

The Anatomical Characteristics of *Salvia* (section *Aethiopsis*) From Mardin and Their Taxonomic Implications

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Abstract

In this study, 4 *Salvia* species found in the *Aethiopsis* section distributed in the province of Mardin in the Southeast of Turkey between the years 2018-2021 were analyzed comparatively in terms of anatomy. Transverse sections taken from the roots, stems, leaves, and petioles of the taxa were examined under a light microscope. *Salvia brachyantha* ssp. *brachyantha*, *Salvia montbretii*, *Salvia palaestina*, and *Salvia syriaca* taxa were analyzed anatomically. *S. montbretii* and *S. syriaca* species were analyzed in detail for the first time anatomically. In the anatomical examinations, it was observed that the root, stem, leaf, and petiole structures of the taxa were similar, but the shapes and sizes, in addition to the tissue layer and pith row numbers, were different. As a result, anatomical characters provide important information in the differentiation of species.

Keywords: Anatomy, Mardin, *Salvia*, taxonomic implication, Turkey

1. Introduction

Salvia L. genus, which constitutes our research subject, is one of the richest members of the Lamiaceae family, which is popularly known as “sage”. Because it is rich in essential oils, aromatic and phenological compounds and secondary metabolites from most of the species belonging to the family; It is used in medicine, pharmacy, food, cosmetics, and perfumery. The family is a very large family with 236 genera, and 7.534 species in World [1]. In our country, there are 45 genera, 546 species, and 731 taxa In Turkey, 89 species and 94 taxa were defined in Flora of Turkey and 45 of them were recorded as endemic [2]. According to recent studies in our country, the number of *Salvia* species is 99 *Salvia* species, 52 (52%) of which are endemic [3]. Although the number of studies on this genus has increased in recent years, studies on the anatomical features of this genus are limited [4-12].

The anatomical characters of most of the *Salvia* species have not been studied so far. For example, *S. montbretii*, *S. suffruticosa*, and *S. syriaca* have not been studied in detail anatomically. This study aims to give a detailed account of anatomical characteristics of the *S. brachyantha* ssp. *brachyantha*, *S. montbretii*, *S. palaestina*, *S. syriaca* taxa of spreading in Mardin. The anatomical significance of these findings is also

discussed with the previous studies on section *Aethiopsis*. In addition, our aim with this research is to introduce *Salvia* species with a wide range of uses and to contribute to the Flora of Turkey in this direction, as well as contribute the literature for the usability of anatomy studies in taxonomy.

2. Materials and Methods

The study area is on the Tigris and Euphrates basin in southeastern Anatolia, eastern Batman, and Şırnak, west Şanlıurfa, north of Diyarbakır, in the south surrounded by Syrian soil Mardin, with a surface area of 8.891 km² [13] (Figure 1). Mardin is located in the Iran-Turan Phytogeographical Region, within the C8 square according to the Grid classification system applied by Davis [14]. The Mediterranean, terrestrial, and desert climates in the region, and the height between the mountain and lowland sections at 600-800 m have resulted in increased plant diversity.

This study was carried out on *Salvia* populations collected from Artuklu, Kızıltepe, Mazıdağı, and Midyat districts of Mardin province between 2018-2021 (Table I). Plant collection studies were carried out between May and September, which are the flowering periods of *Salvia* species. Davis's Flora of Turkey [14] and The checklist of Flora of Turkey (Vascular Plants)

[2] were used to determine plant species. Collected specimens were stored in falcon tubes in 70% alcohol for use in anatomical studies and examined. Cross-sections were taken from the root, stem, leaf, and petiole parts of the plants manually with the help of a razor, the preparations were prepared by staining with safranin-fast green, and their photographs were taken by examining them under a microscope with an imaging system [15]. As a result of the examination of these

preparations, anatomical features showing similarities and differences between taxa were determined. Photographs made with a light microscope were made with an Isolab brand microscope in the Department of Crops and Animal Production at Mardin Artuklu University. The biometric measurement of tissue and cells of root, stem, leaf, and petiole are given in Table 2, 3, 4, 5.

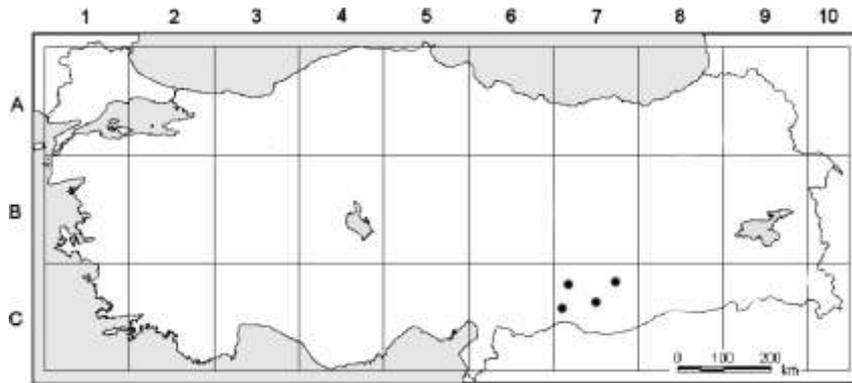


Figure 1. Distribution map of sect. *Aethiopsis* taxa (.)

Table1. *Salvia* taxa used for anatomical studies and collected localities.

Species	Collection areas and habitat	Collector's number
<i>S. brachyantha</i> ssp. <i>brachyantha</i>	Turkey, C8 Mardin: Artuklu, Sultanköy Village	M.Kılıç, F.Mungankılıç 226
<i>S. montbretii</i>	Turkey, C8 Mardin: Artuklu, Hamzabey Village, Sultanköy Village Turkey, C8 Mardin: Midyat, Eskimidyat Village	M.Kılıç, F.Mungankılıç 209, 217
<i>S. palaestina</i>	Turkey, C8 Mardin: Artuklu, Yenişehir Village, Dara Village, Eskikale Village, Hamzabey Village Turkey, C8 Mardin: Kızıltepe, Uluköy Village Turkey, C8 Mardin: Mazıdağı, Ömürlü Village, Kebapçı Village Turkey, C8 Mardin: Midyat, Eskimidyat Village	M.Kılıç, F.Mungankılıç 206, 207, 209, 213
<i>S. syriaca</i>	Turkey, C8 Mardin: Artuklu, Sultanköy Village Turkey, C8 Mardin: Mazıdağı, Enginköy Village Turkey, C8 Mardin: Midyat, Cumhuriyet Village	M.Kılıç, F.Mungankılıç 210, 212, 238

3. Results and Discussion

Transverse sections taken from the root, stem, leaf, and petiole of the plants were analyzed in detail and the obtained results are outlined below. The taxa are given in alphabetical order.

3.1. Root anatomical characteristics

Salvia brachyantha subsp. *brachyantha* (Bordz.) Pobed: The periderm was a crushed thick layer of large cells and fragmented in section. Parenchymatous cells under the periderm were multi-layered and under it, there are several layers of phloem. Cambium was unclear. In the

xylem, besides the large tracheas, tracheids and xylem parenchyma have lignified walls. Pith rays consist of 3-5 rowed narrow cells. As the xylem occupies the pith, it is very narrow (Figure 2, Table 2).

Salvia montbretii Bentham: The periderm was a thick layer that was crushed and fragmented in cross-section. Beneath the periderm is the multi-layered parenchymal cells, and below the parenchyma, several layered phloem. Cambium was unclear. In the xylem, besides the large tracheas, tracheids and xylem parenchyma have lignified walls. Pith rays consist of 1-3 rowed narrow cells. The xylem covering the pith region is very narrow (Figure 2, Table 2).

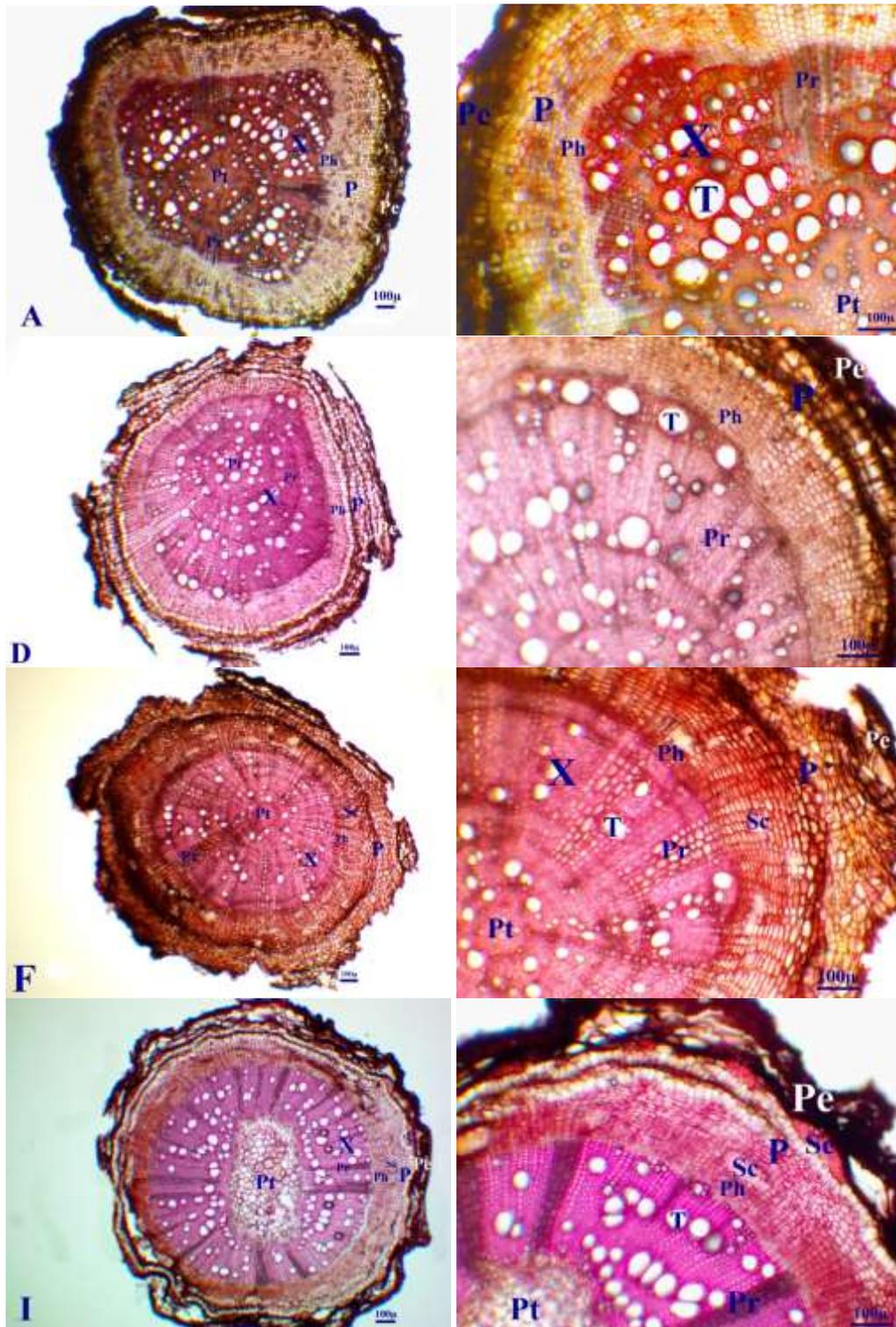


Figure 2. Root anatomical structure of investigated sect. *Aethiopsis* taxa. A. *Salvia brachyantha* subsp. *brachyantha*. D. *S. montbretii*. F. *S. palaestina*. I. *S. syriaca*. Pe: Periderm, P: Parenchyma, Sc: Sclerenchyma, Ph: Phloem, X: Xylem, Pr: Pith ray, T: Trachea, Pt: Pith region.

Table 2. Comparative anatomical measurements root tissues of investigated sect. *Aethiopsis* taxa.

Species	Tissue	Width (μ)		Length (μ)	
		Min.–Max.	Mean \pm S.D.	Min.–Max.	Mean \pm S.D.
<i>S. brachyantha</i> ssp. <i>brachyantha</i>	Periderm	24,04–52,11	36,43 \pm 7,35	33,14–72,68	52,17 \pm 9,97
	Parenchyma	17,63–53,29	35,86 \pm 9,30	17,89–32,39	24,27 \pm 4,06
	Trachea	10,12–34,40	20,98 \pm 7,61	9,30–36,42	23,28 \pm 9,05
	Pith	3,48–8,27	5,68 \pm 1,37	6,30–11,33	8,89 \pm 1,29
<i>S. montbretii</i>	Periderm	19,75–50,46	34,10 \pm 9,00	13,49–30,53	20,27 \pm 5,55
	Parenchyma	16,85–56,12	33,90 \pm 9,39	9,85–58,40	31,62 \pm 16,38
	Trachea	12,90–33,37	20,93 \pm 6,13	11,74–37,20	19,98 \pm 7,08
	Pith	3,74–9,82	6,32 \pm 1,81	4,61–10,92	7,61 \pm 1,93
<i>S. palaestina</i>	Periderm	11,86–59,87	36,07 \pm 13,61	7,91–44,28	19,95 \pm 10,83
	Parenchyma	12,39–36,79	24,04 \pm 6,95	8,62–20,64	13,64 \pm 3,28
	Trachea	14,21–50,50	30,39 \pm 10,85	15,65–56,82	34,28 \pm 11,19
	Pith	12,78–36,57	22,26 \pm 7,19	9,87–41,63	22,69 \pm 9,07
<i>S. syriaca</i>	Periderm	21,25–75,27	42,37 \pm 16,47	10,38–35,33	19,09 \pm 6,88
	Parenchyma	8,37–36,94	21,16 \pm 7,17	5,06–19,01	11,43 \pm 4,30
	Trachea	17,69–49,55	37,17 \pm 9,18	17,17–74,08	42,47 \pm 14,70
	Pith	6,84–22,49	14,62 \pm 4,25	7,83–43,57	20,82 \pm 9,65

S.D.: Standard Deviation

3.2. Stem anatomical characteristics

Salvia palaestina Bentham: The periderm was a thick layer that was crushed and fragmented in cross-section. Beneath the periderm is the multi-layered parenchymal cells, and below the parenchyma, several layered sclerenchyma. 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 rays consist of 2-8 rowed narrow cells. The xylem covering the pith region is wider than other taxa (Figure 2, Table 2).

Salvia syriaca L.: The periderm was a thick layer that was crushed and fragmented in cross-section. At the junction of the periderm and parenchyma, there are intermittent sclerenchyma groups in places. Besides, under the parenchyma, there are sclerenchyma cells in 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 rays consist of 2-6 rowed narrow cells. The xylem covering the pith region is narrow (Figure 2, Table 2).

In all taxa were stem clearly quadrangular in the cross-section. The epidermis, single-layered, was formed by oval, square, and nearly rectangular cells and they are covered by a thin layer of cuticle.

Salvia brachyantha subsp. *brachyantha* (Bordz.) Pobed: The epidermis is seen that the dimensions of opposite corners are close to each other. There are glandular and eglandular hairs on the epidermis. Under the epidermis, there are 6-7 rows of collenchyma cells concentrated at the corners and 3-4 rows of these cells below it. The collenchyma layers consist of ovoidal and quadrilateral cells walls. Parenchyma, formed by parenchymatous, cubic, and oval cells was 3-7 rowed at the edges and 4-5

rowed at the corners. 3-5 rows of sclerenchyma were located on the vascular bundles. The phloem is of 5-7 rows. Below the 5-7 rows of phloem is an indistinct cambium. Xylem part was larger than the phloem part. The trachea is arranged quite regularly. In the center, there is the pith region, which covers a large area. The cells in the pith region are polygonal or orbicular parenchymatous cells that grow towards the center and form triangular spaces between them (Figure 3, Table 3).

Salvia montbretii Bentham: The epidermis is seen that the dimensions of opposite corners are close to each other. There are glandular and eglandular hairs on the epidermis. Under the epidermis, there are 5-6 rows of collenchyma cells concentrated at the corners and 1-3 rows of these cells below it. The collenchyma layers consist of oval, square, and quadrilateral cells walls. Parenchyma, formed by parenchymatous, formless, cubic and oval cells was 4-5 rowed at the edges and 5-6 rowed at the corners. 3-5 rows of sclerenchyma were located on the vascular bundles. The phloem is of several rows. Below the several rows of phloem is an indistinct cambium. Xylem part was larger than the phloem part. The trachea is arranged quite regularly. In the center, there is the pith region, which covers a large area. The cells in the pith region are polygonal or orbicular parenchymatous cells that grow towards the center and form triangular spaces between them (Figure 3, Table 3).

Salvia palaestina Bentham: The epidermis is seen that the dimensions of opposite corners are close to each other. There are many single or multicellular glandular hairs on the epidermis cells. Under the epidermis, there are 7-8 rows of collenchyma cells concentrated at the corners and 3-4 rows of these cells below it. The collenchyma layers consist of oval, square, and quadrilateral cells walls. Parenchyma, formed by parenchymatous, cubic, and oval cells was 1-2 rowed at

the edges and 2-3 rowed at the corners. 3-5 rows of sclerenchyma were located on the vascular bundles. The phloem is of several rows. Below the several rows of phloem is an indistinct cambium. Xylem part was larger than phloem part. The trachea are arranged quite regularly. In the center, there is the pith region, which

covers a large area. The cells in the pith region are polygonal or orbicular parenchymatic cells that grow towards the center and form triangular spaces between them (Figure 3, Table 3).

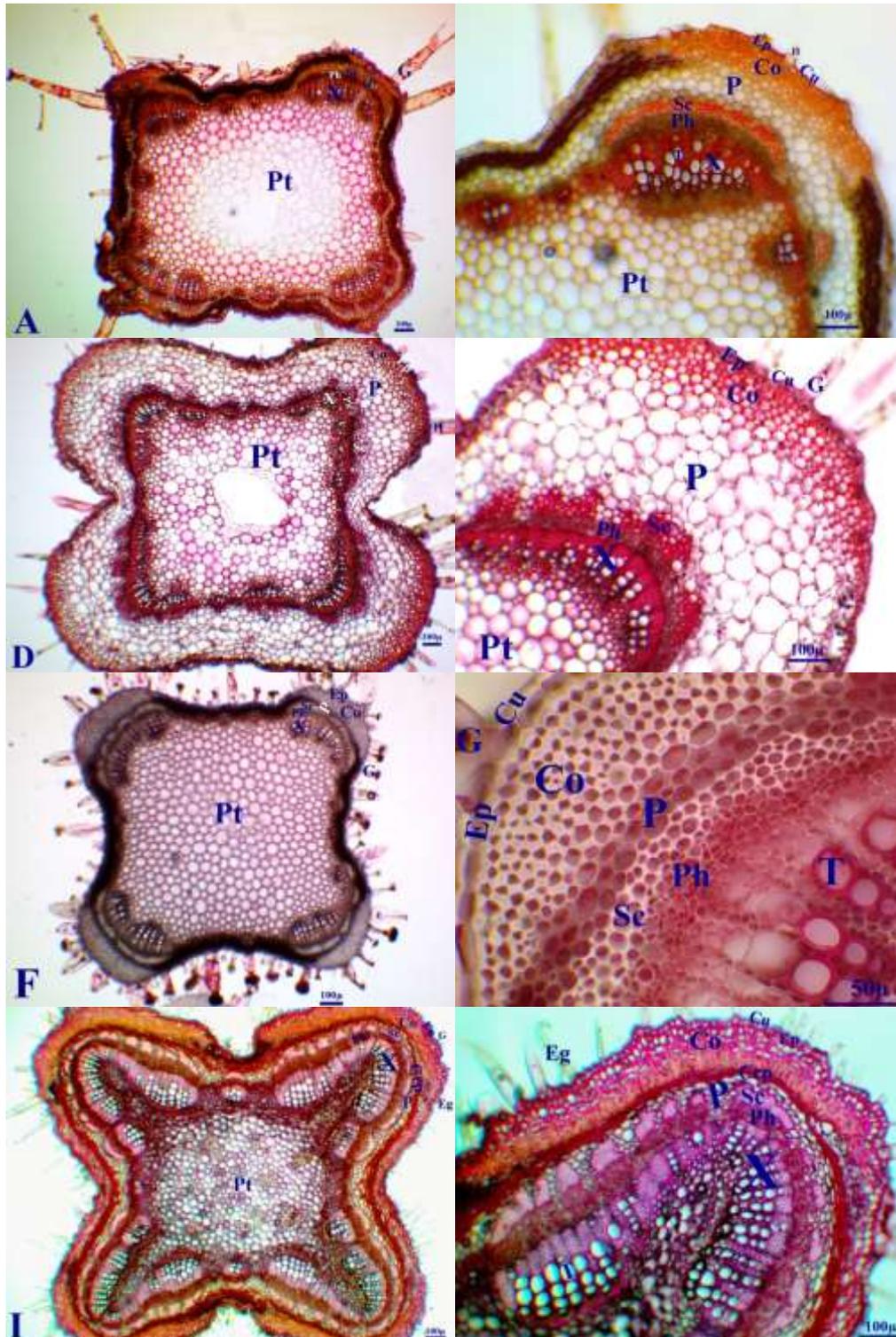


Figure 3. Stem anatomical structure of investigated sect. *Aethiopsis* taxa. A. *Salvia brachyantha* subsp. *brachyantha*. D. *S. montbretii*. F. *S. palaestina*. I. *S. syriaca*. G: Glandular hair, Eg: E glandular hair, Ch: Compound hair, H: Hair,

Cu: Cuticle, Ep: Epidermis, Co: Collenchyma, Crp: Crushed parenchyma, P: Parenchyma, Sc: Sclerenchyma, Ph: Phloem, X: Xylem, T: Trachea, Pt: Pith region.

Table 3. Comparative anatomical measurements stem tissues of investigated sect. *Aethiopsis* taxa.

Species	Tissue	Width (μ)		Length (μ)	
		Min.–Max.	Mean \pm S.D.	Min.–Max.	Mean \pm S.D.
<i>S. brachyantha</i> ssp. <i>brachyantha</i>	Cuticle	–	–	2,11–6,78	4,04 \pm 1,28
	Epidermis	11,36–26,45	17,91 \pm 4,23	10,52–32,59	16,78 \pm 4,98
	Collenchyma	11,52–30,31	19,32 \pm 5,73	11,26–28,52	18,92 \pm 5,70
	Parenchyma	16,52–45,00	30,17 \pm 8,50	12,46–34,56	20,82 \pm 8,51
	Phloem	3,35–13,94	7,84 \pm 2,48	2,91–8,75	5,35 \pm 1,75
	Trachea	11,78–31,98	20,37 \pm 5,70	14,40–35,25	22,75 \pm 4,99
	Pith	25,34–93,50	53,96 \pm 22,44	16,73–98,58	47,94 \pm 23,78
<i>S. montbretii</i>	Cuticle	–	–	3,19–8,45	5,72 \pm 1,21
	Epidermis	10,71–31,29	19,18 \pm 5,28	9,49–27,92	17,32 \pm 4,63
	Collenchyma	7,16–25,93	16,01 \pm 5,28	8,47–25,77	14,79 \pm 4,96
	Parenchyma	14,94–69,79	38,59 \pm 17,74	14,09–77,72	33,34 \pm 15,72
	Phloem	8,64–18,82	13,20 \pm 3,15	4,79–11,83	8,70 \pm 1,88
	Trachea	15,80–54,18	31,05 \pm 9,69	14,00–45,09	26,85 \pm 9,42
	Pith	33,33–134,67	76,25 \pm 29,80	33,42–138,39	74,17 \pm 31,75
<i>S. palaestina</i>	Cuticle	–	–	4,14–7,88	6,15 \pm 1,00
	Epidermis	9,07–27,24	19,26 \pm 5,11	6,35–18,19	10,54 \pm 2,95
	Collenchyma	5,30–15,95	10,12 \pm 3,27	4,25–11,34	7,16 \pm 2,22
	Parenchyma	6,74–24,32	14,40 \pm 4,36	5,05–17,66	10,76 \pm 3,09
	Phloem	2,90–10,19	6,08 \pm 1,90	2,40–7,00	4,03 \pm 1,29
	Trachea	12,72–35,44	24,95 \pm 5,57	13,83–36,57	26,10 \pm 6,76
	Pith	30,57–80,91	51,06 \pm 13,26	26,49–91,53	53,77 \pm 17,10
<i>S. syriaca</i>	Cuticle	–	–	3,85–8,22	6,21 \pm 1,28
	Epidermis	7,94–26,75	17,60 \pm 5,33	5,50–21,94	12,03 \pm 4,66
	Collenchyma	10,50–27,31	18,18 \pm 4,42	7,76–26,73	15,46 \pm 4,77
	Parenchyma	11,37–44,57	28,30 \pm 10,41	6,98–46,21	23,92 \pm 10,70
	Phloem	5,77–12,19	8,22 \pm 1,90	4,42–10,81	7,28 \pm 2,16
	Trachea	5,66–39,58	22,05 \pm 9,69	5,32–39,91	21,58 \pm 10,13
	Pith	9,86–39,16	27,30 \pm 8,75	8,53–41,41	26,29 \pm 10,39

Salvia syriaca L.: The epidermis is seen that the dimensions of opposite corners are close to each other. There are glandular and eglandular hairs on the epidermis. Most of them are eglandular made up of one to or multicellular. Under the epidermis, there are 6-8 rows of collenchyma cells concentrated at the corners and 6-8 rows of these cells below it. The collenchyma layers consist of oval, square, and rectangular cells walls. Parenchyma, formed by parenchymatous, formless, cubic, and oval cells was 3-4 rowed at the edges and 1-3 rowed at the corners. 4-5 rows of sclerenchyma were located on the vascular bundles. The phloem is of several rows. Below the several rows of phloem is an indistinct cambium. Xylem part was larger than the phloem part. The trachea is arranged quite regularly. In the center, there is the pith region, which covers a large area. The cells in the pith region are polygonal or orbicular parenchymatous cells that grow towards the center and form triangular spaces between them (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 brachyantha subsp. *brachyantha* (Bordz.) Pobed: There is a thin cuticle layer around the single-layered epidermis. Epidermis cells are oval or nearly rectangular. The epidermis is usually composed of single or multicellular long glandular hairs. Leaf mesophyll consists of palisade and spongy parenchyma cells. The leaf is bifacial. Palisade parenchyma cells were cylindrical in 2-3 rows, whereas spongy parenchyma cells were circular or polygonal in 2-3 rows. The adaxial surface is convex around the midrib area. Below the adaxial surface are 1-2 rows of collenchyma. Vascular bundles are collateral. The arcuate vascular bundle is surrounded by parenchyma cells. Just below the parenchyma is the xylem consisting of the trachea and tracheids. Phloem is 3-4 rows and is located below the xylem. The axial surface is convex, with 2-3 rows of collenchyma underneath (Figure 4, Table 4).

Salvia montbretii Benth: The epidermis formed by oval and nearly rectangular cells. It is covered by a thin cuticle. There are many glandular and eglandular hairs on the epidermis cells. Most of them are eglandular made up of one or multicellular. Palisade parenchyma cells were 2-3 rowed and cylindrical, whereas spongy parenchyma cells were 1-2 rowed oval and polygonal in shape. Mesophyll type is bifacial. The adaxial surface is slightly convex around the median vein area. 2-3 rows

of collenchyma are found below the adaxial surface. The vascular bundles are collateral. The arcuate vascular bundle is surrounded by parenchyma cells. Just below the parenchyma are the trachea and the xylem consisting of tracheids. The phloem is several layers and

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

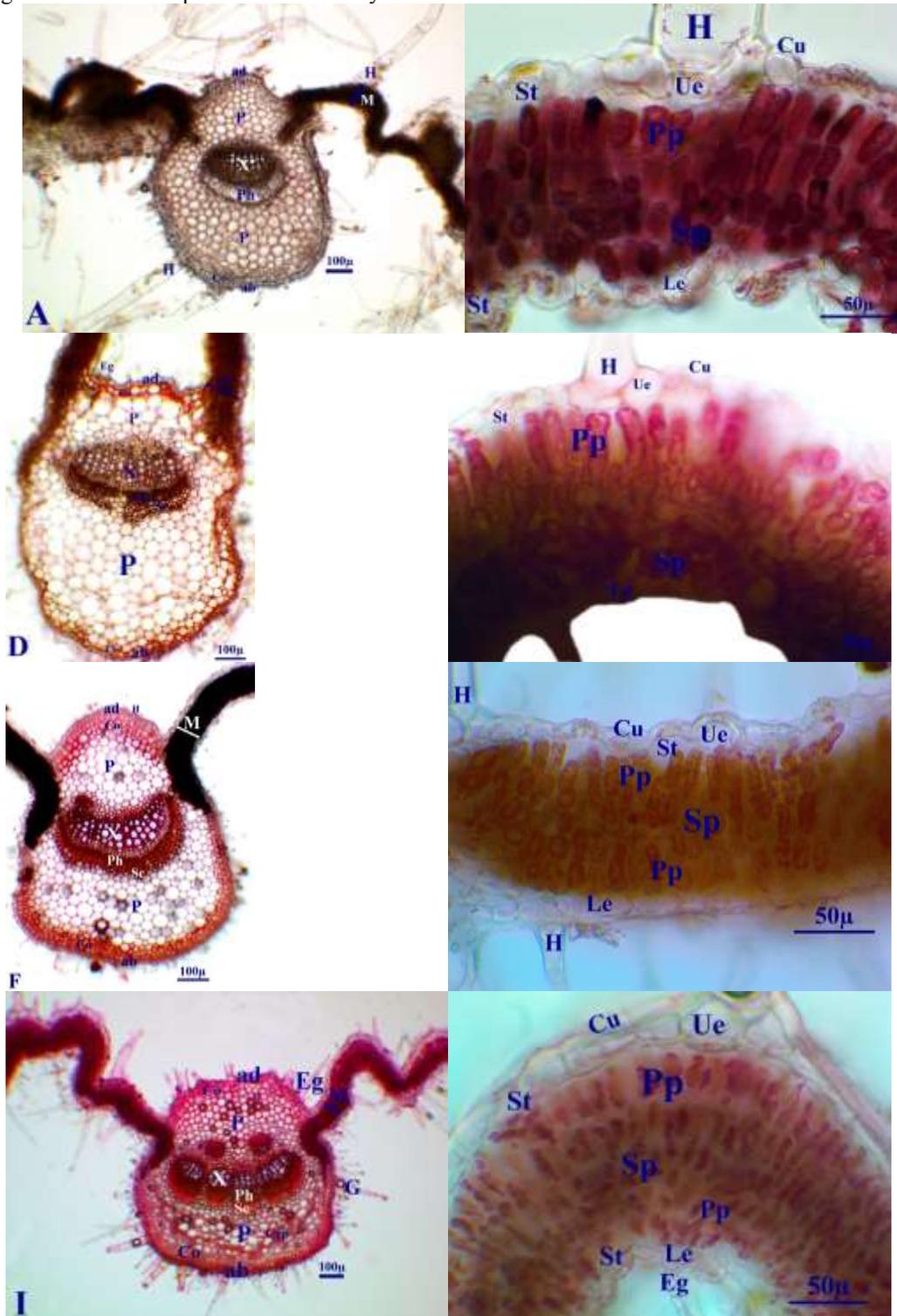


Figure 4. Leaf anatomical structure of investigated sect. *Aethiopsis* taxa. A. *Salvia brachyantha* subsp. *brachyantha*. D. *S. montbretii*. F. *S. palaestina*. I. *S. syriaca*. G: Glandular hair, Eg: Eglanular hair, Ch: Compound hair, H: Hair, M: Mesophyll layer, ad: Adaxial surface, Co: Collenchyma, 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.

Table 4. Comparative anatomical measurements leaf tissues of investigated sect. *Aethiopsis* taxa.

Species	Tissue	Width (μ)		Length (μ)	
		Min.–Max.	Mean \pm S.D.	Min.–Max.	Mean \pm S.D.
<i>S. brachyantha</i> ssp.	Cuticle	–	–	1,92–5,72	3,66 \pm 0,96
	Upper epidermis	12,47–40,91	22,16 \pm 6,56	9,39–34,56	20,78 \pm 7,18
<i>brachyantha</i>	Palisade parenchyma	9,63–15,95	12,14 \pm 2,00	19,68–32,89	27,13 \pm 3,33
	Spongy parenchyma	10,87–16,65	12,83 \pm 1,41	12,17–23,37	17,89 \pm 2,56
	Mesophyll layer	–	–	86,17–205,58	118,70 \pm 35,79
<i>S. montbretii</i>	Lower epidermis	10,14–33,22	22,65 \pm 6,49	10,23–23,97	17,31 \pm 4,16
	Cuticle	–	–	0,72–2,53	1,34 \pm 0,63
	Upper epidermis	7,76–35,41	16,28 \pm 6,25	6,86–17,68	12,13 \pm 3,23
	Palisade parenchyma	8,62–17,18	13,35 \pm 2,18	29,41–58,13	42,97 \pm 8,15
	Spongy parenchyma	9,00–25,65	15,07 \pm 4,37	8,56–24,16	16,34 \pm 4,10
<i>S. palaestina</i>	Mesophyll layer	–	–	73,31–146,53	113,79 \pm 17,36
	Lower epidermis	7,94–29,48	16,85 \pm 5,97	6,75–19,17	13,48 \pm 4,19
	Cuticle	–	–	3,29–7,67	4,85 \pm 1,06
	Upper epidermis	9,11–47,62	20,66 \pm 9,63	6,63–29,15	14,62 \pm 6,10
	Palisade parenchyma	7,16–17,23	11,09 \pm 2,58	15,88–31,68	25,57 \pm 4,44
<i>S. syriaca</i>	Spongy parenchyma	8,58–18,19	10,96 \pm 2,14	9,71–20,91	13,99 \pm 2,66
	Mesophyll layer	–	–	98,53–248,14	168,63 \pm 52,79
	Lower epidermis	7,00–37,79	21,09 \pm 8,12	6,99–27,09	15,74 \pm 4,89
	Cuticle	–	–	3,74–8,17	5,80 \pm 1,29
	Upper epidermis	7,44–41,41	22,98 \pm 8,42	5,86–32,51	17,70 \pm 8,03
<i>S. syriaca</i>	Palisade parenchyma	6,96–15,08	10,06 \pm 1,90	15,29–40,52	27,92 \pm 5,82
	Spongy parenchyma	7,47–13,65	10,13 \pm 1,66	7,38–20,40	13,48 \pm 2,99
	Mesophyll layer	–	–	60,25–215,14	129,55 \pm 42,63
	Lower epidermis	3,80–31,72	9,08 \pm 6,02	5,54–18,02	9,13 \pm 3,37

Salvia palaestina Benthams: The epidermis formed by oval and nearly rectangular cells. It is covered by a thin cuticula. There are many glandular and eglandular hairs on the epidermis cells. Most of them are eglandular made up of one and multicellular. Palisade parenchyma cells are elongated rectangular, 2-3 rowed above and 1-2 rowed below. The spongy parenchyma cells are 1-2 rowed with large intercellular spaces. Mesophyll type is equifacial. The adaxial surface is convex around the median vein area. 2-3 rows of collenchyma are found below the adaxial surface. The vascular bundles are collateral. The arcuate vascular bundle is surrounded by parenchyma cells. Just below the parenchyma are the trachea and the xylem consisting of tracheids. The phloem is several layers and is located below the xylem. The abaxial surface is slightly convex and located below it there are 4-5 rows of collenchyma (Figure 4, Table 4).

Salvia syriaca L.: The epidermis formed by oval and nearly rectangular cells. It is covered by a thin cuticula. There are many glandular and eglandular hairs on the epidermis cells. Most of them are eglandular made up of one and multicellular. Palisade parenchyma cells are elongated rectangular or cylindrical, 2-3 rowed above and 1-2 rowed below. The spongy parenchyma cells are 1-2 rowed with large intercellular spaces. Mesophyll type is equifacial. The adaxial surface is slightly convex around the median vein area. 2-3 rows of collenchyma are found below the adaxial surface. The vascular bundles are collateral. The arcuate vascular bundle is surrounded by parenchyma cells. There are crushed

parenchymal cells between the parenchyma layer. Just below the parenchyma are the trachea and the xylem consisting of tracheids. The phloem is several layers and is located below the xylem. The abaxial surface is slightly convex and located below it there are 1-2 row of collenchyma (Figure 4, Table 4).

3.4. Petiol anatomical characteristics

Salvia brachyantha subsp. *brachyantha* (Bordz.) Pobed: In the cross-section of the petiole, it is anatomically similar to the midrib of the leaf. There is a thin cuticle layer around the single layer of the epidermis. Epidermis cells are similar in size, almost rectangular. There are many glandular and eglandular hairs on the epidermis cells. Most are glandular, consisting of 1-3 cells. Collenchyma cells are in 2-4 rows. Just below is the parenchymatic tissue covering a very large area. Parenchyma cells have a polygonal or nearly circular shape with pronounced triangular spaces between them. The median vascular tissue is inseparable or discrete in the center of the parenchymatic cells. There are well-developed, small vascular bundles at both corners of the petiole. The phloem contains bundles of sclerenchyma. Phloem tissue consists of several rows of cells. Trachea cells are arranged regularly in the xylem tissue (Figure 5, Table 5).

Salvia montbretii Benthams: In the cross-section of the petiole, it is anatomically similar to the midrib of the leaf. There is a thin cuticle layer around the single layer

of the epidermis. Epidermis cells are similar in size, oval, and nearly rectangular. There are many glandular and eglandular hairs on the epidermis cells. Most are glandular, consisting of 1-3 cells. Collenchyma cells are in 1-3 rows. Just below is the parenchymatic tissue covering a very large area. Parenchyma cells have a polygonal or nearly circular shape with pronounced triangular spaces between them. The median vascular

tissue is inseparable in the center of the parenchymatic cells. There are undeveloped, small vascular bundles at both corners of the petiole. The phloem contains bundles of sclerenchyma. Phloem tissue consists of several rows of cells. Trachea cells are arranged regularly in the xylem tissue (Figure 5, Table 5).

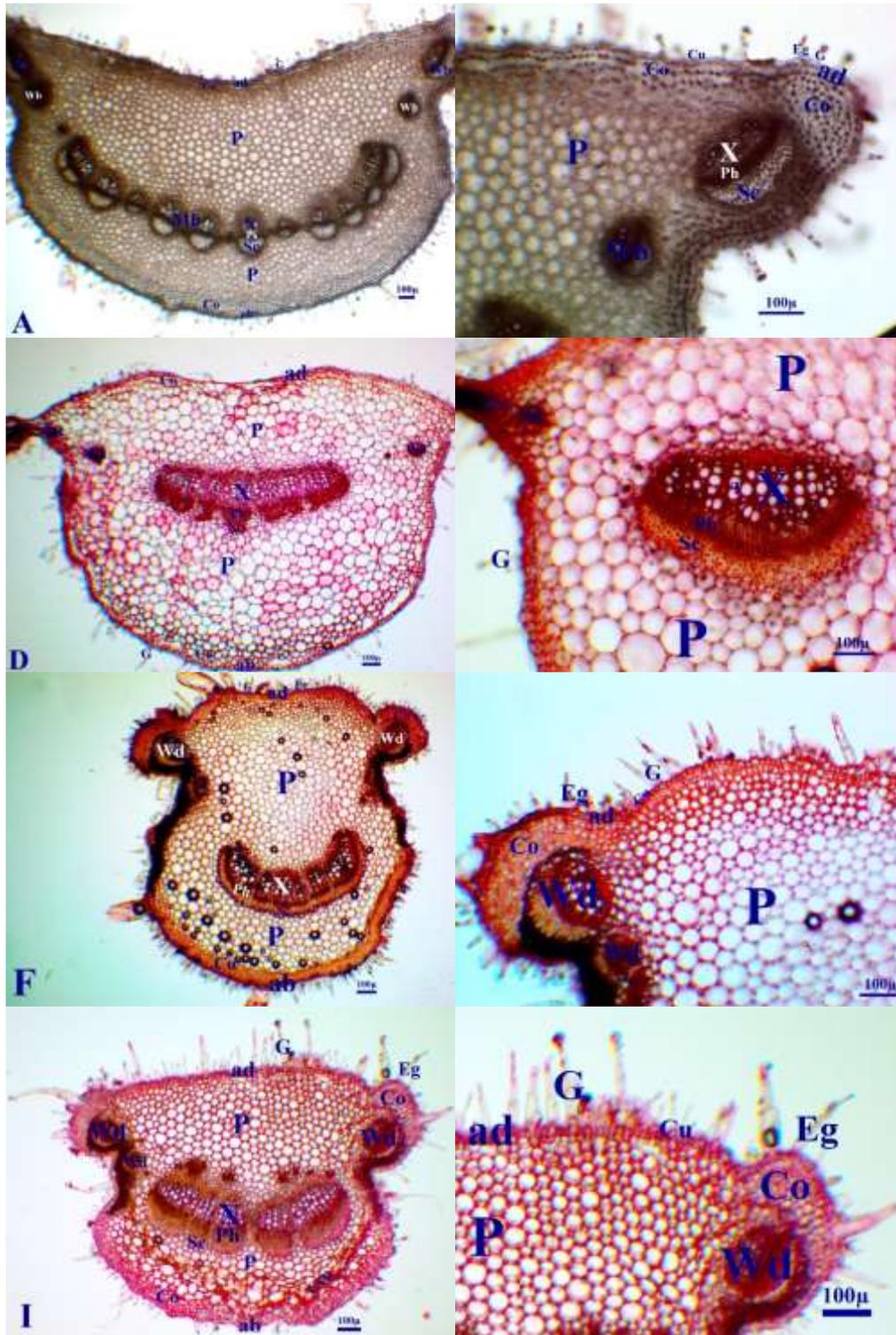


Figure 5. Petiole anatomical structure of investigated sect. *Aethiopsis* taxa. A. *Salvia brachyantha* subsp. *brachyantha*. D. *S. montbretii*. F. *S. palaestina*. I. *S. syriaca*. G: Glandular hair, ad: Adaxial surface, Co: Collenchyma, Crp: Crushed parenchyma, P: Parenchyma, X: Xylem, Ph: Phloem, Sc: Sclerenchyma, Mb: Median bundle, Wb: Wing bundle, ab: Abaxial surface, Cu: Cuticle, Eg: Eglanular hair.

Table 5. Comparative anatomical measurements petiol tissues of investigated sect. *Aethiopsis* taxa.

Species	Tissue	Width (μ)		Length (μ)	
		Min.–Max.	Mean \pm S.D.	Min.–Max.	Mean \pm S.D.
<i>S. brachyantha</i> ssp. <i>brachyantha</i>	Cuticle	–	–	3,32–6,28	4,53 \pm 0,85
	Adaxial epidermis	8,55–18,12	12,00 \pm 2,84	11,94–19,86	14,86 \pm 1,95
	Parenchyma	18,96–52,34	33,41 \pm 9,58	23,27–54,63	37,61 \pm 8,42
	Trachea	8,15–32,70	19,50 \pm 6,18	5,48–39,82	20,10 \pm 9,30
	Phloem	6,82–14,92	10,95 \pm 2,43	3,81–8,79	5,45 \pm 1,27
	Abaxial epidermis	12,18–23,25	17,61 \pm 3,53	12,70–16,74	14,70 \pm 1,13
<i>S. montbretii</i>	Cuticle	–	–	1,69–5,08	3,30 \pm 0,91
	Adaxial epidermis	7,15–20,35	14,48 \pm 3,36	8,14–21,01	12,48 \pm 3,45
	Parenchyma	34,55–96,79	63,26 \pm 16,94	34,51–83,64	53,96 \pm 15,39
	Trachea	12,50–25,64	18,83 \pm 3,80	11,03–24,99	17,62 \pm 4,42
	Phloem	5,00–13,03	8,79 \pm 2,20	3,60–12,36	6,39 \pm 2,18
	Abaxial epidermis	12,77–26,22	20,21 \pm 4,04	11,13–25,39	16,93 \pm 3,96
<i>S. palaestina</i>	Cuticle	–	–	3,96–6,83	5,24 \pm 0,83
	Adaxial epidermis	4,04–13,18	10,04 \pm 2,31	5,01–15,20	10,06 \pm 2,40
	Parenchyma	16,19–79,33	46,11 \pm 22,73	17,43–80,22	43,33 \pm 20,88
	Trachea	8,56–29,98	17,67 \pm 5,85	10,18–29,56	19,70 \pm 5,90
	Phloem	4,84–10,89	8,79 \pm 1,72	3,02–7,98	4,82 \pm 1,28
	Abaxial epidermis	7,91–23,05	13,52 \pm 4,41	6,63–16,89	11,70 \pm 2,99
<i>S. syriaca</i>	Cuticle	–	–	3,98–9,13	6,44 \pm 1,29
	Adaxial epidermis	7,08–27,24	15,20 \pm 5,16	7,61–25,28	13,44 \pm 4,08
	Parenchyma	22,82–82,70	50,44 \pm 19,46	17,44–62,54	39,02 \pm 14,44
	Trachea	11,31–35,14	27,23 \pm 6,41	10,48–41,66	29,82 \pm 8,36
	Phloem	3,21–9,34	6,36 \pm 1,78	3,66–9,96	6,10 \pm 1,69
	Abaxial epidermis	8,90–21,70	16,09 \pm 3,84	7,18–21,42	12,22 \pm 4,21

Salvia palaestina Benth: In the cross-section of the petiole, it is anatomically similar to the midrib of the leaf. There is a thin cuticle layer around the single layer of the epidermis. Epidermis cells are similar in size, oval, square, and nearly rectangular. There are many glandular and eglandular hairs on the epidermis cells. Most are eglandular, consisting of multicellular. Collenchyma cells are in 2-4 rows. Just below is the parenchymatic tissue covering a very large area. Parenchyma cells have a polygonal or nearly circular shape with pronounced triangular spaces between them. The median vascular tissue is inseparable in the center of the parenchymatic cells. There are well-developed, small vascular bundles at both corners of the petiole. The phloem contains bundles of sclerenchyma. Phloem tissue consists of several rows of cells. Trachea cells are arranged regularly in the xylem tissue (Figure 5, Table 5).

Salvia syriaca L.: In the cross-section of the petiole, it is anatomically similar to the midrib of the leaf. There is a thin cuticle layer around the single layer of the epidermis. Epidermis cells are similar in size, oval, square, and nearly rectangular. There are many glandular and eglandular hairs on the epidermis cells. Most are eglandular, consisting of multicellular. Collenchyma cells are in 4-5 rows. Just below is the parenchymatic tissue covering a very large area.

Parenchyma cells have a polygonal or nearly circular shape with pronounced triangular spaces between them. There are crushed parenchymal cells between the parenchyma layer. The median vascular tissue is inseparable in the center of the parenchymatic cells. There are well-developed, small vascular bundles at both corners of the petiole. The phloem contains bundles of sclerenchyma. Phloem tissue consists of several rows of cells. Trachea cells are arranged regularly in the xylem tissue (Figure 5, Table 5).

In this research, 4 *Salvia* species found in the *Aethiopsis* section distributed through Mardin-Turkey, were comparatively investigated in terms of their anatomy. The anatomical measurements of the root, stem, leaf, and petiole are shown in Tables II, III, IV, and V, respectively. The *Salvia* taxa used in our study belong to the *Aethiopsis* sections. In this section, we will compare it with the studies on this section.

Metcalf and Chalk [16], 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 pith rays of *Salvia limbata* C.A., *S. palaestina* Benth (sect. *Aethiopsis*) respectively consist of 2-6, 1-8(-10) rowed cells [17]; *S. brachyantha* (Bordz.) Pobed., *S. montbretii* Benth (sect. *Aethiopsis*)) respectively consist of 1-8, (1-)3-15 rowed cells. Our studies on the

cross-sections of the roots of *S. brachyantha* ssp. *brachyantha*, *S. montbretii*, *S. palaestina*, *S. syriaca* revealed that the taxa comprise respectively 3-4, 1-3, 2-8, 2-8 rowed ray cells. The number of lines of pith rays is a taxonomically important feature for distinguishing sections of the genus [8].

Stem anatomy features of the Lamiaceae; square stem, the shape of the vascular bundle, the location of collenchyma, the swollen or non-swollen shape of corners, and presence or absence [1]. In this study, we found the same anatomical features in the stem cross-section. Kahraman [18] has examined the stem anatomy of *Salvia* species. It can be seen that some data obtained by Kahraman [18] were similar to the results of our study. However, while the collenchyma was reported by Kahraman [18] to be 1-10 layers at the corners, 1-4 layers at the edges, and also the parenchyma contains 1-15 layers, we have found they to respectively consist of 5-10, 1-8, and 1-10 layers. In addition, Kahraman and Doğan [17] have examined the stem anatomy of *S. palaestina* species, while the parenchyma was reported to be 4-7 layers, we have found it to consist of 1-3 layers.

The leaf mesophyll of *Salvia* species is entirely parenchymatic and the midrib is surrounded by collenchymatous cells [16]. According to the mesophyll structure, the leaves of *S. palaestina*, *S. syriaca* are equifacial but other all species had bifacial mesophylls. This of *S. palaestina* [17] are equifacial. The palisade parenchyma had three-five rows in *S. palaestina*, *S. syriaca* and two-three rows in the other species. It can be seen that the data obtained by Kahraman [18] regarding the anatomy of the leaf of *S. brachyantha* is the same but other species are different from our study. The structure of palisade parenchyma in the leaf anatomy of *Salvia* species can't be used as a helpful key for distinguishing the species. The structure of vascular bundles in the leaf anatomy of *Salvia* species can be used as a helpful key for distinguishing the species [8]. In the midrib of *Salvia* taxa, there are one or two large vascular bundles or absent on sides. It can be seen that the data obtained by Kahraman [18] regarding the anatomy of the vascular bundles of *S. montbretii* and *S. palaestina* are different but other species compatible with our study. Besides, Kahraman and Doğan [17] have examined the leaf anatomy of *S. palaestina* species, while the vascular bundles were reported to be single in the center, we have found it to same.

The structure of the petiole shows differs between the genera and species. Helpful anatomical characters of the petiole can be determinable in the specified taxonomical structures of some species [19]. According to Metcalfe and Chalk [16], the vascular bundles in the petiole of the Lamiaceae family are very important as a diagnostic feature. In the petiole of *Salvia* taxa, there is a single

and lobed large bundle and there are two or three small subsidiary bundles in petiolar wings.

S. cyanescens, as indicated by Kahraman [18], has two broad vascular bundles in the middle of the petiole and two-four small bundles in its wings, *S. limbata* [17] has a four broad vascular bundle in the center of the petiole and eight small lateral bundles, four small bundles in its wings, *S. sclarea* [20] has two large bundles in the center and three small bundles in the wings, and *S. blepharochlaena* [4] has one large bundle in the center and two small bundles in the wings.

4. Conclusion

The examined taxa show the anatomical features of the Lamiaceae family. Different and similar anatomical features of taxa have been stated.

In conclusion, the anatomical characters (such as the number of ray rows in the root, vascular bundles in the stem, mesophyll structures in the leaf, the shape of the midrib, and the presence of sclerenchyma tissue in the petiole) we found in the cross-sections of the taxa we examined are not only for the standardization and revision of these characters. Besides, it is also important in terms of contributing to the definitions and distinctions of the examined taxa.

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Author's Contributions

Fatma Mungan Kılıç: Conducted the field work. Wrote and gave comments to the manuscript.

Murat Kılıç: Conducted the field work and anatomical analysis. Wrote and gave comments to the manuscript. Authors read and approved the final version of the manuscript.

Ethics

Conflict of Interest The authors declare that they have no conflict of interest.

Research involving Human Participants and/or Animals Not applicable.

Informed consent Not applicable.

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