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Comparative anatomical study of leaf , stem epidermis and stomatal patterns in some species of the genus Salvia L. (Lamiaceae) in Iraq

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Abstract :

Plants have specialized cell in epidermis called guard cell that contain special pores and called stomata. Epidermis contains different shape and has different number of stomata and subsidiary cells and guard cells. This research carried out from the end of March to the end of June of 2022, to examine anatomy and morphology of leaves and stem epidermis and stomata shape of 29 species belong to *Salvia* L. using the compound light microscope. Epidermal cells varied in their shapes and dimensions. Results obtained from this study showed that the anatomical characters variations in the configuration of epidermal cells could be used as important supportive taxonomic tools to demarcate many species under the study. Eight types of stomatal complexes were identified in the studied species distributed in the upper and lower surfaces of the leaves and stem surfaces.

Key words: Salvia, Lamiaceae, Dicots, Epidermis, Stomata, Guard cells.

دراسة تشريحية مقارنة لبشرة الورقة والساق وأنماط الثغور في بعض أنواع الجنس *Salvia* L. (Lamiaceae) في العراق

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مستخلص:

تملك النباتات خلية متخصصة في البشرة تسمى الخلية الحارسة تحتوي على ثقب خاص وتسمى الثغور. تحتوي البشرة على أشكال مختلفة من الخلايا ولها عدد مختلف من الثغور والخلايا المساعدة والخلايا الحارسة. تم إجراء هذا البحث من نهاية شهر اذار إلى نهاية حزيران/ 2022 ، لدراسة تشريح وشكل البشرة للأوراق وسيقان وشكل الثغور لـ 29 نوعًا تنتمي إلى الجنس *Salvia* L. باستخدام المجهر الضوئي المركب. تختلف خلايا البشرة في أشكالها وأبعادها. أظهرت النتائج التي تم الحصول عليها من هذه الدراسة أن الاختلافات في الصفات التشريحية في تكوين خلايا البشرة يمكن استخدامها كأدوات تصنيفية داعمة مهمة لتحديد العديد من الأنواع قيد الدراسة. تم تشخيص ثمانية أنواع من معقدات الثغور في الأنواع المدروسة موزعة في السطحين العلوي والسفلي للأوراق وسطح الساق.

الكلمات المفتاحية: Salvia ، Lamiaceae ، ذوات الفلقتين ، البشرة ، الثغور ، الخلايا الحارسة.

Introduction:

Lamiaceae is a large family represented by about 258 genera and 3500 species in the world (Duarte and lopes, 2007; Akcin et al., 2011). They distributed worldwide, but mostly in Mediterranean region and South West Asia (Ke, 1994). Salvia was Lamiaceae's biggest genus, with over 900 species worldwide (Martinez-Gordillo et al., 2017; Hu et al., 2018), aside from their species richness and endemism, numerous species are economically,medicinally, or ornamentally important. (Moss et al., 2010, Akaberi et al., 2016). The Salvia species (Generally, there are 33 species in this genus in the Iraqi flora (Abbas et al., 2013) which is considered one of the largest genera in this family) spread across wide range of Iraqi districts, where the mountainous region and hills include most of the Salvia species, especially in Amadiyah, and Rawanduz in Sulaymaniyah provinces Locally, other species of Salvia can be found in different geographical regions of the country such as S. spinosa and S. palaestina, while other species are naturally growing in desert areas such as S. lanigera and S. aegyptiaca (Radford et al., 1974; Al-Musawi and Al-Azzawi , 1986; Abbas et al., 2013). Plants have two types of specialized cell in epidermis one is called guard cell that contain special pores called stomata. Second cell is called trichomes that allows exchanges of gas transport in plants. These cells separated from each other and get differentiated by are separated by pavement cells spacing that has prime importance (Larkin et al, 1997). Epidermis is the outermost layer of the leaf. It is waxy in nature and contains a special layer called cuticle that is effective barrier against injury, loss of water and infection. There are modified epidermal cells that are involved in controlling the rate of transpiration, regulate re-absorption of water and section of chemical substances. The terrestrial plants of land have evolved special openings or pores called stomata present on the epidermis of leaf cells that allow exchange of water and carbon dioxide between interior surface of leaf and atmosphere(Crane and Kenrick, 1997).Stomata mostly occurs in land plants especially on sporophyte but stomata also reported on gametophyte also known as prothallus of model fern catoptrics. The pair of guard cells of land plants separated by one pavement cell of epidermis that also follows the rule that one cell line spacing is more favorable as compared to other multi-spacing. The most important type of stomata is paralytic that is more advantageous for plants included in group of angiosperms. On the other hand, lateral subsidiary cells of paralytic stomata has special cells known as subsidiary cells which can be eperigenesenn as in family of grasses also mesogene seen as some angiosperms such as magnolia (Rudall et al., 2013). In the recent research on physiology and morphological changes in guard cells showed that these specialized guard cells regulate the both extracellular and intracellular signals while in controlling of apertures of stomata. These specialized cells integrate both extra- and intra-cellular signals in the control of stomatal apertures (Acharya and Assmann,2009). Stomatal Precursor cells of stomata also called meristemoids showed changes in the shape of guard cells by undergoing several asymmetric divisions before going into stages of further differentiation (Pillitteri et al., 2007). Recent studies on biological aspects of stomata showed that space in epidermis of leaf to stomata in order to regulate normal balance between carbon dioxide that a plant needs for growth and development and use of water for regulation of transpiration (Boer et al., 2016). The main objective of this research work is to examine the morphology of epidermis and stomata shape of 29 species belong to Salvia with particular emphasize on leaves and stem using the compound light microscope also to predict algometric relationships between morphologically stomata traits in relation to gaseous exchange in leaf and the required allocation of epidermal area to stomata.

Materials and methods:

During various field trips from the Iraqi governorates: Baghdad, Najaf, Karbala, Wasit, Diyala, Irbil, Kirkuk, Sulaymaniyah and Basrah in the growing seasons in the period from the end of March to the end of June of 2022, which was approximately the flowering period for most Salvia species (Abbas et al., 2013). In addition to the samples collected from field trips, also, dry samples preserved in Iraqi Herbaria were used, such as the Herbarium of the University of Baghdad (BUH) and National Herbarium of Iraq (BAG), also by visiting the Herbarium of the College of Science, University of Salahaddin (SUH) to see the preserved species of the genus Salvia. Samples of 29 species were collected and the epidermis of both stem and leaf were peeled from specimen. The specimen were immersed in water to prevent desiccation to procure epidermal cells. Peels from stem and both adaxial and abaxial surfaces of leaf were obtained with the help of the razor blade. Epidermal peels were stained with safranin 0.5% : glycerin mixture (1:10) (Ismaeel, 2022). After preparing, slides were observed under light microscope. The parameters studied were: the shape, length and width of epidermal cells, presence and absence of stomata on each epidermis, type of stomata, stomatal index and length and width of the guard cells. The percentage proportion of the ultimate division of the epidermis of leaf and stem which have been converted into stomata is termed as Stomatal Index (SI) and is represented by the formula of Salisbury (1927):

$$SI = \frac{S}{S+E} \, x \, 100$$

Where:

S = number of stomata per unit area, E = number of ordinary epidermal cells in the same unit area

For measurements, 15 readings were taken to obtain the mean.

Results:

- Surface view of foliar and stem epidermis

Table (1) summarized the observed stomatal complexes and measurements of foliar and stem epidermal cells as well as stomatal complexes in each studied species. Results revealed presence of variation in stomatal complex types and epidermal cells configuration at different taxonomic levels .

- Ordinary epidermal cells

In the studied species of Saliva, foliar epidermal cells varied in their shapes. They were irregular with undulating walls on both adaxial and abaxial surfaces of S. multicaulis. In S. palaestina and S. poculata The shape of epidermal cells on both surfaces seen to be polygonal with feebly sinuous walls. The adaxial and abaxial surfaces of the leaves of S. trichoclada and S. syriaca have nearly rectangular or subcircular epidermal cells in outline with straight to feebly undulated walls. In S. syriaca, the epidermal cells of both surfaces were polygonal with undulated walls. S. nemorosa could be distinct by rounded or tetragonal epidermal cells in outline with straight to feebly sinuous adaxially and irregular with undulating abaxially. Lower epidermal cells are generally rather large, being 40.8 - 73.44µm long and 27.2 - 48.96µm wide; the upper epidermal cells are of comparable size, being 35.36 - 54.4µm long and 27.2 - 35.36µm wide. In the studied species S. sclarea and S. kurdica, the epidermal cells of the adaxial surfaces, as well as the abaxial surface of S. sclarea, distinct by tetragonal or polygonal shape with straight to feebly sinuous walls. While, on the abaxial surface of S. kurdica, the epidermal cells were irregularly with feebly undulated walls.

The adaxial and abaxial epidermal cells of S. compressa were found irregular with undulated walls, while in S. margasurica , the epidermal cells were polygonal in outline and characterized by undulated walls on the adaxial surface and sinuous walls on the abaxial surface. In S. pinnata, foliar epidermal cells were polygonal in outline with slightly undulated walls on both surfaces. In S. reuterana, the cells were irregular with feebly sinuous adaxially and variously undulated shaped abaxially, while in S. indica, they were nearly rectangular with undulating walls on the upper surface and irregular undulating walls on the lower surface. In S. russellii, the epidermal cells were irregular with undulating walls in both surfaces. The epidermal cells of S. verticillata and S. virgata distinct by a presence of special ornamentation of thickenings on the undulated walls. These thickenings were more in S. verticillata than S. virgata. The shape of epidermal cells was irregular with sinuous walls on both leaf surfaces of S. verticillata, while in S. virgata, they were polygonal with slightly undulated in the adaxial surface. The adaxial and abaxial epidermal cells of S. atropatana and S. arabica were irregular with undulating walls. S. aegyptiaca upper and lower foliar epidermal cells were nearly rectangular or sub - circular outline with straight to feebly undulated walls. Epidermal cells in the examined species S. sclareopsis and S. spinosa varied in their shapes. They were irregular shaped with feebly undulate walls in the first examined species and pentagonal to polygonal with straight to feebly undulate walls in the other The epidermal cells of the adaxial and abaxial surfaces of S. lanigera, S. brachyantha, S. candidissima and S. bracteata were highly unulated to irregular shaped. In these species, the adaxial side has larger length and width than the abaxial side. Epidermal cells in the examined species of S. montbertii, S. macrosiphon and S. hypergia were varied in their shapes. They were highly undulating to irregular shaped in the adaxial and abaxial surfaces of S. montbertii and S. macrosiphon and seem to be polygonal in both leaf surfaces of S. hypergia. In S. officinalis, the upper and lower foliar epidermal cells were seem to be pentagonal to polygonal with straight to slightly sinuous walls. The adaxial surface has the larger mean length and width; it was about 52.58 and 30.82µm, respectively. In the given studied species, the cells of the lower epidermis can usually be distinguished from these of the upper epidermis by their anticlinal walls. In these walls, the undulations of sinuosities more deeper than the cells in the upper side. In addition, they are easier to peel, especially in fresh material, because they are overlie the spongy layer, while the upper epidermal cells have compact cells of palisade tissue directly beneath them.

In this investigation, the stem epidermal cells of all the examined species were compacted oblong with straight walls except the epidermal cells of S. margasurica, S. reuterana, S. candidissima, S. montbertii and S. officinalis, they were polygonal with straight to feebly sinuous walls.

- **Stomatal complexes**

Generally, stomata occur on both surfaces, the leaves are amphistomatic except leaves of S. sclarea and S. candidissima which bear stomata only on their lower surfaces, so they were hypostomatic. Stomatal axes were oriented in different directions. Different types of stomatal complexes were observed in the examined species.

- Stomatal index

-Stomatal index is one of the useful tools in order to distinguish species. It was found that stomatal index has low value on the adaxial surface as compared to the abaxial surface except in S. multicaulis, S. lanigera and S. pinnata. It was about 56.75, 37.42 and 22.05% adaxially and 47.13, 24.52 and 18.84% abaxially, for S. multicaulis, S. lanigera and S. pinnata., respectively. Bar chart for the stomatal index is shown in Figure (1).

Table (1): Quanitative data of foliar and stem epidermis of the studied species
(Ad: Adaxial surface of leaf ; Ab: Abaxial surface of leaf ; St: Stem epidermis)

Species	Sur-face	Observed stomatal complex	Dimensions of epidermal cells		Dimensions of Stomata		Sto-matal index
			Length (µm)	Width (µm)	Length (µm)	Width (µm)	
S. multicaulis	Ad	anomocytic	(54.4 -108.8)85.22	(21.76-40.8)31.28	(13.6-24.48)19.04	(10.88-16.32)13.6	56.75
	Ab	anomocytic	(59.84-95.2)80.88	(19.04-40.8)30.82	(24.48-27.2)25.84	(16.32-19.04)17.68	47.13
	St	anisocytic	(136-244.80)193.8	(38.08-46.24)42.16	(21.76-27.2)24.48	(16.32-24.48)19.94	26.47
S. palaestina	Ad	anisocytic	(81.6-108.8)103.36	(35.36-68)52.58	(27.2-29.92)28.56	(24.48-25.62)25	30.48
	Ab	anisocytic diacytic	(54.4-136)90.66	(27.2-59.84)40.8	(24.48-38.08)32.64	(19.04-21.76)20.4	44.21
	St	anisocytic	(108.8-190.4)136	(55.04-63.2)59.17	(27.2-29.92)28.56	(19.04-21.76)20.4	12.5
S. poculata	Ad	anisocytic	(81.6-176.8)131.46	(13.6-27.2)21.76	(27.2-32.64)29.92	(19.04-21.76)20.4	26.66
	Ab	anisocytic	(108.8-163.2)140.53	(32.64-51.68)41.7	(27.2-32.64)29.92	(21.76-24.48)23.12	44.44
	St	anisocytic paracytic	(299.2-544)417.06	(19.04-40.8)29.01	(40.8-46.24)43.52	(24.48-27.2)25.84	16.66
S. trichoclada	Ad	anomocytic	(81.6-114.24)101.54	(21.76-65.28)47.14	(27.2-29.92)28.56	(21.76-24.48)23.26	15.23
	Ab	anomocytic	(54.4-87.04)71.62	(27.2-40.8)34.45	(27.2-29.92)28.56	(19.04-21.76)20.4	20
	St	anomocytic	(76.16-103.36)91.57	(32.64-54.4)45.33	(27.2-29.92)28.56	(21.76-24.48)23.26	11.11
S. syriaca	Ad	anisocytic paracytic tetracytic polycytic	(127.84-217.6)168.64	(32.64-62.56)47.6	(21.76-24.48)23.12	(16.32-21.76)19.04	59.48
	Ab	anisocytic tetracytic diacytic	(68-73.44)70.72	(62.56-65.28)63.46	(21.76-24.48)23.12	(19.04-21.76)20.4	74.84
	St	anisocytic tetracytic	(150-170)160	(27.2-29.92)28.56	(65.28-108.8)87.94	(19.04-40.8)29.92	9.3
S. nemorosa	Ad	anomocytic	(54.4-495.2)71.97	(27.2-48.96)36.26	(21.76-24.48)23.12	(16.32-19.04)17.68	32.14
	Ab	anomocytic anisocytic	(95.2-163.2)131.46	(21.76-40.8)29.92	(27.2-29.92)28.56	(21.76-24.48)23.12	39.53
	St	anisocytic	(68-160.48)116.96	(13.6-35.36)25.38	(4.8-45.24)44.22	(21.76-27.2)24.77	7.4
S. sclarea	Ad	—	(35.36-54.4)46.24	(27.2-35.36)31.73	—	—	—
	Ab	anomocytic anisocytic	(40.8-73.44)56.21	(27.2-48.96)38.98	(19.04-24.48)21.76	(10.88-13.6)12.24	11.21
	St	—	(81.6-100.64)88.85	(38.08-48.96)44.42	—	—	—

Species	Surface	Observed stomatal complex	Dimensions of epidermal cells		Dimensions of Stomata		Stomatal index
			Length (µm)	Width (µm)	Length (µm)	Width (µm)	
S. kurdica	Ad	brachypara-tetracytic	(40.8-68)56.21	(27.2-48.96)38.98	(32.64-35.36)34	(19.04-21.76)20.4	17.04
		anisocytic					
		tetracytic					
	Ab	tetracytic	(40.8-54.4)47.14	(27.2-43.52)36.26	(21.76-24.48)23.12	(16.32-19.04)17.68	35.36
		polycytic					
	St	anomocytic	(46.24-54.4)50.76	(24.48-32.64)29.01	(30-38.75)34.37	(17.5-25)21.24	12.76
S. compressa	Ad	anisocytic	(48.96-81.6)66.18	(27.2-28.96)38.98	(27.2-29.92)28.56	(16.32-19.04)17.64	20.33
		tetracytic					
		polycytic					
	Ab	anomocytic	(40.8-68)52.58	(21.76-40.8)29.92	(35.36-38.08)36.72	(27.2-29.92)28.56	34.78
	St	tetracytic	(32.64-50.4)42.61	(13.6-27.2)20.85	(27.2-29.92)28.56	(21.76-27.2)24.77	9.63
		brachypara-hexacytic					
S. margasurica	Ad	anomocytic	(108-127.84)119.41	(35.36-46.24)40.8	(40.8-46.24)43.52	(27.2-29.92)28.56	25.41
	Ab	anomocytic	(122.4-127.84)125.12	(81.6-95.2)89.76	(38.08-40.8)39.44	(24.48-35.36)30.82	26.48
	St	tetracytic	(225.76-122.4)179.52	(19.04-27.2)22.66	(35.36-38.08)56.72	(32.64-29.92)31.28	2.5
S. pinnata	Ad	anomocytic	(59.84-108.8)83.41	(40.8-54.4)47.14	(40.8-43.52)42.16	(27.2-29.92)28.56	22.05
	Ab	anomocytic	(108.8-190.4)158.66	(40.8-81.6)58.93	(38.08-40.8)39.44	(27.2-29.92)28.56	18.84
	St	anomocytic	(54.4-136)90.66	(16.32-27.2)21.76	(29.92-32.64)31.28	(27.2-29.92)28.56	12.63
S. reuterana	Ad	anomocytic	(68-108.8)90.67	(54.4-81.6)68	(29.92-32.64)31.28	(27.2-29.92)28.56	25
	Ab	anomocytic	(54.4-163.2)122.4	(40.8-81.6)63.46	(16.32-21.76)19.04	(13.6-15.7)14.65	35.89
	St	anomocytic	(54.4-163.2)117.86	(13.6-27.2)19.04	(29.92-32.64)31.30	(16.32-19.04)17.68	6.97
S. indica	Ad	anomocytic	(51.68-68)58.02	(24.48-40.8)30.82	(16.32-19.04)17.68	(10.88-13.6)12.24	9.09
	Ab	anomocytic	(35.36-68)48.05	(19.04-28.52)23.78	(19.04-21.76)20.4	(10.88-13.6)12.24	20
	St	anomocytic	(35.36-46.24)39.89	(10.88-16.32)13.6	(32.5-34.25)41.6	(20-25)22.5	4.5
S. russellii	Ad	anomocytic	(73.44-116.96)94.29	(40.8-70.72)55.3	(27.2-29.9)28.56	(21.76-24.48)23.12	24.24
	Ab	anomocytic	(81.6-108.8)94.29	(48.96-54.4)51.68	(24.48-29.92)27.2	(19.04-21.76)20.4	28.12
	St	anisocytic	(81.6-149.6)109.7	(16.32-24.48)20.85	(32.64-35.36)34	(24.48-27.2)25.84	10.2
S. verticillata	Ad	anomocytic	(95.2-171.36)121.24	(24-54.4)33.5	(24.48-29.92)27.6	(13.6-21.76)18.88	31.88
	Ab	anomocytic	(58-95.2)74.53	(13.6-38)27.65	(19.27-32.64)26.06	(13.6-21.76)18.88	73.5
	St	paracytic	(163.2-258.2)223.31	(40-62.56)49.15	(27.2-40)33.44	(19.21-27.2)22.68	44
		anisocytic					

<table>
<tr><th rowspan="2">Species</th><th rowspan="2">Sur-face</th><th rowspan="2">Observed stomatal complex</th><th colspan="2">Dimensions of epidermal cells</th><th colspan="2">Dimensions of Stomata</th><th rowspan="2">Sto-matal index</th></tr>
<tr><th>Length (μm)</th><th>Width (μm)</th><th>Length (μm)</th><th>Width (μm)</th></tr>
<tr><td rowspan="3">S. virgata</td><td>Ad</td><td>anomocytic</td><td>(54.4-95.2)72.53</td><td>(27.2-43.52)34.45</td><td>(21.76-24.48)22.86</td><td>(13.6-16.32)15.06</td><td>21.49</td></tr>
<tr><td>Ab</td><td>anomocytic</td><td>(54.4-136090.66</td><td>(16.32-32.64)29.92</td><td>(24.48-27.2)25.77</td><td>(19.04-21.76)20.44</td><td>30</td></tr>
<tr><td>St</td><td>anomocytic</td><td>(156.4-222.6)195.2</td><td>(35.23-54.56)44.14</td><td>(27.5-50)35.75</td><td>(15-23)20.4</td><td>15.26</td></tr>
<tr><td rowspan="4">S. atropatana</td><td>Ad</td><td>anomocytic</td><td>(28.55-54.4)39.34</td><td>(13.6-24.48)19.24</td><td>(21.76-25.02)23.65</td><td>(19.04-21.76)20.08</td><td>7.21</td></tr>
<tr><td>Ab</td><td>anomocytic</td><td>(28.55-95.2)59.38</td><td>(8.16-29.92)18.13</td><td>(24.48-26.56)24.69</td><td>(13.6-16.86)14.94</td><td>26.47</td></tr>
<tr><td rowspan="2">St</td><td>anisocytic</td><td rowspan="2">(122.4-244.8)214.93</td><td rowspan="2">(27.2-40.8)33.36</td><td rowspan="2">(32.64-35.9)34</td><td rowspan="2">(24.48-27.74)25.86</td><td rowspan="2">27.27</td></tr>
<tr><td>paracytic</td></tr>
<tr><td rowspan="5">S. arabica</td><td>Ad</td><td>anomocytic</td><td>(68-92.48)78.88</td><td>(53.36-46.24)39.89</td><td>(21.76-29.92)26.29</td><td>(13.6-19.04)16.32</td><td>30</td></tr>
<tr><td>Ab</td><td>anomocytic</td><td>(70.72-108.8)92.48</td><td>(38.8-43.52)41.16</td><td>(27.2-29.92)28.56</td><td>(13.6-16.32)14.96</td><td>47.82</td></tr>
<tr><td rowspan="3">St</td><td>polycytic</td><td rowspan="3">(116.96-231.2)170.45</td><td rowspan="3">(24.48-38.08)31.73</td><td rowspan="3">(21.76-32.64)27.2</td><td rowspan="3">(19.04-21.76)20.4</td><td rowspan="3">11.9</td></tr>
<tr><td>tetracytic</td></tr>
<tr><td>pericytic</td></tr>
<tr><td rowspan="3">S. aegyptiaca</td><td>Ad</td><td>anomocytic</td><td>(106.08-22.4)112.42</td><td>(19.04-54.4)38.2</td><td>(27.2-29.92)28.56</td><td>(16.32-18.49)17.12</td><td>21.05</td></tr>
<tr><td>Ab</td><td>anomocytic</td><td>(95.2-171.36)129.62</td><td>(16.32-32.64)25.38</td><td>(27.2-28.33)27.95</td><td>(13.6-15.77)14.82</td><td>33.33</td></tr>
<tr><td>St</td><td>anomocytic</td><td>(35.36-54.4)43.52</td><td>(19.04-32.64)24.48</td><td>(29.92-31.28)30.6</td><td>(24.48-26.92)25.25</td><td>13.95</td></tr>
<tr><td rowspan="5">S. sclareopsis</td><td rowspan="2">Ad</td><td>anomocytic</td><td rowspan="2">(54.4-92.48)71.62</td><td rowspan="2">(32.64-40.8)37.17</td><td rowspan="2">(27.2-29.92)28.65</td><td rowspan="2">(13.6-16.32)14.96</td><td rowspan="2">28.73</td></tr>
<tr><td>diacytic</td></tr>
<tr><td rowspan="2">Ab</td><td>anomocytic</td><td rowspan="2">(48.96-68)57.12</td><td rowspan="2">(24.48-35.36)29.01</td><td rowspan="2">(24.48-27.2)25.84</td><td rowspan="2">(21.76-24.48)23.12</td><td rowspan="2">38.09</td></tr>
<tr><td>diacytic</td></tr>
<tr><td>St</td><td>anomocytic</td><td>(81.6-141.44)110.61</td><td>(10.88-19.04)15.41</td><td>(25-55)35.24</td><td>(12.5-32.5)24.5</td><td>17.69</td></tr>
<tr><td rowspan="3">S. spinosa</td><td>Ad</td><td>anomocytic</td><td>(54.4-95.2)77.06</td><td>(24.48-28.08)25.73</td><td>(24.48-26.85)25.76</td><td>(15.52-18.52)16.77</td><td>18.64</td></tr>
<tr><td>Ab</td><td>anomocytic</td><td>(27.2-40.8)34.83</td><td>(13.6-29.92)23.16</td><td>(24.48-27.2)24.77</td><td>(16.23-19.54)18.14</td><td>30</td></tr>
<tr><td>St</td><td>anisocytic</td><td>(217.6-299.2)267.46</td><td>(13.6-32.64)22.66</td><td>(27.2-29.92)28.47</td><td>(21.76-24.48)23.12</td><td>10.63</td></tr>
<tr><td rowspan="5">S. lanigera</td><td rowspan="2">Ad</td><td>anisocytic</td><td rowspan="2">(68-95.2)81.6</td><td rowspan="2">(27.2-38.92)31.56</td><td rowspan="2">(27.2-29.92)28.56</td><td rowspan="2">(19.04-21.76)20.4</td><td rowspan="2">37.42</td></tr>
<tr><td>tetracytic</td></tr>
<tr><td rowspan="2">Ab</td><td>anisocytic</td><td rowspan="2">(81.6-149.6)109.7</td><td rowspan="2">(62.65-95.2)74.34</td><td rowspan="2">(35.36-38.08)37.72</td><td rowspan="2">(19.04-24.48)21.76</td><td rowspan="2">24.52</td></tr>
<tr><td>tetracytic</td></tr>
<tr><td>St</td><td>anisocytic</td><td>(81.6-116.96)102.45</td><td>(27.2-48.96)37.17</td><td>(27.2-29.92)28.56</td><td>(19.04-24.48)21.76</td><td>12.5</td></tr>
<tr><td rowspan="3">S. brachyantha</td><td>Ad</td><td>anomocytic</td><td>(108.8-204)201.24</td><td>(40.8-81.6)68.43</td><td>(81.6-24.48)87.36</td><td>(62.56-68)64.96</td><td>20</td></tr>
<tr><td>Ab</td><td>anomocytic</td><td>(108.8-132.2)111.66</td><td>(19.04-54.4)38.08</td><td>(68-76.16)71.62</td><td>(43.52-54.4)49.2</td><td>28.57</td></tr>
<tr><td>St</td><td>anomocytic</td><td>(90-250)127.2</td><td>(40.55-71.22)53.92</td><td>(30-50)39.24</td><td>(15-30)22.66</td><td>10.14</td></tr>
</table>

Species	Surface	Observed stomatal complex	Dimensions of epidermal cells		Dimensions of Stomata		Stomatal index
			Length (µm)	Width (µm)	Length (µm)	Width (µm)	
S. candidissima	Ad	—	(176.8-225.76)200.37	(40.8-81.6)62.56	—	—	—
	Ab	anomocytic	(95.2-149.6)117.86	(40.8-62.56)52.58	(24.48-27.74)25.85	(16.32-19.31)17.76	12.72
	St	anomocytic	(144.42-199.2)188.84	(24.42-53.2)47.65	(30-37.5)33.75	(12.5-17.5)15	9.9
S. bracteata	Ad	anomocytic	(55.42-90.76)73.44	(23.22-54.76)49.82	(27.2-29.92)28.56	(13.6-16.32)14.96	13.24
	Ab	anomocytic	(51.68-81.6)65.17	(21.76-34.4)35.91	(24.48-27.2)25.84	(16.32-19.04)17.68	15.78
	St	diacytic	(97.92-152.32)119.8	(24.48-40.8)30.82	(32.64-35.36)34	(13.6-16.32)14.96	12.12
S. montbertii	Ad	anomocytic	(40.8-68.4)58.05	(21.6-27.76)23.57	(19.04-24.48)21.76	(10.88-13.6)12.24	32.14
	Ab	anomocytic	(41.68-54)44.74	(13.6-19.04)17.24	(24.48-27.2)25.84	(13.6-16.32)14.96	14.35
	St	anomocytic	(81.6-149.6)115.6	(27.2-35.36)19.04	(20-30)27.5	(15-20)17.5	17.5
S. macrosiphon	Ad	anomocytic	(54.4-81.6)65.28	(16.32-38.08)26.29	(32.64-33.36)34	(21.76-24.48)23.12	22.22
	Ab	anomocytic	(27.2-54.4)38.98	(10.88-19.04)14.5	(24.48-27.2)25.84	(16.32-19.04)17.68	22.58
	St	—	(27.2-40.8)33.54	(19.04-32.64)26.29	—	—	—
S. hypergia	Ad	anomocytic	(54.4-68)61.65	(27.2-40.8)33.54	(24.48-27.2)25.84	(16.32-19.04)17.68	23.07
	Ab	anomocytic diacytic	(48.96-57.12)53.49	(21.76-35.36)29.01	(21.76-24.48)23.12	(16.32-19.04)17.68	35.71
	St	—	(108.8-157.76)134.18	(27.2-68)46.24	—	—	—
S. officinalis	Ad	anomocytic	(27.2-48.96)38.98	(13.6-27.2)20.85	(21.76-25.02)23.39	(16.32-19.04)17.68	14.28
	Ab	anomocytic	(40.8-62.56)52.58	(13.6-40.8)30.82	(29.92-31.28)30.6	(21.76-24.48)23.12	19.52
	St	anomocytic	(46.24-81.6)64.48	(19.04-40.8)29.01	(25-27.5)26.25	(12.5-15)13.75	12.7

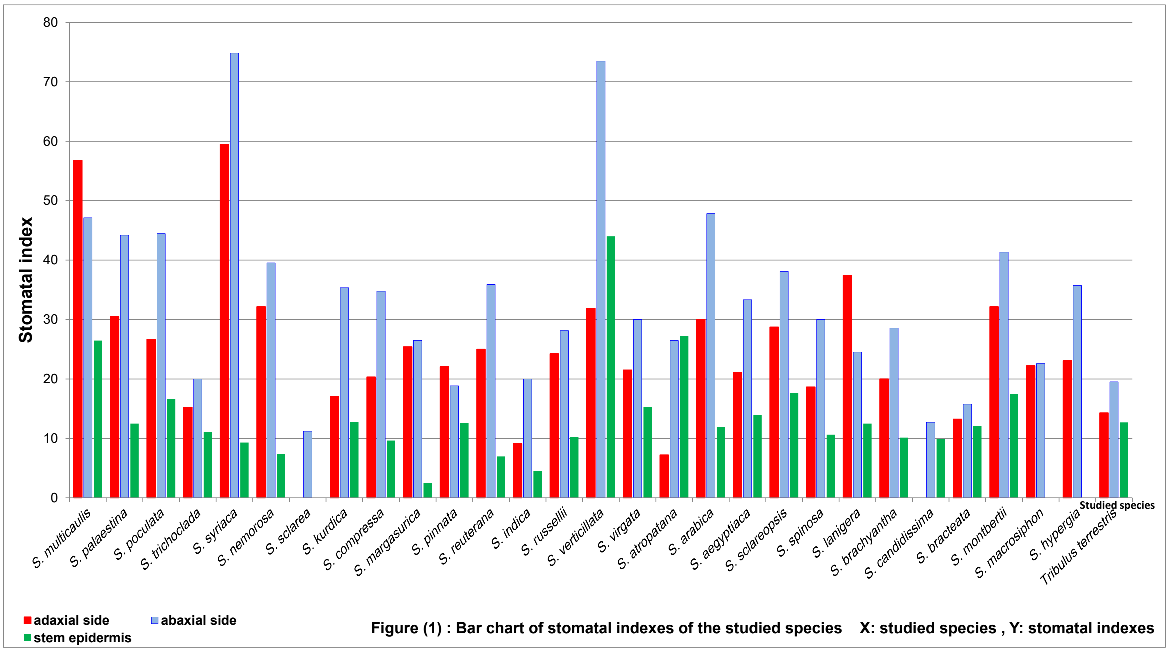

Figure (1) : Bar chart of stomatal indexes of the studied species X: studied species , Y: stomatal indexes

Discussion:

Anatomical studies have been used successfully to clarify taxonomic status and help in identification of different species (Scatena et al., 2005; Munir et al., 2011). Results obtained from this study showed that the anatomical characters can separate species and resulted in exploration of valuable inter generic and inter specific variations in the configuration of epidermal cells that can be used as an important supportive taxonomic tools to demarcate many species under the study. Stem and leaf epidermal tissue characters have an important role in taxonomy and determination of numbers of plant genera and species. Leaf epidermis study is becoming more important because taxonomists have found it useful in plant identification. A number of workers have used leaf features to reclassify many species within a genus or genera within a family (Adegbite, 1995; Ogunkunle and Oladale, 2000). The results revealed clear cut differences in size and shape of stomata, epidermal cells, presence of macro and micro hairs, their size and type,… etc. Although studies conducted on gross morphology and wood anatomy which have proved valuable in the identification of the plant, identification criteria would be incomplete without foliar epidermal morphology (Kadiri et al., 2006). Taxonomic studies of a number of families are based on leaf epidermal anatomy (Kong, 2001; Bibi et al., 2009). However, Carlquist (1961), Matcalfe (1968) and Stace (1984) had stated that leaf epidermis characters are the most varied anatomical features in Angiosperms. Some of the leaf epidermis anatomical characters of the studied species showed many typical or common foliar characters to their family, as described by Metcalfe and Chalk (1950). Metcalfe and Chalk (1988) and Beerling and Wood ward (1997) reported that large stomata usually gave low stomatal index, while small stomata gave high stomatal index. This statement did not hold true for some of the studied species. Eight types of stomatal complexes were identified in the studied species. Anomocytic type was dominant in the epidermis of both leaf and stem surfaces of the studied species. Surface which has the most variations was the adaxial surface of S. syriaca, has mixture of 4 stomatal patterns: anisocytic, tetracytic, paracytic and polycytic stomatal complexes.

Brachyparahexacytic type, which characterized by presence of four short cells lateral to guard cells with two wide polar cells, observed only on the stem epidermis of S. compressa and never be seen in any epidermis of all the other studied species. Brachyparatetracytic type, which characterized by presence of two short cells lateral and parallel to the guard cells and two wide polar cells, observed only on the adaxial surface of S. kurdica and never be seen in any epidermis of all the other studied species. Presence of pericytic stomatal complex, which characterized by presence of one subsidiary cell enclosing both guard cells, observed only on the stem epidermis of S. arabica and did not noticed on any epidermis of the studied species.

The reasons of decrease or absence of stomatal complexes in some studied species may be due to genetic reason or environmental factors such as drought, as well as, increasing in day length which means increasing exposure to sun light. This opinion was ensured by Esaue (1965) and Fahn (1974). The distribution of stomata on leaves was not random, but ordered. Although the mechanism of their patterning is not known, environmental conditions reportedly influence their frequency (El-Hashani and Pearson, 1995) and sometimes their patternings. Boctsch et al. (1996) indicated that elevated Co_2 affected stomatal patterning in two important ways:

1. Augmentation of the number of subsidiary cells associated with stomatal complexes.
2. Recruitment of these cells from the epidermal cell population.

Most of the species in this study have undulating on the abaxial cell walls more than the cells on the adaxial side. This observation was ensured by Esaue (1953) who revealed the variable in wall waviness and gave his opinion that the waviness of the walls depending on the location in the leaf, often undulation occur only on the lower side, or are more pronounced here than on the upper side. Appearances of the undulation may be due to:

1. Sudden growth of cells during leaf differentiation.
2. The method of hardening of the differentiated cuticle.
3. Environmental conditions prevailing during leaf development.

The undulation patterns have an important taxonomic value (Metcalf and Chalk, 1950; Culter et al., 2007). Stace (1969), as well as, Ayodele and Olwokudejo (2006) noted that undulation of the walls is a mesomorphic character and the environment conditions such as humidity, play a significant role in determining the pattern of anticlinal cell walls. Straight or curved walls were identified as characteristic of species growing in drier conditions, while undulated walls were found mostly in species growing in area of high humidity.

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