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Taxonomic Significance of Anatomical Characters in Some Species of *Minuartia* L. (Caryophyllaceae)

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Abstract

This paper elaborated the epidermis properties, transverse sections of leaves and stems of eight species of *Minuartia*. They are *M.juniperina*(L.) Maire & Petitm , *M.hamata* (Hausskn.) Mattf., *M.hybrida* (Vill.) Schischk., *M.intermedia* (Boiss.) Hand.-Mazz , *M. meyeri* (Boiss.)Bornm., *M.montana* L. and *M. picta* (Sibth. & Sm.) Bornm. It was clear that certain structural characteristics were of significant importance in separation of these taxa, such as anticlinal walls of epidermal cells in upper surface straight in *M.picta*, strongly undulate in *M.juniperina* , *M. meyeri* and *M.intermedia*, and sinuate in the remaining species. Number of epidermal cells is often recorded on the upper epidermis ranging between 52.80 and 579.22 cells/mm^2, while it was ranging between 60.11 and 606.31 cells/ mm^2 on the lower epidermis in *M.montana* and *M.hybrida*. Three types of mesophyll has been recognized, dorsiventral (Bifacial) in the *M.hybrida* subsp. *turcica*, ground tissue in *M. hamata* and *M.juniperina* , as well as isobilateral in the remaining species. Anatomical characters of stems are semi-circular in most species except *M. picta* it was quadrangular but circular in *M.intermedia* and *M.hybrida.* The pericycle is wide and consists of 6-8 sclerenchyma cells in *M. montana* and 2-3 in *M.hybrida*, *M.meyeri* and *M.intermedia*, the other species between this range.

Keywords: *Minuartia*, Caryophyllaceae, Anatomy, Stem, Leaves.

Introduction

The genus *Minuartia* L. belongs to the Caryophyllaceae family, according to Takhtajan (1997), *Minuartia* is a comprises an estimated 175 species distributed in temperate and arctic areas of Asia, Europe, Northern Africa, North and South America (Rabeler *et al.*, 2005). Only eight species were distribution in north and west region of Iraq.

The previous studies that carried out on anatomy of Caryophyllaceae had been done by (Metcalfe and Chalk,1950). Carlquist (1995) studied wood anatomy of Caryophyllaceae. Some anatomical properties of the *Saponaria kotschyi* Boiss. (Caryophyllaceae) studied by (Ataslarm, 2004). Schwingruber (2007) described and analyzed the xylem and phloem of 88 species from Caryophyllaceae. Stomatal observations of 18 species of Dicotyledons including three species of *Minuartia* (Caryophyllaceae) studied by (Zarinkamar, 2007), which reported that the stomatal number of *M.recurva* ، *M.lineata* and *M.acuminata* on upper surface more than lower surface. Some characters such as epidermal characters on *Silene* species in Iran studied by (Jafari *et al*., 2008). Yildiz and Minareci (2008) focused on the adaptation of glandular hairs and stomata on both surfaces of leaves of *Silene urvillei*. While anatomical and pollen characters investigated in the genus *Silene* from Turkey studied by (Kilic, 2009). Anatomical studies of 16 species of the genus *Silene* have been carried out from Pakistan by light microscopy studied by (Sahreen *et al*., 2010), they reported that diacytic type of stomata is the diagnostic character of family Caryophyllaceae. In *Silene* basic type of stomata is diacytic but some other stomatal types are also present such as anisocytic and anomocytic type of stomata, shape and size of epidermal cells, trichomes, the number of epidermal cells and stomata, the shape of stem cross section, arrangement of xylem elements in peduncle, arrangement of mesophyll in leaf and the number of sclerenchymatous layers are significant to separating species (Shamsabad et al., 2013).Gucel (2013) studied anatomy of stem, root and leaves of *Minuartia nifensis* from West Anatolia.

No detailed reports are available on anatomical study for genus *Minuartia* from Iraq so that the aim of this study is to do anatomical study for eight species of the *Minuartia* in Iraq and describes the variation within taxa of *Minuartia* and assesses the value of anatomy in determining interrelationships between species.

Materials and Methods

In the present study, nine taxa of the *Minuartia* have been investigated. Leaves and stems of these species were collected from herbarium specimens deposited in BAG (National Herbarium of Iraq, Baghdad, Abo-Ghraib) during 2013 -2014.Fresh material of species of *Minuartia* was collected from northern and west region of Iraq. The cuticles were prepared by macerating the leaves in Jeffrey's solution (equal parts of 10% chromium trioxide solution and concentrated nitric acid), and therefore mounted in safranin stained glycerine jelly.

For sectioning, fresh material of leaves and stems was fixed at least 48 hours in formalin acetic acid alcohol solution (FAA) and preserved in 70% alcohol, then dehydrated in ethyl alcohol series, sectioned on a rotary microtome and stained in safranin and fast green and then mounted in Canada balsam (Johansen, 1940).

The sections were examined with Olympus CH4 light microscope and photographed with Digital camera type DCE-2. Stomatal index was calculated as mentioned by (Ditcher, 1974). Anatomical terms used are cited from (Radford,1974; Ditcher, 1974; Esau,1965).

Results and Discussion

Lamina: Epidermis and Stomata

Measurements of epidermal cells are summarized in (Table 1; Figure 1-4). There are usually differences in cell form and dimensions between the adaxial and abaxial surfaces of the leaf as well as between taxa studied. The average length of epidermal cells in the adaxial surface ranged between 60.37 - 307.50 um in *M.montana* and *M.picta* .The average breadth was 23.50- 50.83 um in *M.montana* and *M.juniperina* respectively. In the abaxial surface the average length ranged between 31.85 – 355.33 um in *M.juniperina* and *M.picta* respectively (Table 1). Anticlinal walls of epidermal cells exhibit a difference between species; In upper surface they are normally straight in *M.picta*, strongly undulate in *M.montana* and *M.meyeri* , straight- sinuate in *M.intermedia* and *M.hybrida* subsp.*hybrida*, sinuate in the remaining species. In lower surface all species was undulate except *M.recurva and M.meyeri* was strongly undulate, and straight in *M.picta* (Figure 1-4). Larger number of epidermal cells is often recorded on the upper epidermis ranging between 52.80 and 579.22 cells/mm^2, while it was ranging between 60.11 and 606.31 cells/ mm^2 on the lower epidermis in *M.montana* and *M.hybrida* subsp.*hybrida* respectively (Table 1).

Stomatal complexes can be believed as a significant character in the identification of species (Table 2).Stomata are rounded or elliptic shaped present on either sides (Amphistomatic leaves) then often more numerous on the abaxial epidermis (Figures 3,4). Although caryophllaceous (Diacytic type) stomata are present in all taxa but *M.hybrida* subsp.*hybrida*, *M.juniperina*, *M.recurva* and *M.meyeri* showed another types in it was ranunculaceous type(Anomocytic type) , addition to the hemidiacytic type was found in *M.picta* and *M.hybrida* subsp.*turcica* (Figure 1-4) .The basic type of stomata is diacytic in Caryophyllaceae family according to Metcalfe and Chalk (1950) and Hill *et al*.,(1976),in this study observed in *Minuartia* some other stomata types such as hemidiacytic and anomocytic were observed in several species, which in agreement with Taia and Ismael (1994) they recorded anomocytic type in studied some species of Caryophyllaceae, and Zarinkamar (2007) reported caryophyllacous type found on both surfaces of leaves of *M.recurva*, in addition, anomocytic type and diacytic type in some species of Caryophyllaceae .Similarly, anomocytic types of stomata were reported in some *Silene* species by (Jafari *et al*.,2008) and (Sahreen et al., 2010). Guard cells are kidney shaped. Stomatal index percent on the adaxial surface is higher in *M.juniperina* (27.51%) followed by *M.recurva* and *M.picta*, while on the abaxial surface *M.juniperina* has a high stomatal index percent (Table 2). Stomatal index on the lower surface more than upper surface except *M.intermedia* and *M.recurva* , this results agree with (Zarinkamar ,2007).

Table-1: Dimensions of epidermal cells in leaves of *Minuartia* (in micrometer).

Species	Anticlinal cell shape		Epidermal cells				Number of cells	
			Lower		Upper			
	Upper epidermis	Lower epidermis	Length	width	Length	width	Upper epidermis	Lower epidermis
M.hamat a (Hausskn.) Mattf.	undulate	undulate	(50-75) 62.12	(20-32.5) 26.25	(62.5-95) 80.75	(17.5-37.5) 26.13	(444-360) 403.71	(540-396) 474
M.hybrida subsp. *hybrida* ((Vill.) Schischk.	*Straight*-sinuate	undulate	(35-67.5) 48.33	(22.5-50) 28.43	(47.5-100) 64.44	(25-40) 31.81	(606-540) 579	(570-660) 606
M.hybrida subsp.*turcica* McNeill	undulate	undulate	(67.5-102) 80.41	(27.5-62.5) 39.58	(62.5-175) 90.62	(35-55) 43.57	(222-132) 187.2	(300-324) 312
M.intermedia (Boiss.) Hand-Mazz.	*Straight*-sinuate	undulate	(37.5-110) 58.43	(15-40) 29.68	(32.5-87.5) 69.25	(22.5-42.5) 29.75	(300-396) 337.99	(414-450) 438.10
M.juniperina (L.) Maire & Petitm	undulate	undulate	(50-97.5) 31.85	(37.5-62.5) 47.85	(87.5-162.5) 128.33	(50-55) 50.83	(240-180) 216.25	(270-198) 222.99
M.meyeri (Boiss.) Bornm.	Strongly undulate	Strongly undulate	(25-50) 35.41	(20-50) 35.83	(50-95) 74.25	(27.5-62.5) 40.12	(270-456) 361.99	(480-540) 507.60
M.montana L.	Strongly undulate	undulate	(32.5-37.5) 35.82	(25-35) 30.41	(37.5-75) 60.37	(20-25) 23..50	(30-96) 52.80	(42-90) 60.11
M.picta (Sibth. & Sm.) Bornm	*straight*	*straight*	(175-575) 355.33	(25-30) 25.71	(212.5-362.5) 307.50	(25-30) 26.50	(114-144) 125.17	(96-186) 139.99
M.recurva (All.) Schinz & Thell	undulate	Strongly undulate	(37.5-75) 60.93	(22.5-50) 36.56	(60-95) 81.87	(25-37.5) 30.35	(107.5-160) 289.99	(510-606) 548.57

The values between arches represent the mean and the values out the arches represent the minimum and maximum values.

Table- 2: Dimensions of stomata in leaves of *Minuartia* (micrometer).

Species	Number of stomata		Stomata dimension				Index of stomata	
			Upper epidermis		Lower epidermis			
	Upper epidermis	Lower epidermis	length	width	length	width	Upper epidermis	Lower epidermis
M.hamata (Hausskn.) Mattf.	(48-156) 99.42	(132-210) 160.80	(20-25) 23.12	(12.5-20) 16.50	(20-27.5) 25.31	(12.5-17.5) 14.06	19.79	25.33
M.hybrida subsp. *hybrida* ((Vill.) Schischk..	(72-90) 78.99	(96-120) 102.99	(22.5-25) 24.06	(17.5-20) 15.65	(25-27.5) 26.50	(17.5-20) 19.16	12	14.52
M.hybrida subsp.*turcica* McNeill	(18-48) 36	(60-78) 66	(27.5-32.5) 30.20	(20-25) 22.50	(25-30) 27.85	(20-22.5) 21.25	16.12	17.46
M.intermedia (Boiss.) Hand-Mazz.	(48-102) 69.99	(60-102) 76.99	(22.5-37.5) 27.25	(15.17.5) 16.75	(25-37.5) 27.77	(15-37.5) 23.05	17.15	14.94
M.juniperina (L.) Maire & Petitm	(72-96) 81.99	(96-162) 121.99	(35-40) 37.08	(30-32.5) 30.83	(32.5-37.5) 35.62	(25-35) 29.68	27.51	35.36
M.meyeri(Boiss.) Bornm.	(12-42) 30.99	(72-96) 82.50	(25-27.5) 25.41	(17.5-22.5) 19.58	(22.5-25) 24.46	(15-17.5) 16.25	7.88	13.98
M.montana L.	(6-12) 9.22	(24-36) 27.96	(25-30) 26.5	(12.5-17.5) 14.50	(30-35) 31.65	(15-25) 20. 20	17.04	31.78
M.picta(Sibth .& Sm.) Bornm	(24-60) 38.57	(42-78) 60.10	(32.5-37.5) 35.41	(20-25) 23.54	(25-37.5) 30.50	(17.5 -25) 21.75	23.55	30
M.recurva(All.) Schinz & Thell	(84-102) 91.99	(102-156) 137.14	(25-32.5) 29.02	(20-22) 21.25	(22.5-28.75) 26.87	(22.5-25) 23.75	24.08	19.99

The values between arches represent the mean and the values out the arches represent the minimum and maximum values.

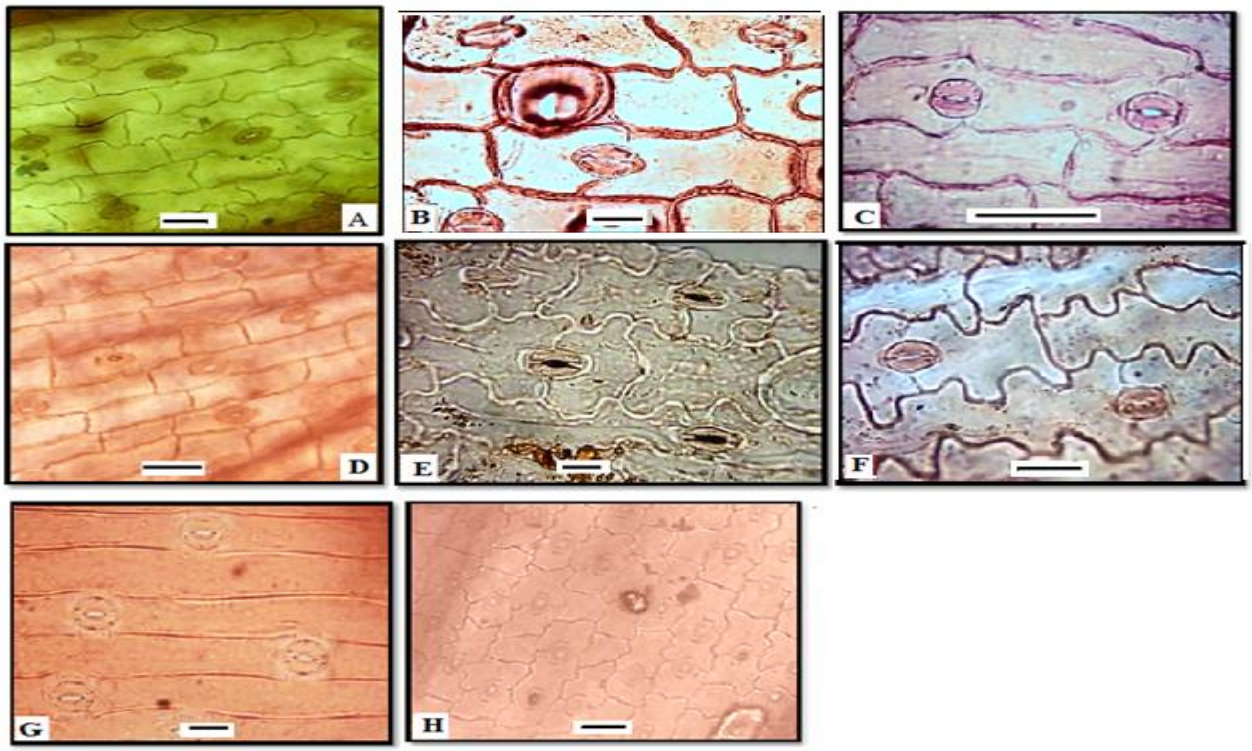
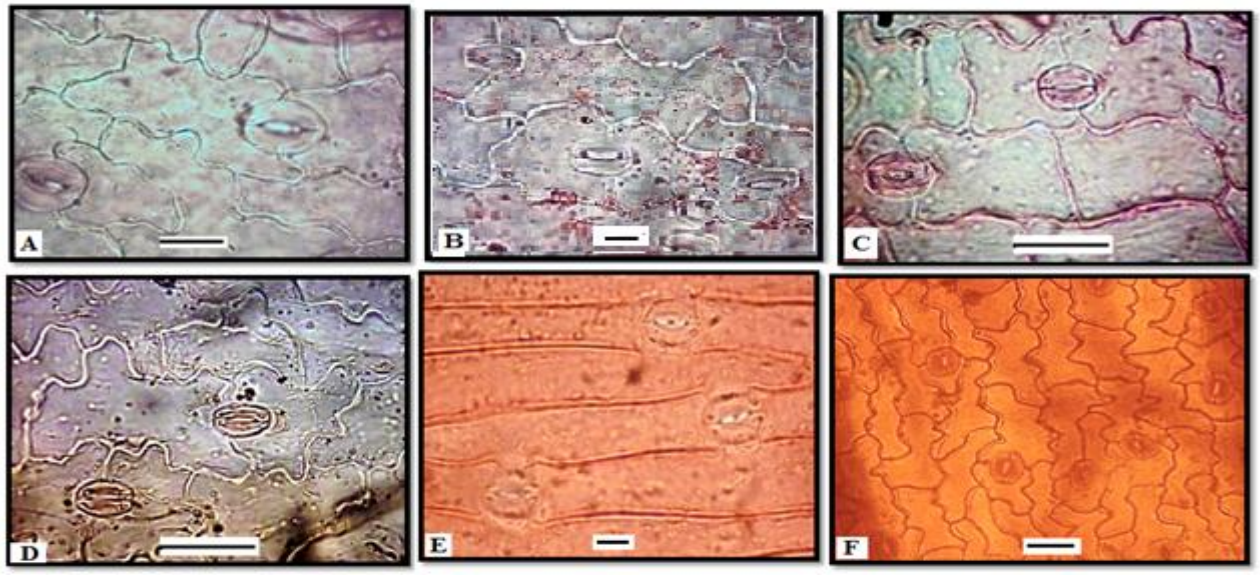


Figure-1: Surface view of leaf epidermis in light microscope on upper surface(scale 25 um)
A-M.juniperina B- M.hamata C- M.hybrida* subsp.*hybrida D- M.intermedia E- M.meyeri F- M.montana G- M.picta H- M. recurve.



Figeur-2: Surface view of leaf epidermis in light microscope on lower surface(scale 25 um)
A- *M.juniperina* B- *M.hamata* C- *M.hybrida* subsp.*hybrida* D- *M.meyeri* E- *M.picta* F- *M. recurve*

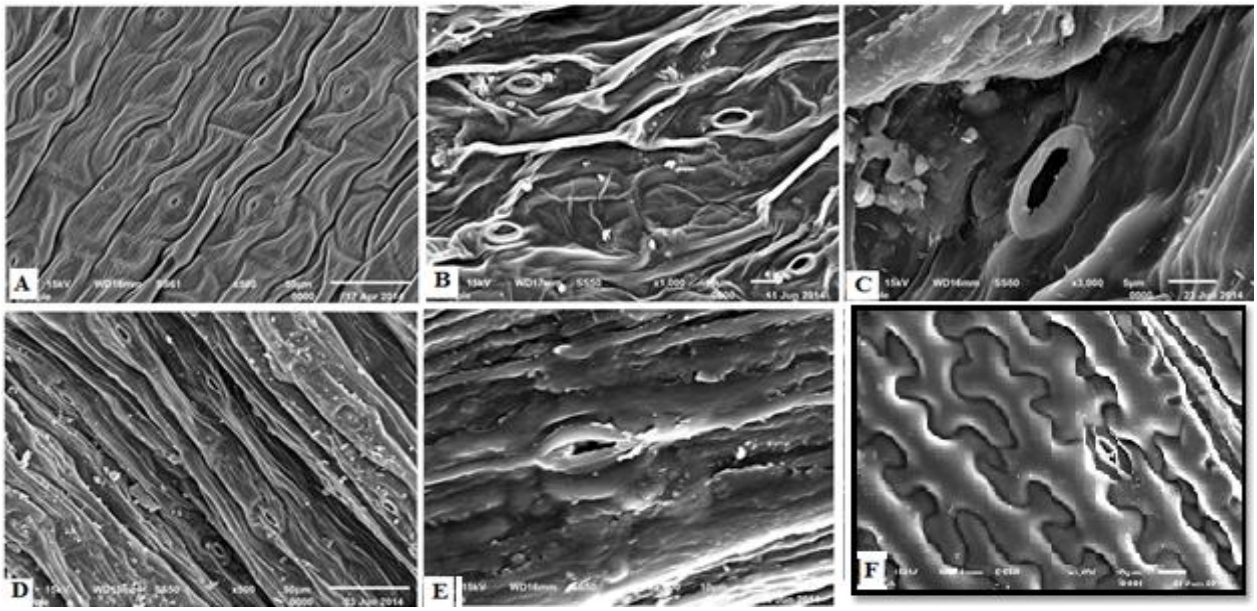


Figure-3: Surface view of leaf epidermis in scanning electron microscope on upper surface
A- *M.juniperina* B- *M.hamata* C- *M.hybrida* subsp.*hybrida* D- *M.meyeri* E- *M.picta* F- *M.hybrida* subsp.*turcica*

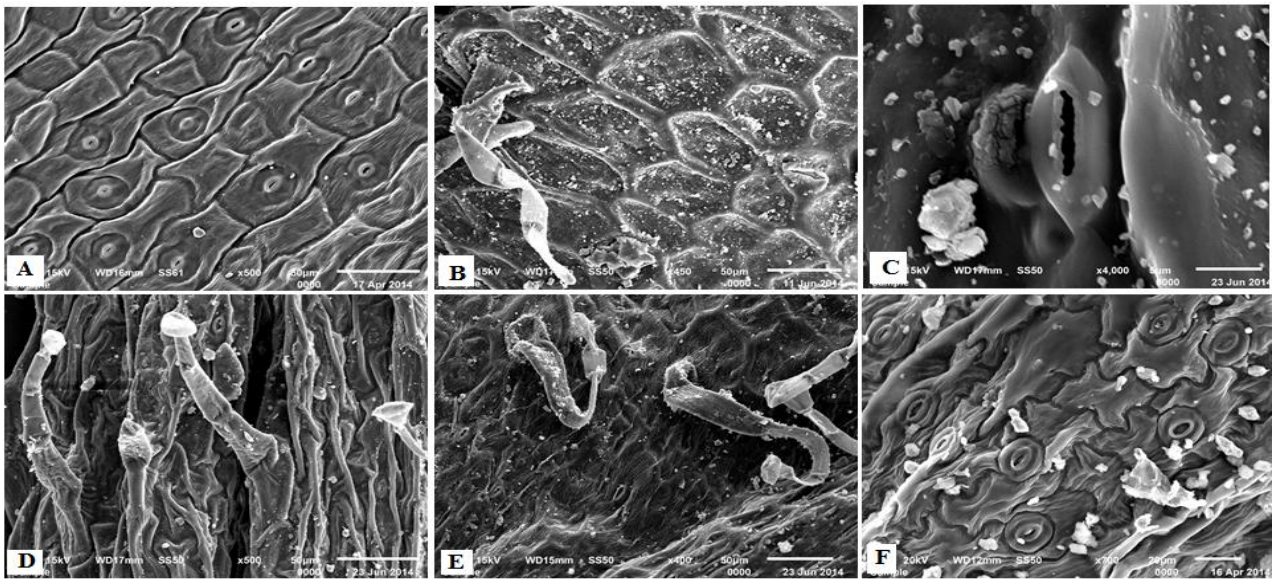


Figure- 4 : Surface view of leaf epidermis in scanning electron microscope on lower surface
A- *M.juniperina* B- *M.hamata* C- *M.hybrida* subsp.*hybrida* D- *M.intermedia* E- *M.montana* F- *M. recurve*

Transverse Sections

Transverse Sections of Lamina

The transverse section of the lamina revealed the following elements (Figure 5). In transverse section, the upper and lower epidermises comprise uniseriate, large circular, oval and orbicular cells, thin lateral walls. Both epidermises are covered with a thin cuticle(Table 3). Covering trichomes are dense on the lower surface.

Three types of mesophyll has been recognized, dorsiventral (Bifacial) in the *M.hybrida* subsp. *turcica* as well as ground tissue in *M. hamata* and *M.juniperina* and isobilateral in the remaining species (Table 3, Figure 5) . So that some are of high taxonomic significance the presence of variation in mesophyll in leaves, the occurrences of isobilateral and dorsiventral leaf type as well as presence ground tissue (not recognized to palisad and spongy tissue) in *M.juniperina* and *M.hamata* appears to be a good diagnostic characteristic for the generic level.

Thickness of lamina between 119.92 um in *M. intermedia* and 341.25um in *M.hybrida* subsp. *turcica* . Cuticle thickness occurred between 1.98 um in *M. recurva* and 3.19 um in *M. intermedia* (Table 3). The druses crystal presences in the leaves in all species of *Mnuartia*, which agree with (Metcalfe and Chalk, 1950). This study is also characters found another species of Caryophyllaceae (Jafari *et al.*, 2008) & (Sahreen *et al*., 2010).

Epidermal cells are square-shaped or rectangular, uniserrate. The whole of the mesophyll is composed of many layers of palisade tissue differ between *Minuartia* species. Mesophyll of 1-2 layers of palisade cells in most species except *M.picta* contain 3-4 layers, of compact or loose spongy tissue, or two layers of palisade cells on adaxial and abaxial surfaces enclosing spongy tissue (Figure 5). Mid-rib usually grooved from above erect downward, curved or flattened in both directions, supplied with one bicollateral vascular strand ovate or circular in all species. These anatomical features observed on the leaves are consistent with those of (Metcalfe and Chalk, 1950).

Transverse Sections of Stems

Stem gives a good character in separation of the species, such as shape and size; the numbers of sclerenchymatous layers are taxonomically significant to identify species. *M.intermedia, M.montana* and *M.meyeri* recognized by hallow stem compared with other species. This characters supported in one section : Minuartia (Davis, 1967). The analysis of the stem cross-section showed that the cortex is narrow except in *M.picta* was broad and the endodermis frequently well distinguished. Outline stem is semi-circular in most species except *M.intermedia* and *M.hybrida* subsp.*hybrida* was circular (Figure 6).

Epidermis uniserriate covered with a layer of cuticle followed by multilayered cortex rich of wide crystal. Metcalfe and Chalk (1950) reported that calcium oxalates are commonly present in the form of large conspicuous crystals in many genera and species of Caryophyllaceae family including *Minuartia* . In this study calcium oxalate crystals are observed both in endodermis and pith that are dissent with Metcalfe and Chalk (1950), they reported that crystals in Caryophyllaceae are placed only in endodermis.

Three types of distinct tissues are recognized in cortex, chlorenchyma, collenchyma and parenchyma in taxa under investigation, the taxa *M.picta, M. hamata*, in *M.intermedia, M.juniperina, M.meyeri, M.recurva* and *M.hybrida* subsp.*turcica* where chlorenchyma was absent, as well as absent collynchyma in *M.picta, M.juniperina, M. recurva* and *M.hybrida* subsp.*hybrida* (Figure 6).

The pericycle is characterised by a sclerenchymatous ring whose width varies between different species of the *Minuartia*, as well as the number of sclerenchymatous and parenchymatous layers in stem variable between species (Table 4). Sclerenchymatous thick walled cells layers are well developed and expanded in *M.montana* 98.33um about (6-8) whereas sclerenchymatous thin walled cell layers in *M.hybrid* , *M.meyeri* and *M.intermedia* (2-3) layers and the other species between this range(Table 4), in *M.recurva* sclerenchymatous layers was absence.

Vascular tissue is a continuous bicollateral cylinder in all species, the xylem and phloem also form a continuous ring in certain *Minuartia* species. These results are consistent with the description given by (Metcalfe and Chalk, 1950). The phloem is 2-4 layered and consists of irregular cells. The xylem is composed of trachea and tracheids. The tracheas consist of large circular and orbicular cells. The tracheids consist of irregular cells (Figures 6). Thickness of xylem variable between 21.36 um in *M.hybrida* subsp. *turcica* and 208.08 um in *M.recurva*, while phloem was 7.80 um in *M.picta* and 13.54 um in *M.recurva* (Table 4).

Pith presenting the center of stem composed of parenchymatous storage cells of isodimetric to polyhederal thin layered cells with more or less large intercellular spaces. Cells are rich of druses crystals. Cell dimensions increases towards the center of stem.

The *Minuartia* species studies has been divided into two subgenus where *M. picta* is placed in subgenus: spergella (Davis, 1967 , Rechinger, 1988), we showed some characters separating it from other species such as having anticlinal walls of epidermal cells straight. The other subgenus: Minuartia has been divided into four sections, we also can separated subspecies *M.hybrida* subsp. *turcica* and *M.hybrida* subsp.*hybrida* by characters of mesophyll, it was dorsiventral in *M.hybrida* subsp. *turcica* and isobilateral in *M.hybrida* subsp.*hybrida*.

Although the species *M. hamata, M.intermedia, M.juniperina, M.meyeri,M.montana* are closely related species of same section: Minuartia (Davis, 1967 , Rechinger, 1988) ,anatomical characters having a useful taxonomic characters for separating them, this species differ in mesophyll type, thichness of schlernchyma layers and present or absent the chlorenchyma and collenchyma layer(Table 4).

Conclusion

It is concluded that anatomical leaves , stem, epidermal features can help in identification and classification of taxa up to the species in the genus *Minuartia*.Stomatal index higher in *M.juniperina* ,so that has larger stomatal size and length of epidermal cell within this spices. The subgenus *M.hybrida* subsp.*turcica* and *M.hybrida* subsp.*hybrida* can be distinguished as the type of mesophyll, it was dorsiventral in *M.hybrida* subsp.*turcica* and isobilateral in *M.hybrida* subsp.*hybrida*.

Table-3: Anatomical characters of lamina in *Minuartia.*

Species	Lamina thichness (um)	Type of mesophyll (um)	Mesophyll thickness (um)	Cuticle thickness (um)	Epidermis thickness (um)		number or row of palisad layer	Thickness of palisad layer (um)	Spongy layer		Vascular bundle			
					Lower	Upper			number of row of spongy layer	Thickness of spongy layer (um)	Phloem thickness (um)	Xylem thickness (um)	Number of bundle	Thickness of vascular bundle (um)
M.hamata	(212.5-287.5) 240.38	Ground tissue	(175-260) 230.12	(2.5-3.75) 2.55	(17.5-26.25) 22.11	(12.5-17.78) 13.21	-	-	-	-	(4-6) 5.12	(7.5-12.5) 9.58	3-5	(32.3-25.5) 30.03
M.hybrida subsp. *hybrida*	(260-290) 275.5	Isobilateral	(200-250) 223	(2-3.75) 3.11	(21.25-31.25) 25.25	(15-25) 20.5	2-3	(82.5-120) 94.2	4-6	(100-161..25) 131.37	(3.75-13.75) 8.37	(12.5-26.25) 19.85	3	(23.75-55) 39.12
M.hybrida subsp. *turcica*	(317.5-375) 341.25	Bifacial	(270-307.5) 291.87	(2-3.75) 3.15	(16.25-40) 31.62	(15-25) 18.75	2-3	(75-137.5) 94.62	4-6	(176.25-212.5) 193.62	(8.75-13.75) 10.82	(10-15) 12.72	3	(25-32.5) 30.5
M.intermedia	(87.5-187.5) 119.92	Isobilateral	(75-112.5) 98.5	(2.5-3.75) 3.19	(12.5-17.5) 15.17	(10-13.75) 12.53	1-2	(30-46.25) 40.11	1-2	(17.5-37) 32.55	(5-7.5) 6.55	(17.5-25) 22.12	5	(51.25-95) 76.71
M.juniperina	(112.5-387.5) 243.75	Ground tissue	(87.5-362.5) 259.11	(1.5-2.5) 2.25	(17.5-15) 16.25	(8.75-12.5) 10.62	-	-	-	--	(7.5-12.5) 9.68	(15-21.25) 17.49	3	(50-150) 95.21
M.meyeri	(62.5-162.5) 125.11	Isobilateral	(22.5-145) 79.79	(2.5-3.5) 3.06	(7.5-18.75) 11.95	(7-13.75) 10.33	2-3	(23.75-47.5) 36.66	3-4	(31.25-187.75) 125.21	(2.37-5.5) 4.27	(15-25) 20.22	3-5	(42.5-87.5) 67.70
M.montana	(100-245) 158.37	Isobilateral	(88.75-187.5) 114.87	(2-3.5) 2.99	(12.5-18.75) 15.12	(12.5-17.5) 15.12	2-3	(33.75-63.75) 55.25	2-3	(45-50) 44.51	(4.5-8.75) 6.31	(17.5-25) 21.37	3	(56.25-125) 87.25
M.picta	(270-345) 299.12	Isobilateral	(237.5-312.5) 273.5	(2.5-3) 2.71	(11.25-16.75) 14.8	(12.5-16.25) 13.92	1-3	(62.5-100) 80.37	1-3	(30-56.25) 41.25	(5-15) 9.15	(6.25-22.5) 14.87	1	(25-48.75) 34.62
M.recurva	(87.5-250) 159.37	Isobilateral	(112.5-225) 166.66	(1-2.5) 1.98	(15-19.5) 18.11	(8.5-11) 9.99	1-2	(25.5-40) 37.49	1-2	(14-25.5) 16.25	(7.5-10) 8.75	(12.5-16.25) 14.58	3	(50-70) 60.83

Table-4: Anatomical characters of stem in *Minuartia* (in micrometer).

species	Stem diameter	icle thicknessCut	Epidermis thickness	thicknessCortex				Phloem thickness	Length of wood arm	Pith diamet
				Chlorenchyma	Collenchyma	Paranchyma	sclernchyma			
M.hamata	(683.75-712.5) 693.19	(2-4.62) 2.62	(10-16.25) 12.58	-	(10-17.5) 14.11	(12.5-18.75) 15.25	(62.5-87.5) 73.88	(10-15) 11.58	(45-62.5) 51.94	(312.5-405) 351.5
M.hybrida subsp.*hybrida*	(550-475) 502.77	(2.25-4.5) 3.58	(12.5-30) 19.02	(12.5-37.5) 24.44	-	(12.5-67.5) 38.88	(22.5-50) 32.91	(8.75-20) 12.08	(25-42.5) 31.52	(150-253) 181.94
M.hybrida subsp.*turcica*	(405- 437.5) 420.27	(2.5-5.4) 3.19	(12.5-20.75) 16.77	-	(11.25-15) 12.99	(12.5-21.25) 15.83	(17.5-26.25) 21.33	(10-11.25) 10.58	(15-25) 21.36	(150-175) 160.55
M.intermedia	(487.5-780) 632.5	(2.5-6.25) 3.55	(11.25-17.5) 14.11	-	(61.25-87.6) 74.58	(8.75-25) 17.08	(22.5-38.75) 32.5	(7.5-12.5) 10.83	(20-87.5) 52.91	-
M.juniperina	(625-650) 634.3	(7.5-10) 8.75	(12.5-18.75) 15.11	-	-	(75-107.5) 79.85	(25-62.5) 38.12	(10-12.5) 10.75	(25-33.75) 29.75	-
M.meyeri	(650-712.5) 690.11	(2.5-3.75) 3.05	(7.5-12.5) 10.19	-	(6.25-12.5) 9.68	(10-12.5) 11.01	(33.75-51.25) 41.52	(10-15) 12.77	(25-45) 35.69	-
M.montana	(787.5-1000) 877.91	(2.5-5.25) 3.52	(10-18.75) 13.08	(25-37.5) 29.86	(4.5-7) 6.05	(8.5-11) 10.22	(80-112.5) 98.33	(10-13.75) 11.38	(12.5-33.75) 27.22	-
M.picta	(487.5-550) 530.5	(2.25-3.75) 2.83	(13.75-23.75) 17.91	-	-	(15-21.25) 19.83	(27.5-2.5) 34.86	(6.25-10.25) 7.80	(25-40) 34.61	(137.5-210) 164.16
M.recurva	(875-636) 752.77		-	-	-	(25-53.75) 42.62	-	(11.25-16.25) 13.54	(137.5-250) 208.08	-

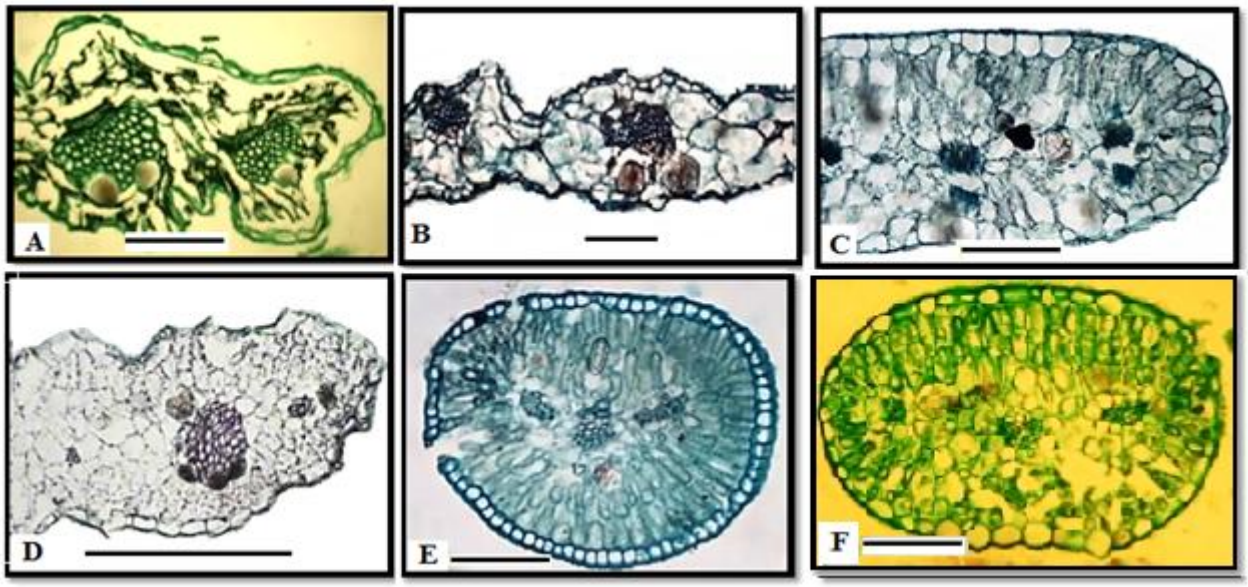


Figure -5: Tranverse section of leaf lamina and midrib(scale 50 um)
A- M.juniperina **B-** ***M.hamata*** **C-** ***M.hybrida*** **D-** ***M.intermedia*** **E-** ***M.picta*** **F-** ***M.hybrida*** **subsp.*turcica***

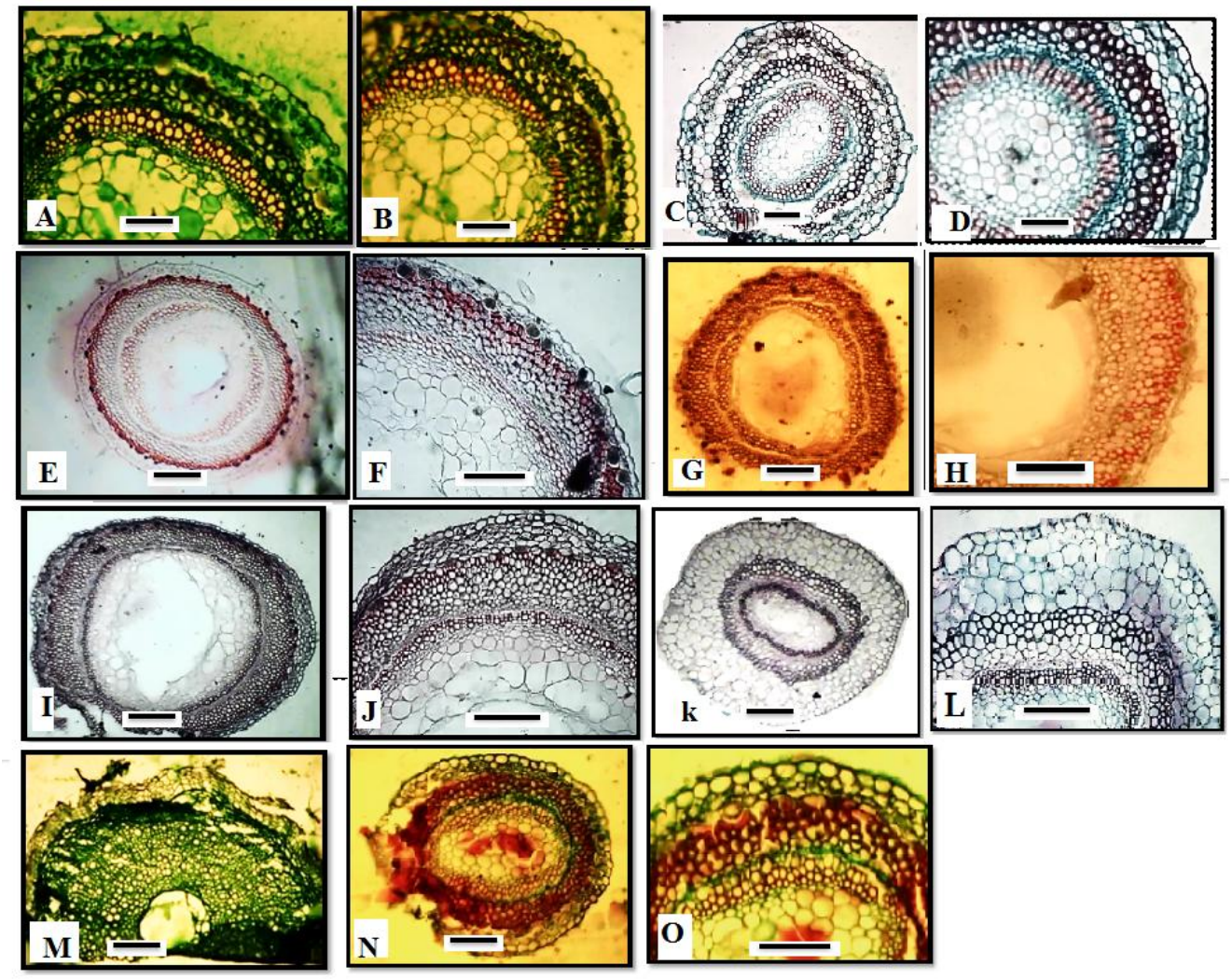


Figure- 6: Tranverse section of stem(scale 100 um)
A,B- ***M.hamata*** **C,D-** ***M.hybrida*** **subsp.*hybrida*** **E,F-** ***M.intermedia*** **G,H-** ***M.meyeri*** **I,J-** ***M.montana***
K,L- ***M.picta*** **M-** ***M. recurva*** **N,O -** ***M.hybrida*** **subsp.*turcica***

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