



Anatomical characters used to delimit species of some genera of Brassicaceae in Iraq.

Sahar A. A. Malik Al-Saadi¹, Karzan Omer Qader² & Heyder Uthman Fetah²

¹Basrah University, College of Science, Department of Biology

²Sulaimani University, College of Science, Department of Biology.

E-mail: karzanqader65@gmail.com

Article info	Abstract
Original: 12 January 2019 Revised: 15 April 2019 Accepted: 21 May 2019 Published online: 20 June 2019 Key Words: Epidermis, Brassicaceae, Trichomes, Stomata.	<p>The anatomical characters of the leaf epidermal cells and trichomes of 13 species of Brassicaceae family were studied by light and scanning electron microscopy. The results showed cell walls thicker in <i>Cheiranthus cheiri</i>, <i>Camelina rumelica</i>, <i>Biscutella didyma</i>; and also, in lower epidermis of <i>Crambe orientalis</i>. While they were thin in <i>Calepina irregularis</i>, <i>Lobularia maritima</i>, <i>Nasturtium officinale</i> and <i>Thlaspi perfoliatum</i>. Cells of upper epidermis were with strongly undulate anticlinal cell walls in <i>Capsella bursa-pastoris</i>, <i>Draba bruniifolia</i>, <i>Nasturtium officinale</i> and <i>Sameraria stylophora</i>. Cells were with sinuous anticlinal walls in <i>Calepina irregularis</i>, <i>Cheiranthus cheiri</i> and <i>Biscutella didyma</i>. There were straight-sinuate anticlinal cell walls in the rest of the species studied.</p> <p>Five types of stomatal complex were found: 1. Anisocytic (Cruciferous), 2. Anomocytic (Rununculaceous), 3. Hemiparacytic, 4. Paracytic, in <i>Cheiranthus cheiri</i>, <i>Crambe orientalis</i>, <i>Nasturtium officinale</i>, <i>Cardaria draba</i> subsp. <i>draba</i> and <i>Thlaspi perfoliatum</i>, and 5. Tetracytic in <i>Cardaria draba</i> and <i>Thlaspi perfoliatum</i>. The highest Stomatal index percent was 36.4% on the abaxial surface of <i>Cheiranthus cheiri</i>, and the lowest 7.81% in abaxial of <i>Draba bruniifolia</i>.</p> <p>Eight trichome types are distinguished: Simple, T-shaped, Y-shaped, V-shaped, Vesiculate, Clavate, Dendroid, Stellate and Long membranous. In addition, glabrous species also were found.</p>

Introduction

Brassicaceae is one of the largest families of Angiosperms including 350-571 genera and 2000-3350 species. It is distributed in temperate regions of the northern hemisphere [1- 3]. About 80 genera and more than 177 species are distributed in most regions of Iraq [4]. Many of the Brassicaceae species are economically important crops and some of them are ornamentals [5].

In previous studies on anatomy of Brassicaceae Metcalfe and Chalk [6] mentioned that some of them contain nonglandular, unicellular, bicellular and multicellular, unbranched or branched trichomes. But glandular trichomes are rare. T-shaped or star-shaped also are found. Stomata commonly are anisocytic [7-9]. Orcan and Binzet [10] reported leaves of *Alyssum obtusifolium* with anisocytic stomata, with both surfaces covered with stellate hairs. Abdel Khalik [9] recorded glandular and non-glandular trichomes in 82 species of this family. Sun and Li [11]; and Ahmad *et al.* [12] recorded stomata in both epidermises, and the types mainly anisocytic, occasionally paracytic and rarely anomocytic. They distinguished polygonal epidermal cells with sinuous or straight cell walls. Cansaran *et al.* [13] described morphology and anatomy of *Erysimum amasianum*. Gostin [14] studied *Erysimum wittmanii* ssp. *wittmanii* and reported anisocytic stomata on both sides of leaf epidermis. Three-armed trichomes, rarely 2-armed, with thick, warty cell walls

are also present. Tuo and Zhou [15] reported shapes of leaf epidermal cells of 3 species of *Isatis* and 5 singles genera of Euclidieae as usually polygonal or irregular and stomata mainly anisocytic, rarely anomocytic.

Stomatal observations of 34 Brassicaceae species in Saudi Arabia [16] reported thin or thick anticlinal cell walls, with straight or sinuous, smooth or warty cuticle. Based on these epidermal characteristics they divided the species into four groups according to presence or absence of nonglandular trichomes. In a comparative anatomy of stems and leaves of *Ricotia* species growing in Turkey, Selvi and Paksoy [17] calculated stomatal index rate, leaf epidermal characteristics and presence or absence of trichomes.

Our work aims to study in detail the anatomical features by using epidermal characteristics in leaves of 13 Brassicaceae species growing in Iraq, the study including leaf epidermal features like epidermal cells, stomata and trichomes to delimit the species within the genera of Brassicaceae.

Materials and methods

In the present study, 13 taxa of the family have been investigated. Fresh material of leaves was collected from the northern region of Iraq in MRO and MSU district, during 2017-2018, fixed for 48 hours in formalin-acetic acid-alcohol solution, FAA and preserved in 70% alcohol. The cuticles and epidermal preparations were done by macerating the leaves in Jeffrey's solution (equal parts of 10% chromium trioxide solution and concentrated nitric acid), and thereafter mounted in safranin-stained glycerin jelly.

Epidermal characters were examined by Olympus CH4 light and scanning electron microscopes; and photographed with Digital camera type DCE-2. Anatomical terms are cited from [18-20].

Stomatal index was found using the formula mentioned in [19], as follows:

$$\text{Stomatal index (\%)} = \frac{\text{number of stomata}}{\text{number of stomata} + \text{number of epidermal cells}} \times 100$$

The numbers of stomata and epidermal cells were counted in microscopic view fields for both surfaces of leaves.

Results and Discussion

Epidermal cells

Features and measurements of epidermal cells are summarized in (Figures 1-3 and Table 1). 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 epidermal cells of upper and lower leaf surfaces are polygonal, isodiametric or elongated in all species under investigation. The cell walls are thicker in *Cheiranthus cheiri*, *Camelina rumelica*, *Biscutella didyma* and lower epidermis of *Crambe orientalis*. They were thin in *Calepina irregularis*, *Lobularia maritima*, *Nasturtium officinale* and *Thlaspi perfoliatum* (Fig. 1,2).

The anticlinal cell walls of upper epidermis appeared strongly undulate in *Calepina irregularis*, *Draba bruniifolia*, *Nasturtium officinale* and *Sameraria stylophora*. Cells with sinuous anticlinal walls in *Capsella bursa-pastoris*, *Cheiranthus cheiri* and *Biscutella didyma* were seen. There were straight-sinuate anticlinal cell walls in the rest of the species (Figures 1,2).

Lower epidermal cells were with strongly undulate anticlinal walls in most of the studied species, but it was straight-sinuate in *Calepina irregularis*, *Lobularia maritima*, *Crambe orientalis*, *Cardaria draba* subsp. *draba*, *Cheiranthus cheiri* and *Sameraria stylophora*.

The average length of epidermal cells in the adaxial surface ranged between 38.25 μm in *Draba bruniifolia* and 177.08 μm in *Thlaspi perfoliatum*. In the abaxial surface the average length ranged between 35.75 μm in *Cheiranthus cheiri* and 188.22 μm in *Lobularia maritima* (Table 1).

Numbers of epidermal cells recorded on the upper epidermis ranged between 420 cells/mm² in *Lobularia maritima* and 1920.83 cells/mm² in *Nasturtium officinale*. On the lower epidermis they ranged between 361 cells/mm² in *Lobularia maritima* and 1665 cells/mm² in *Sinapis alba* (Table 1). Scanning electron microscope showed that stomata of most species were sunken, and the surface of epidermis had thick cuticle (Figure 3).

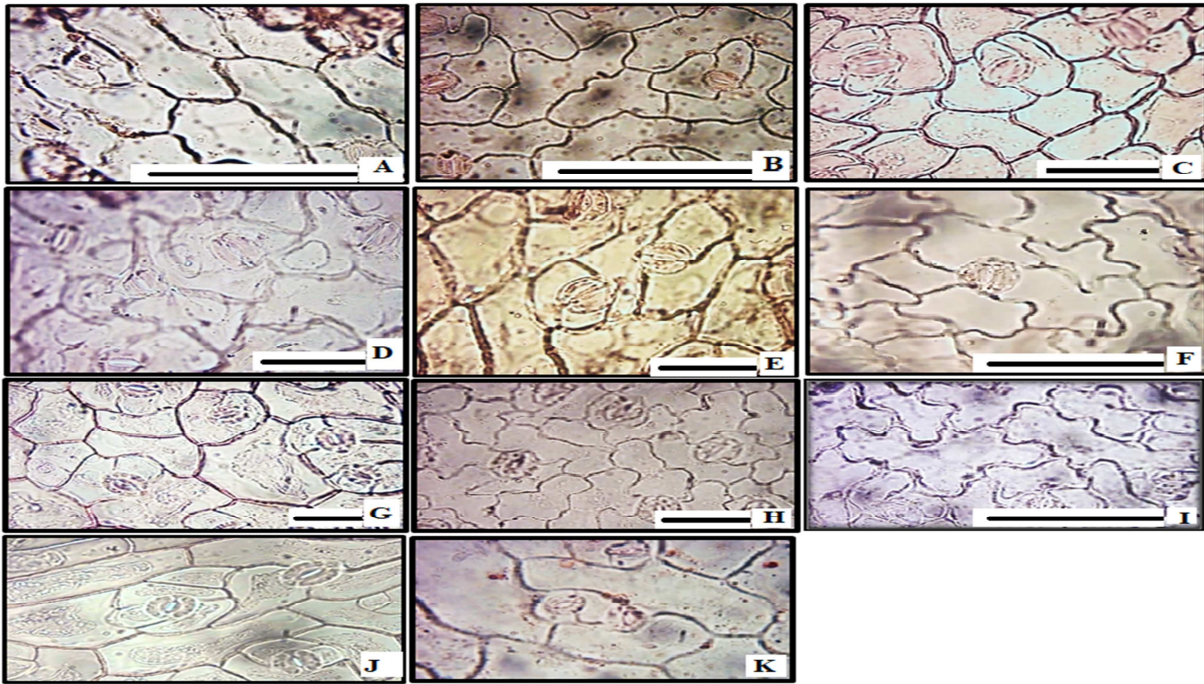


Figure 1. The upper surface of the leaves (Scale 50 μm): A. *Capsella bursa-pastoris*. B. *Calepina irregulare*. C. *Cardaria draba* subsp. *draba*. D. *Camelina rumelica*. E. *Crambe orientalis*. F. *Draba bruniifolia*. G. *Lobularia maritima*. H. *Nasturtium officinale*. I. *Sameraria stylophora*. J. *Sinapis alba*. K. *Thlaspi perfoliatum*.

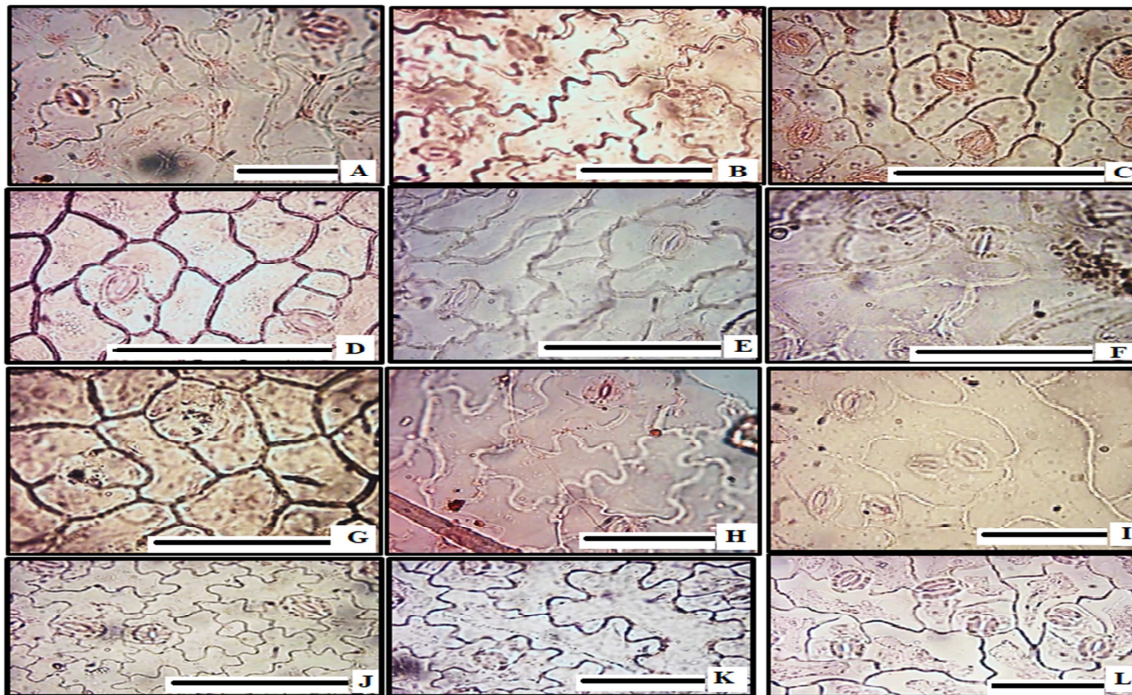


Figure 2. The Lower surface of the leaves (Scale 50 μm): A. *Biscutella didyma*. B. *Capsella bursa-pastoris*. C. *Calepina irregulari*. D. *Cardaria draba* subsp. *draba*. E. *Camelina rumelica*. F. *Cheiranthus cheiri*. G. *Crambe orientalis*. H. *Draba bruniifolia*. I. *Lobularia maritima*. J. *Nasturtium officinale*. K. *Sameraria stylophora*. L. *Sinapis alba*.

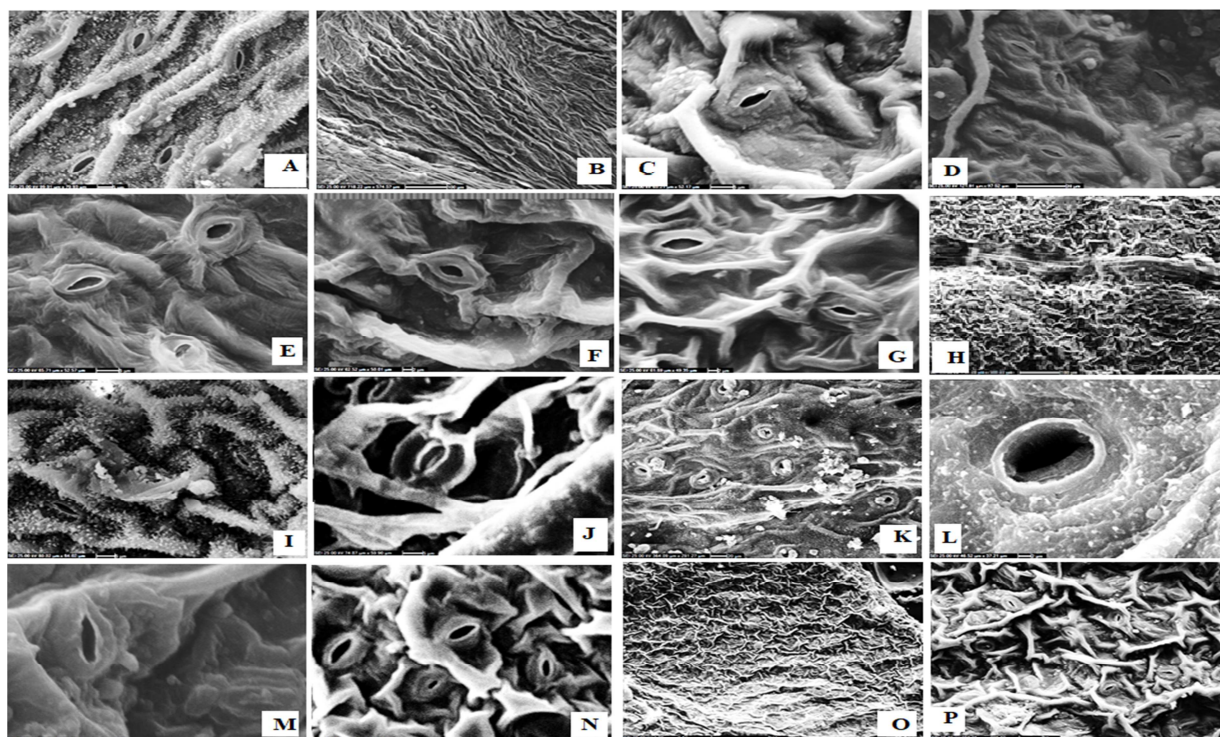


Figure 3. Electromicrographs of leaf surfaces : A, B. *Cheiranthus cheiri*. C, D. *Cardaria draba* subsp. *draba*. E, F. *Sameraria stylophora*. G. *Capsella bursa-pastoris*. H, I. *Draba bruniifolia*. J. *Lobularia maritima*. K, L. *Crambe orientalis*. M. *Thlaspi perfoliatum*. N. *Nasturtium officinale*. O, P. *Sinapis alba*.

Stomatal Complexes

There are five types of stomatal complex: anisocytic (cruciferous); anomocytic (rununculaceous); hemiparacytic; paracytic in *Cheiranthus cheiri*, *Crambe orientalis*, *Nasturtium officinale*, *Cardaria draba* and *Thlaspi perfoliatum*; and tetracytic in *Cardaria draba* and *Thlaspi perfoliatum*. They are commonly anisocytic in the leaf epidermises of all species but intermixed with anomocytic and hemiparacytic types (Figs. 1- 3). These results agreed with the findings of [6, 10-15]. Stomatal complex can be believed as a significant character in the identification of species. Stomata of round or elliptic shapes are present on either side of amphistomatic leaves, and often more numerous on the abaxial epidermis (Figures 1,2). Although in Brassicaceae the anisocytic type is dominant, other types are present in all taxa. Anomocytic and hemidiacytic types were found in most species (Figure 1-3). Guard cells are kidney-shaped. *Biscutella didyma*, *Calepina irregularis*, *Cardaria draba* and *Capsella bursa-pastoris* have some T-type shape. The shape of stomata differs between the species. It is circular in *Crambe orientalis*, *Sinapis alba* and *Cheiranthus cheiri*; circular-oblong in *Nasturtium officinale* and elliptic to elliptic-oblong in the rest.

The lengths of stomata on adaxial epidermis range between 19.05 μm in *Lobularia maritima* and 28.33 μm in *Nasturtium officinale*. On abaxial epidermis they were 19.1 μm in *L. maritima* and 27.5 μm in *Cheiranthus cheiri*. Number of stomata on adaxial epidermis ranged between 120 stomata/ mm^2 in *Capsella bursa-pastoris* and 361/ mm^2 in *Cheiranthus cheiri*. On the abaxial epidermis the range was 486 stomata/ mm^2 in *Sinapis alba*, and 100 stomata/ mm^2 in *Draba bruniifolia* (Table 1).

Stomatal index on the abaxial surface ranged from 7.81% in *Draba bruniifolia* to 36.4% in *Cheiranthus cheiri*. While on the adaxial surface they were 10.22% in *Crambe orientalis* and 35.32% in *Cheiranthus cheiri* (Table 1; Figure 4).

The differences in stomatal complex characters indicated the differentiation and adaptation to the ecological environments. Similarity in characters was found in most of the other species of Brassicaceae family [6, 11-13, 15].

Table 1. Measurements of cells, stomata and stomatal index.

Species	Cell dimensions (µm)				Stomata dimensions (µm)				No. / (mm) ² of:				Stomatal Index %	
	Upper epidermis		Lower epidermis		Upper epidermis		Lower epidermis		Epidermal cells		Stomata		Upper	Lower
	Length	Width	Length	Width	Length	Width	Length	Width	Upper	Lower	Upper	Lower		
<i>Biscutella didyma</i>	(62.5-125) 87.5	(15-30) 24.37	(60-130) 90.15	(15-41.22) 26.1	(20-30) 25.3	(20-25) 21.75	(20-26) 25.33	(18-27) 22.32	(720-1080) 850	(672-1130) 878	(120-210) 160	(110-254) 184	15.84	17.32
<i>Calepina irregularis</i>	(37.5-175) 90.42	(25-80) 45.82	(37.5-137.5) 92.61	(25-55) 33.33	(20-25) 23.32	(17.5-20) 19.1	(22.5-27.5) 24.57	(15-20) 17.42	(600-900) 720	(1440-7780) 980	(108-204) 156	(108-204) 300	17.8	21.73
<i>Camelina rumelica</i>	(37.5-100) 58.42	(22.5-55) 43.75	(25-75) 55.15	(17.5-55) 36.65	(22.5-27.5) 24.5	(22.5-27.5) 23.9	(22.5-27.5) 25.5	(17.5-22.5) 19.37	(570-732) 663	(600-1020) 822	(240-492) 328	(240-300) 270	33.09	24.72
<i>Capsella bursa-pastoris</i>	(40-100) 54.53	(10-35.5) 27.91	(37.5-150) 86.12	(27.5-62.5) 42.07	(22.5-27.5) 25.21	(17.5-22.5) 20.1	(22.5-30) 25.82	(15-20) 17.56	(600-1260) 984	(840-1200) 1009	(90-150) 120	(300-450) 385	10.86	27.61
<i>Cardaria draba subsp. draba</i>	(42.5-100) 58.32	(17.5-42.5) 26.25	(25-107.5) 53.55	(12.5-50) 38.75	(25-35) 26.25	(20-50) 27.5	(20-27.5) 22.5	(17.5-22.5) 20.32	(600-1200) 924	(720-1020) 900	(168-192) 184.52	(168-210) 186.23	16.64	17.14
<i>Cheiranthus cheiri</i>	(19-100) 50.12	(10-50) 32.22	(25-100) 35.75	(12.5-45) 34.10	(22-30) 25	(15-25) 20.12	(25-30) 27.50	(17.5-22.5) 20.75	(550-750) 661	(600-780) 681.42	(250-430) 361	(330-450) 390	35.32	36.4
<i>Crambe orientalis</i>	(27.5-75) 48.32	(25-45) 33.55	(30-50) 39.15	(25-62.5) 34.57	(15-30) 24.15	(17.5-30) 22.50	(23-30) 25.95	(17.5-22.5) 20.83	(1500-1800) 1659.96	(720-1260) 999.96	(192-252) 189.10	(270-372) 318.25	10.22	24.14
<i>Draba brunifolia</i>	(25-62.5) 38.25	(17.5-50) 31.75	(37.5-100) 64.50	(12.5-50) 29.37	(22.5-27.5) 24.15	(17.5-22.5) 20.20	(20-25) 22.50	(20-25) 21	(720-1080) 948	(1080-1320) 1180	(144-198) 177	(66-144) 100	15.73	7.81
<i>Lobularia maritima</i>	(25-287.5) 155.67	(40-87.5) 59.10	(75-301) 188.22	(30-101) 72.22	(17.5-25) 19.05	(20-25.5) 19	(15-25) 19.10	(15-26.5) 19.11	(360-480) 420	(350-525) 361	(132-180) 154	(150-220) 162	26.82	30.97
<i>Nasturtium officinale</i>	(187.5-25) 94.15	(20-37.5) 30.42	(47.5-112.5) 93.25	(20-62.5) 36.07	(25-32.5) 28.33	(17.5-27.5) 23.33	(22.5-37.5) 26.25	(12.5-25) 20.41	(1530-2700) 1920.83	(750-1200) 654.62	(330-660) 359.25	(240-276) 259.53	15.75	28.39
<i>Sameraria stylophora</i>	(55-162) 88.75	(25-62.5) 39.06	(37.5-150) 106.66	(35-125) 75.31	(17.5-25) 22.14	(17.5-25) 21.52	(20-30) 25.71	(15-22.5) 18.21	(520-650) 510	(560-1320) 622.50	(110-156) 101.11	(138-180) 158	16.54	20.24
<i>Sinapis alba</i>	(15-25) 23.75	(12.5-50) 40.75	(25-150) 80.67	(15-50) 37.12	(17.5-27.5) 20.92	(15-20) 17.08	(20-27.5) 21.55	(15-30) 18.5	(720-1080) 900	(960-2400) 1665	(360-480) 340	(450-470) 486	27.41	22.59
<i>Thlaspi perfoliatum</i>	(112.5-250) 177.08	(30-80) 56.78	(37.5-212.5) 112.23	(35.6-87.5) 60.35	(25-37.5) 27.65	(15-20) 18.33	(22.5-27.5) 25.31	(17.5-22.5) 19.64	(330-490) 486	(348-480) 403	(150-306) 178	(168-210) 175.50	26.8	30.33

Note: Each pair parentheses contains the least and most limits, followed by a mean value outside.

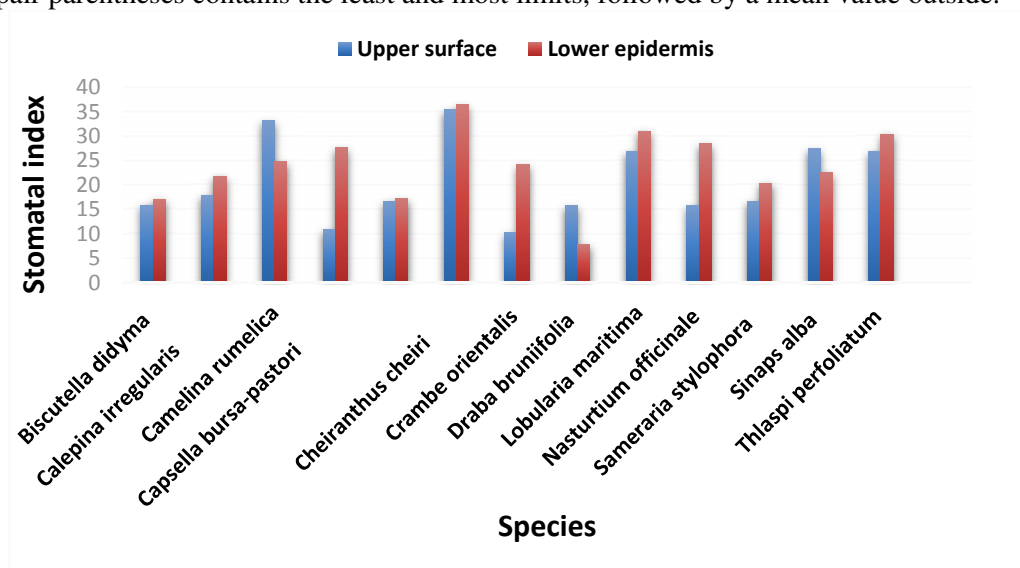


Figure (4) Stomatal index in some species if Brassicaceae. Note: The 5th bar is of *Cardaria draba draba*.

Trichomes

The observations of this study showed that trichomes on leaves are mostly sessile or stalked. Eight types of trichomes can be recognized: Simple, T-shaped, Y-shaped, V-shaped, clavate, dendroid, stellate and long membranous. Simple hairs were found in most Brassicaceae species, in addition to some glabrous. All shapes of trichomes found are imaged in (Figures 5-7). Shapes of trichomes provide important diagnostic characters for species. The results showed that two species were glabrous, namely *Calepina irregularis* and *Crambe orientalis*. *Biscutella didyma* showed two types of trichomes, a simple hair straight or curved and a vesiculate (Figure 5A, B), the vesiculate type same as that found in *Sisymbrium runcinatum* [9].

Simple hairs were observed in *Sinapis alba*, but their bases contained collars or straps surrounding the hairs. Trichomes of *Nasturtium officinale* were simple with swollen bases. Long membranous hairs and unicellular short simple ones were observed in *Capsella bursa-pastoris*, *Cardaria draba* and *Camelina rumelica*. Some species had more than two types of trichomes. In *Lobularia maritima* the trichomes were recognized as simple of two types, long membranous with small warts, and stellate sessile trichomes with 3 branches, each branch two-armed, and warty.

Draba bruniifolia contains six types of trichomes: simple hairs, straight or curved; long membranous simple hairs; Y-shaped; dendrite; clavate and stellate stalked trichomes. Clavate trichomes also were observed in *Cheiranthus cheiri*. *Thlaspi perfoliatum* showed dendrite, stellate stalked and Y-shaped trichomes. V-shaped and T-shaped with smooth cell walls occurred only in *Camelina rumelica* along with stalked stellate type (Figure 6).

Glandular trichomes were not observed in any leaf epidermis of all the species studied (Figures 5-7). Metcalfe and Chalk [6] reported the trichomes in Brassicaceae as variable in form, but they were unicellular and very rarely glandular in [9]. But the present study did not agree with Abdel Khalik [9] in that *Nasturtium officinale* was glabrous. Here it is assured that *Nasturtium officinale* does contain simple hairs. Scanning electron microscopy (SEM) of leaf trichomes showed that there are warty cell walls in *Sameraria stylophora*, *Sinapis alba* and *Nasturtium officinale*. They are smooth in *Lobularia maritima* (Figure 7).

Conclusion

The thirteen taxa belonging to Brassicaceae in different locations of Iraq were recognized as different groups based on epidermal, stomatal and trichome characters, and as two groups according to presence or absence of glandular trichomes. In the present study, nonglandular, unicellular, unbranched trichomes were observed in the leaf epidermis of 9 species. They had variable forms: thick warty cell walls in *Biscutella didyma*, *Sameraria stylophora* and *Cardaria draba* subsp.*draba*; thin warty cell walls in *Nasturtium officinale* and *Sinapis alba*; and thin smooth cell walls in *Capsella bursa-pastoris* and *Camelina rumelica*. Similar results were reported by [6] and [8]. Same trichomes were found in other species of Brassicaceae [9], [16], and [21, 22]. As well as this study supported with other studies on family Brassicaceae [23] and [24].

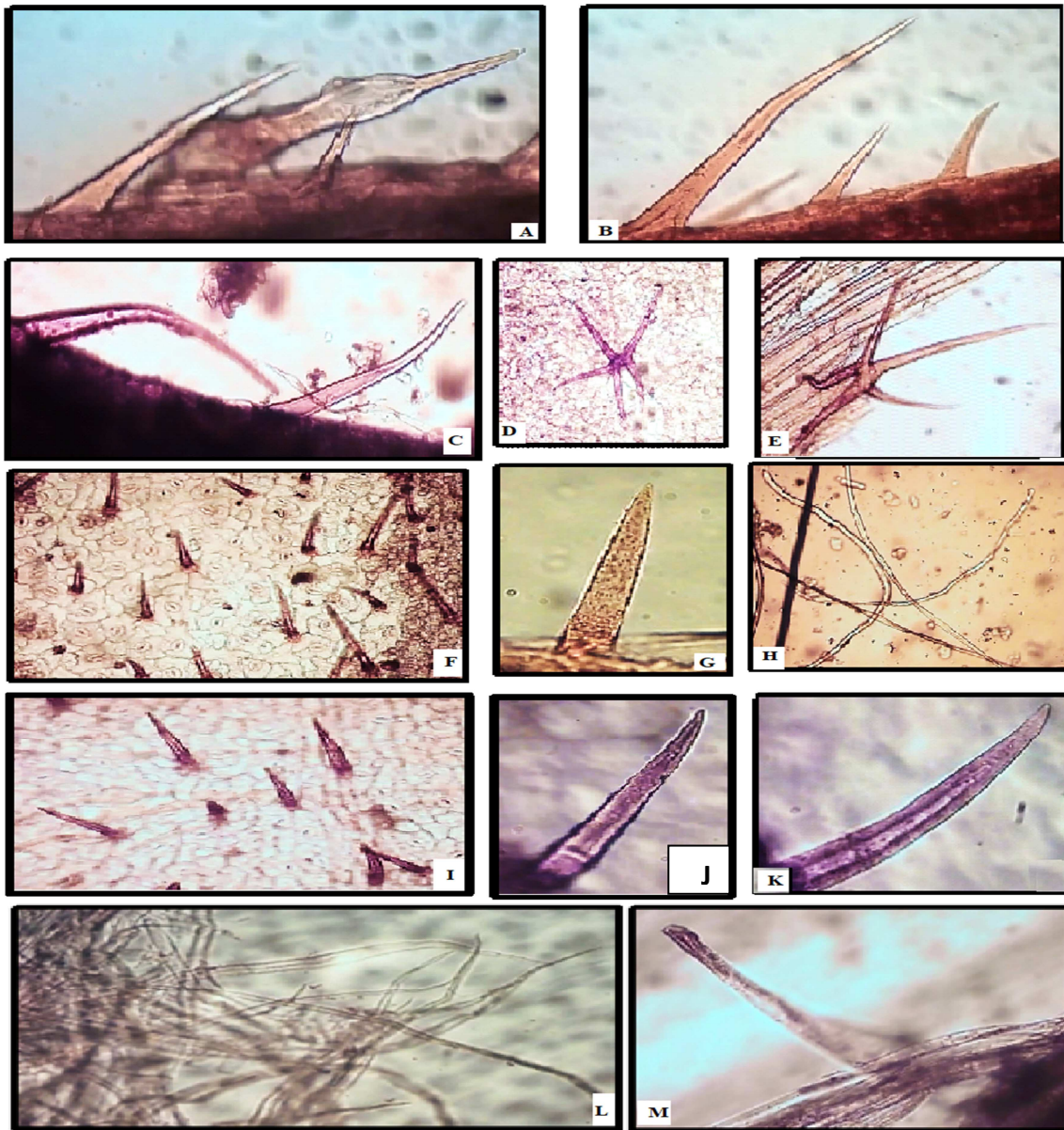


Figure 5. Trichomes: A, B. *Biscutella didyma*. C-E. *Capsella bursa-pastoris*. F- K. *Cardaria draba* subsp. *draba*. L, M. *Cheiranthus cheiri*.

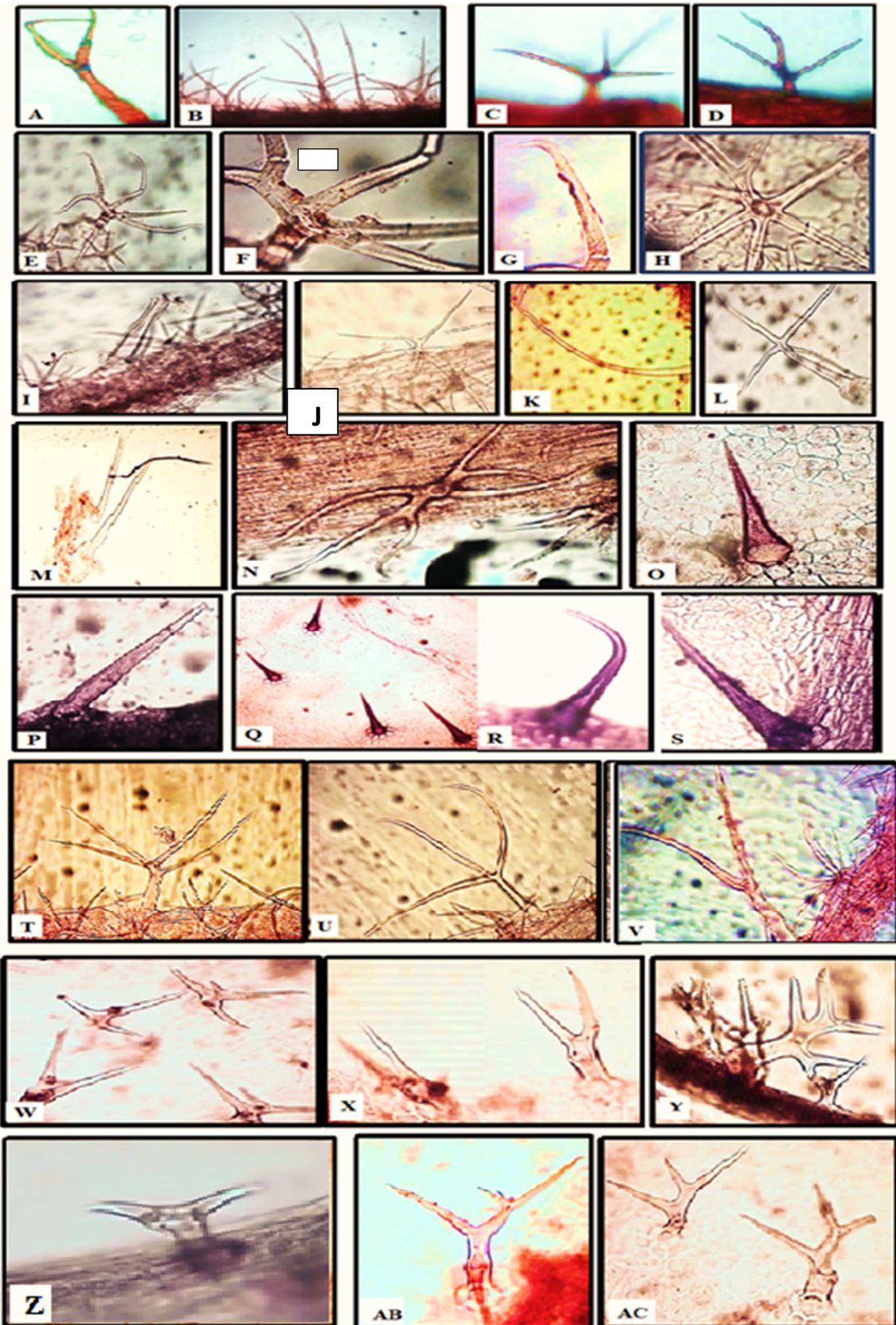


Figure 6. Trichomes: A-L: *Draba bruniifolia*. M-O: *Lobularia maritima*. P: *Nasturtium officinale*. Q-S: *Sinapis alba*. T-V: *Thlaspi perfoliatum*. W-AC: *Camelina rumelica*.

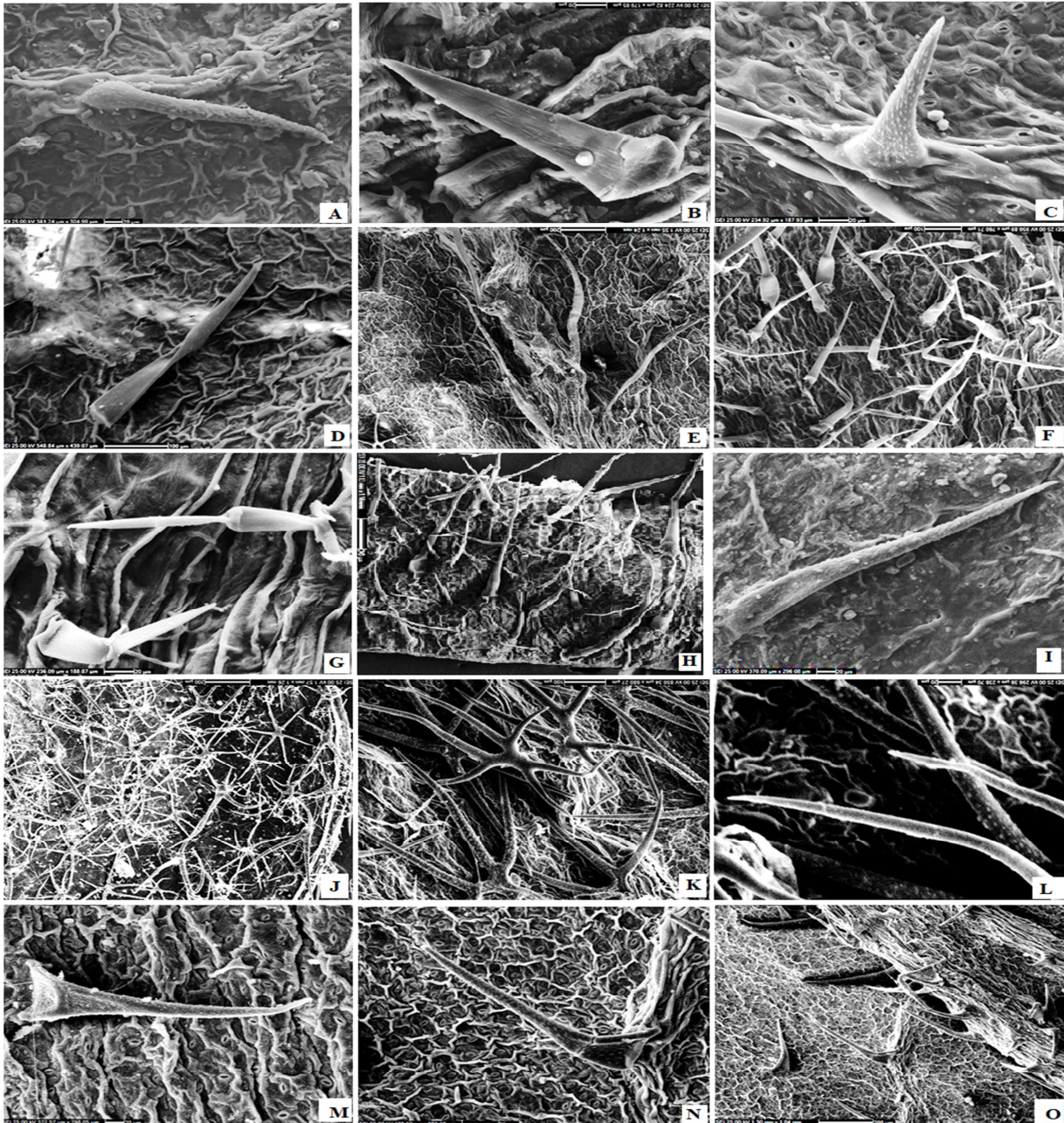


Figure 7. SEM of epidermis: A. *Biscutella didyma*. B,C. *Sameraria stylophora*. D, E. *Capsella bursa-pastoris*. F-H. *Camelina rumelica*. I. *Nasturtium officinale*. J-L. *Lobularia maritima*. M-O. *Sinapis alba*.

References

- [1] V. H. Heywood, "Flowering plants of the world". Oxford. Uni. Press: pp. 119- 122. (1978).
- [2] A. Perveen, M. Qaiser, and R. Khan. "Pollen flora of Pakistan XLII. Brassicaceae". Pak. J. Bot., Vol. 36, No. 4, pp. 683-700. (2004).
- [3] S. I. Warwick, A. Francis and I. A. Al-Shehbaz, "Brassicaceae: species", (2006).
- [4] C. C. Townsend and E. Guest. "Flora of Iraq". Vol.4, part 2. Iraqi Ministry of Agriculture & Kew Botanical Gardens, UK. (1980).
- [5] I. A. Al-Shehbaz, M. A. Beilstein and E. A. Kellogg. "Systematics and phylogeny of the Brassicaceae (Cruciferae): an overview". Plant. Syst. Evol. Vol. 259, pp. 89-120. (2006).
- [6] C. R. Metcalfe and L. Chalk . "Anatomy of Dicotyledon". Clarendon Press, Oxford, Vol. 2, 724 pp. (1950).
- [7] E. Dennert. "Beiträge zur vergleichenden anatomie des Laubstengels der Cruciferen", Marburg. (1884).

- [8] J. A. Inamdar and N. V. Rao. "Light and scanning electron microscopic studies on trichomes of some Brassicaceae". Feddes Rep. Vol. 94, pp. 183-190. (1983).
- [9] K. Abdel Khalik. "Morphological studies on trichomes of Brassicaceae in Egypt and taxonomic significance", Acta. Bot. Croat, Vol. 64, No. 1, pp. 57-73. (2005).
- [10] N. Orcan and R. Binzet. "The Anatomical and palynological properties of *Alyssum obtusifolium* Steven ex D. C. (Brassicaceae)". Turk. J. Bot. Vol. 27, pp. 63-68. (2003).
- [11] Z. Y. Sun and F. Z. Li. "Studies on the leaf epidermal features of *Lepidium* (Brassicaceae) from China. *Zhongyaocai*". Journal Of Chinese Medicinal Materials, Vol. 30, No. 7, pp. 780-785. (2007).
- [12] K. Ahmad, M. A. Khan, S. Ahmad and N. A. Nazir. "Taxonomic diversity in epidermal cells of some sub-tropical plant species". Int. Agric. Biol. Vol. 12, pp. 115-118. (2010).
- [13] A. Cansaran, O. E. Akcin and N. Kandemir. "A study on the morphology, anatomy and autecology of *Erysimum amasianum* Hausskn. & Bornm. (Brassicaceae) distributed in central black sea region (Amasya – Turkey)". In. J. Sc. Tec. Vol. 1, pp. 13-24. (2007).
- [14] I. N. Gostin. "Anatomical and micro-morphological particularities of vegetative organs in endemic *Erysimum wittmanii* Zaw. ssp. *wittmanii*". Tom. XVI: pp. 74-79. (2009).
- [15] Z. Tuo and G. Zhou. "Micromorphologic characteristics of leaf epidermis of eight species in Brassicaceae (Cruciferae)". Journal of Xinjiang Agricultural University. Vol. 1. (2010).
- [16] A. Doaigey, I. El-Habashy, A. Al-Watban, A. Milagy, A. Al Sahli, M. Siddiqui, M. Al-Whaibi and M. El-Zaidy. "Epidermal characteristics of 34 species of Brassicaceae growing in deserts of Saudi Arabia". Wulfenia Journal. Vol. 20, No. 9, pp. 22-221. (2013).
- [17] S. Selvi and M. Y. Paksoy. "Comparative anatomy of stem and leaf of *Ricotia* L. growing in Turkey". Bangladesh J. Bot. Vol. 42, No. 1, pp. 123-130. (2013).
- [18] A. E. Radford, W. C. Dikison, J. R. Massey, and C. R. Bell. "Vascular Plants Systematics", Harper and Row, New York. (1974).
- [19] D. L. Ditcher. "Approaches to the identification of angiosperm Leaf remains", Botanical Review, Vol. 4, No. 1, pp. 1-157.(1974).
- [20] K. Esau. "Plant Anatomy". 2nd ed. Wiley Eastern Limited, New Delhi, Calcutta, Madras: 767 pp. (1965).
- [21] M. Ancev and V. Goranova. "Trichome morphology of eleven genera of the tribe Alysseae (Brassicaceae) occurring in Bulgaria". Willdenowia Vol. 36, pp. 193-204. (2006).
- [22] A. Mousavi, and J. S. Rad. "Anatomical, palynological and micromorphological study of seed, trichome and stomata of *Cardaria draba* L. Desv. (Brassicaceae) in Sistan, Iran". Int. J. Biosci. Vol. 5, No. 11, pp. 63-69. (2014).
- [23] K.R. Qader. "Taxonomic Significance of anatomical characters in some species of Brassicaceae family in Iraq". J.Thi-Qar Sci. Vol. 6, No. 2, pp. 77-83. (2018).
- [24] S. S. Albermani, A. Albermani, and H. J. Altameme. "Systematic study of the genus *Nasturtium* R. Br (Brassicaceae) in Iraq". Journal of Chemical and Pharmaceutical Sciences. Vol. 10, No. 1, pp. 352-358. (2017).