteata*. **B**, *S. macrochlamys*. **C**, *S. suffruticosa*. **D**, *S. trichoclada*. G: Glandular hair, Eg: Eglanular hair, Ch: Compound hair, H: Hair, Cu: Cuticle, Ep: Epidermis, Co: Collenchyma, Crp: Crushed parenchyma, P: Parenchyma, Sc: Sclerenchyma, Ph: Phloem, X: Xylem, T: Trachea, Pt: Pith region

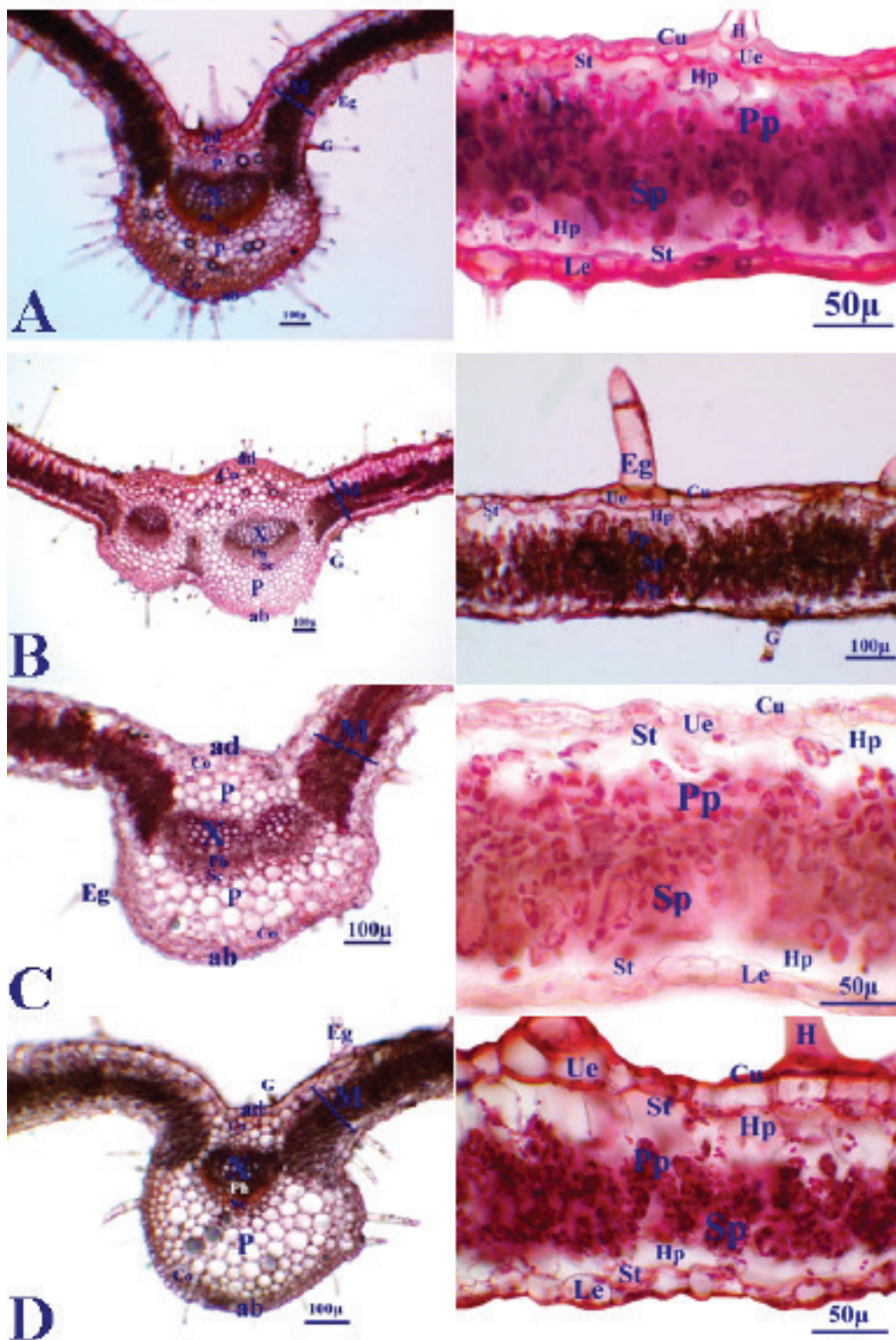


Figure 4. Cross-section of leaf. **A**, *S. bracteata*. **B**, *S. macrochlamys*. **C**, *S. suffruticosa*. **D**, *S. trichoclada*. G: Glandular hair, Eg: Eglandular hair, Ch: Compound hair, H: Hair, M: Mesophyll layer, ad: Adaxial surface, Co: Collenchyma, Crp: Crushed parenchyma, P: Parenchyma, X: Xylem, Ph: Phloem, ab: Abaxial surface, Ue: Upper epidermis, Le: Lower epidermis, Pp: Palisade parenchyma, Sp: Spongy parenchyma, Hp: Hypodermis, St: Stomata



*Salvia trichoclada*: The epidermis is oval and almost rectangular covered with a thin cuticle. There are copious amounts of glandular and eglandular hairs on the epidermis. Below the upper and lower epidermis layers are the hypodermis. Palisade parenchyma cells were 2-3 rowed and cylindrical or quadrangle, whereas spongy parenchyma cells were 1-2 layered oval or elongated oval in shape. Mesophyll type is bifacial. The adaxial surface is slightly convex around the median vein area. Collenchyma is below adaxial, and 1-2 rows. The vascular bundles are collateral. The arcuate vascular bundle is surrounded by parenchyma cells. Under the parenchyma is the Xylem. The phloem is multi-layers and is located below the xylem. The abaxial surface is slightly convex and located below it there are 2-3 rows of collenchyma (Figure 4, Table 4).

Table 4

Comparative anatomy of leaf of *Salvia* section

Species	Tissue	Width ( $\mu$ )		Length ( $\mu$ )	
		Min.–Max.	Mean $\pm$ S.D.	Min.–Max.	Mean $\pm$ S.D.
<i>S. bracteata</i>	Cuticle	–	–	2,15–6,38	4,27 $\pm$ 1,38
	Upper epidermis cell	6,37–40,72	20,11 $\pm$ 10,72	6,33–23,09	13,71 $\pm$ 5,02
	Palisade parenchyma	7,47–13,31	10,87 $\pm$ 1,57	17,47–35,51	26,14 $\pm$ 5,08
	Spongy parenchyma	7,25–15,57	12,25 $\pm$ 2,59	6,91–19,31	12,11 $\pm$ 4,15
	Mesophyll layer	–	–	77,36–148,43	103,89 $\pm$ 17,86
	Lower epidermis cell	9,61–33,47	20,31 $\pm$ 7,93	7,66–16,12	12,05 $\pm$ 2,21
<i>S. macrochlamys</i>	Cuticle	–	–	4,00–11,74	7,44 $\pm$ 3,10
	Upper epidermis cell	12,93–57,32	24,77 $\pm$ 11,01	9,28–39,49	17,93 $\pm$ 6,61
	Palisade parenchyma	9,98–17,50	13,74 $\pm$ 1,77	18,74–44,05	28,22 $\pm$ 6,16
	Spongy parenchyma	8,32–15,52	12,10 $\pm$ 2,00	9,79–24,60	17,72 $\pm$ 4,52
	Mesophyll layer	–	–	155,54–207,88	180,79 $\pm$ 15,79
	Lower epidermis cell	8,15–31,00	21,14 $\pm$ 11,68	8,24–22,77	16,13 $\pm$ 5,46
<i>S. suffruticosa</i>	Cuticle	–	–	1,85–5,77	3,22 $\pm$ 1,17
	Upper epidermis cell	11,65–37,58	20,62 $\pm$ 6,47	8,99–19,34	14,24 $\pm$ 2,90
	Palisade parenchyma	7,11–18,78	14,02 $\pm$ 2,82	23,40–42,66	34,50 $\pm$ 5,18
	Spongy parenchyma	9,74–17,37	13,69 $\pm$ 2,17	11,73–23,98	18,40 $\pm$ 3,38
	Mesophyll layer	–	–	172,58–269,08	211,54 $\pm$ 23,41
	Lower epidermis cell	8,11–32,30	19,05 $\pm$ 7,57	7,94–22,22	12,43 $\pm$ 4,72
<i>S. trichoclada</i>	Cuticle	–	–	1,96–6,61	4,14 $\pm$ 1,56
	Upper epidermis cell	9,09–43,73	20,66 $\pm$ 8,58	11,20–31,55	19,43 $\pm$ 5,75
	Palisade parenchyma	12,71–25,34	16,82 $\pm$ 3,23	27,46–45,48	38,38 $\pm$ 5,64
	Spongy parenchyma	11,68–21,44	16,94 $\pm$ 3,19	9,54–25,40	16,95 $\pm$ 3,99
	Mesophyll layer	–	–	106,59–144,46	125,97 $\pm$ 12,27
	Lower epidermis cell	8,52–32,15	18,33 $\pm$ 7,39	8,06–23,90	15,28 $\pm$ 5,64

### 3.4. Petiol anatomical characteristics

*Salvia bracteata*: In the cross-section of the petiole, the adaxial surface is slightly convex and the abaxial surface is convex. Both surfaces are composed of almost rectangular epidermal cells and are covered with numerous glandular and eglandular hairs. There are 2 rows of collenchyma under the adaxial and 4 rows under the abaxial. There are polygonal and almost circular parenchyma cells surrounding the crescent-looking median vascular bundle that fills the inside of the petiole. Sclerenchyma tissue surrounds the phloem, not the xylem. There is 2 bundle at the wings of the petiole (Figure 5, Table 5).

*Salvia macrochlamys*: In the cross-section of the petiole, the adaxial surface is slightly convex and the abaxial surface is convex. Both surfaces are composed of oval and almost rectangular epidermal cells and are covered with numerous glandular and eglandular hairs. There are 1-2 layers of collenchyma under the adaxial and 2-3 rows under the abaxial. There are polygonal and almost circular parenchyma cells surrounding the arced-looking median vascular bundle that fills the inside of the petiole. Sclerenchyma tissue surrounds the phloem, not the xylem. There is 2 bundle at the wings of the petiole (Figure 5, Table 5).

*Salvia suffruticosa*: In the cross-section of the petiole, the adaxial surface is slightly concave and the abaxial surface is convex. Both surfaces are composed of oval, square, and almost rectangular epidermal cells and are covered with numerous glandular and eglandular hairs. There are single layers of collenchyma under the adaxial and 2-3 rows under the abaxial. There are polygonal and almost circular parenchyma cells surrounding the arced-looking median vascular bundle that fills the inside of the petiole. Sclerenchyma tissue surrounds the phloem, not the xylem. There is 2-3 bundle at the wings of the petiole (Figure 5, Table 5).

*Salvia trichoclada*: In the cross-section of the petiole, the adaxial surface is concave and the abaxial surface is convex. Both surfaces are composed of oval, square, and almost rectangular epidermal cells and are covered with numerous glandular and eglandular hairs. There are 1-2 rows of collenchyma under the adaxial and 3-4 rows under the abaxial. There are polygonal and almost circular parenchyma cells surrounding the arced-looking median vascular bundle that fills the inside of the petiole. Sclerenchyma tissue surrounds the phloem, not the xylem. There is 2-3 bundle at the wings of the petiole (Figure 5, Table 5).

In this investigation, 4 *Salvia* species spread in Artuklu-Mardin have analyzed comparison in terms of their anatomy. The anatomical measurements of the root, stem, leaf, and petiole are shown in Tables 2, 3, 4, and 5, respectively. The *Salvia* species used in our study belong to the *Salvia* section. In this section, we will compare it with the studies on this section.

Metcalfe & Chalk (1972), regarding the root anatomy of the Lamiaceae family, stated that the pith rays of the roots consist of 2-12 or more rows of cells. The rays of *S. bracteata*, *S. macrochlamys*, *S. suffruticosa*, *S. trichoclada* (sect. *Salvia*) respectively are 1-3, 1-4(-6), 1-2, 1-3 rowed (Kahraman et al., 2010; Kahraman, 2011). Our studies on the cross-sections of the roots of *S. bracteata*, *S. macrochlamys*, *S. suffruticosa*, *S. trichoclada* revealed that the taxa comprise respectively 1-2, 1-2, 1-2, 2-4 rowed ray cells. The number of pith rays can be used as an aid to taxonomy, to separate the section of the genus (Kahraman et al., 2010).

The stems of Lamiaceae are quadrangular, have collenchyma plating a broad area at the corners and have sclerenchymatous tissue circumambient the vascular bundle tissue (Metcalfe & Chalk 1950). This study is similar to that of Metcalfe and Chalk. In addition, some data obtained from the stem anatomy of *Salvia* species by Kahraman (2011) are similar to the results of the current study. In addition to this, while the collenchyma was reported by Kahraman to be 1-9 layers at the corners, 1-4 layers at the edges and also the parenchyma contains of 1-15 layers, we have found they to respectively consist of 5-10, 1-8 and 1-10 layers. Kahraman et al. (2010) have examined the stem anatomy of *S. macrochlamys* species, while the parenchyma was reported to be 2-6 layers, we have found it to consist of 4-10 layers.

The leaf mesophyll of *Salvia* species is entirely parenchymatic and the midrib is surrounded by collenchymatous cells (Metcalfe & Chalk 1972). According to the mesophyll structure, the leaves of *S. macrochlamys* is equifacial but other all species had bifacial mesophylls. Those of *S. macrochlamys* (Kahraman et al., 2010) is equifacial. The palisade parenchyma had 3-5 rows in *S. macrochlamys* and 2-3 rows in the other species. In his study, Kahraman (2011) showed that the anatomy data of the leaf of *S. bracteata* are the same but other species different with our study. These results show that; while the structure of the vas-

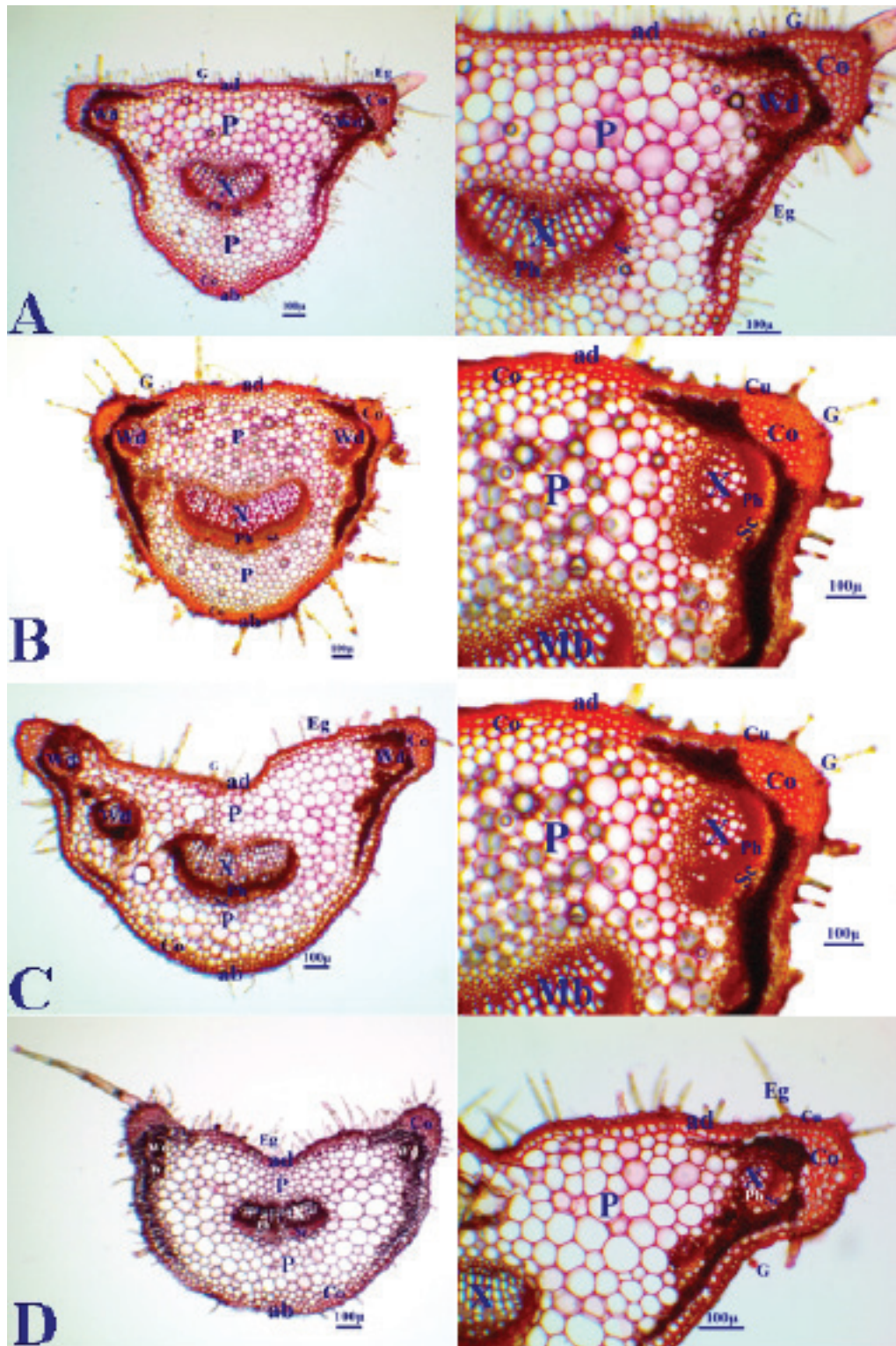


Figure 5. Cross-section of petiol. **A**, *S. bracteata*. **B**, *S. macrochlamys*. **C**, *S. suffruticosa*. **D**, *S. trichoclada*. G: Glandular hair, ad: Adaxial surface, Co: Collenchyma, Crp: Crushed parenchyma, P: Parenchyma, X: Xylem, Ph: Phloem, Sc: Sclerenchyma, Mb: Median bundle, Wb: Wing bundle, ab: Abaxial surface, Cu: Cuticle, Eg: Eglandular hair

Table 5  
Comparative anatomy of petiol of *Salvia* section

Species	Tissue	Width ( $\mu$ )		Length ( $\mu$ )	
		Min.–Max.	Mean $\pm$ S.D.	Min.–Max.	Mean $\pm$ S.D.
<i>S. bracteata</i>	Cuticle	–	–	2,44–7,33	4,12 $\pm$ 1,26
	Adaxial epidermis	7,61–19,59	12,76 $\pm$ 2,82	5,01–13,78	9,17 $\pm$ 2,33
	Parenchyma cell	21,53–94,59	55,52 $\pm$ 21,41	14,25–87,40	50,07 $\pm$ 18,94
	Trachea cell	5,55–16,74	10,65 $\pm$ 2,82	3,17–12,71	7,78 $\pm$ 2,50
	Phloem cell	9,34–24,04	17,51 $\pm$ 4,00	10,92–23,51	17,58 $\pm$ 3,99
	Abaxial epidermis	6,72–19,69	14,50 $\pm$ 4,02	5,47–14,79	10,32 $\pm$ 2,72
<i>S. macrochlamys</i>	Cuticle	–	–	1,94–5,86	3,33 $\pm$ 0,94
	Adaxial epidermis	9,49–25,01	16,80 $\pm$ 4,11	6,44–21,35	11,72 $\pm$ 3,59
	Parenchyma cell	28,94–75,52	48,05 $\pm$ 13,12	22,38–75,21	44,30 $\pm$ 12,98
	Trachea cell	11,16–26,92	15,70 $\pm$ 4,43	12,27–35,57	22,07 $\pm$ 5,20
	Phloem cell	5,83–13,81	9,37 $\pm$ 2,28	5,00–16,62	8,12 $\pm$ 2,70
	Abaxial epidermis	8,83–22,29	15,24 $\pm$ 3,96	6,25–20,21	10,81 $\pm$ 3,60
<i>S. suffruticosa</i>	Cuticle	–	–	2,18–7,08	4,39 $\pm$ 1,26
	Adaxial epidermis	6,24–21,67	14,46 $\pm$ 4,13	6,02–14,91	10,28 $\pm$ 2,63
	Parenchyma cell	21,91–108,86	62,22 $\pm$ 22,98	20,02–98,40	59,47 $\pm$ 25,53
	Trachea cell	7,01–24,19	16,72 $\pm$ 4,79	9,67–32,01	22,09 $\pm$ 6,82
	Phloem cell	2,48–9,82	6,45 $\pm$ 1,95	2,66–8,23	5,11 $\pm$ 1,60
	Abaxial epidermis	12,83–33,01	22,29 $\pm$ 6,01	6,80–22,80	11,15 $\pm$ 4,16
<i>S. trichoclada</i>	Cuticle	–	–	2,29–5,26	3,72 $\pm$ 0,70
	Adaxial epidermis	3,67–18,96	12,19 $\pm$ 3,79	6,53–15,31	10,50 $\pm$ 2,28
	Parenchyma cell	15,62–64,76	41,72 $\pm$ 13,99	12,59–70,12	44,33 $\pm$ 15,59
	Trachea cell	5,21–15,49	11,70 $\pm$ 2,75	4,54–18,78	12,54 $\pm$ 3,86
	Phloem cell	6,00–12,84	9,91 $\pm$ 2,20	3,70–10,16	6,89 $\pm$ 2,04
	Abaxial epidermis	4,67–20,95	12,53 $\pm$ 4,12	4,73–15,16	9,04 $\pm$ 2,77

cular bundles in the leaf anatomy of *Salvia* species can be used for species differentiation, the structure of the palisade parenchyma cannot be used (Kahraman et al., 2010). In the midrib of *Salvia* taxa, there are 1-2 large vascular bundles or absent on sides. It is seen by Kahraman (2011) that the data on the anatomy of the vascular bundles are compatible with our study, but the results for *S. suffruticosa* are different.

The anatomical features of the petiole differ between species. However, the structure of the petiole can be used as a helpful key in taxonomic classification (Akcin et al., 2011). Accordingly to Metcalfe & Chalk (1972), the vascular bundles in the petiole of the Lamiaceae family are very important as an identification feature. In the petiole of *Salvia* species, there is a single and lobed large bundle and there are 2-3 small helper bundles in petiolar wings.

*S. cyanescens*, as designated by Kahraman (2011), has 2 broad vascular bundles in the middle of the petiole and 2-4 small bundles in its wings, *S. limbata* (Kahraman & Doğan 2010) has a 4 broad vascular bundle in the center of the petiole and 8 small lateral bundles, 4 small bundles in its wings, *S. sclarea* (Özdemir & Şe-

nel 1999) has 2 large bundles in the center and 3 small bundles in the wings, and *S. blepharochlaena* (Özkan & Soy, 2007) has 1 large bundle in the center and 2 small bundles in the wings. For the petiole anatomy is a taxonomic character in *Salvia* species, it can be used to distinguish taxa.

#### 4. Conclusion

The anatomical structure of the cross-section parts of the species demonstrates typical Lamiaceae family characteristics.

As a result of all these discussed data, the anatomical traits such as number of ray rows in the root, number of collenchyma layers in the stem, mesophyll forms in leaves, the shape of midrib, and number of vascular bundles in petiole, ensure important taxonomic knowledge.

In conclusion, it is obvious that conducting and encouraging such studies will contribute to modern plant science as well as taxonomic classification of species and genus.

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#### Author Contributions

MK, FMK planned the study and carried out fieldwork. MK, FMK analyzed the datum and interpreted the study. MK wrote the manuscript and read and approved it together with FMK.

#### Conflicts of Interest

The authors accept that there is no clash of interest.

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