

ANATOMICAL STUDY OF SOME SPECIES BELONGING TO THE PAPAVERACEAE FAMILY IN NORTH OF IRAQ

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Received Date: 23 May 2019; Accepted Date: 29 July 2019; Published Date: 26 December 2019

ABSTRACT

The anatomical features of leaves and stems of seven species belonging to five genera of the Papaveraceae family were studied, including: *Fumaria bracteosa* Pomel, 1875; *Glaucium grandiflorum* Boissier & A. Huet, 1856; *Hypecoum pendulum* Linnaeus, 1753; *Papaver fugax* Poiret, 1804; *Papaver macrostomum* Boissier & A. Huet, 1867; *Papaver rhoeas* Linnaeus, 1753 and *Roemeria refracta* de Candolle, 1821. The results showed that the anticlinal cell walls of the adaxial surface were more thickened in *P. fugax*, *H. pendulum*, *P. macrostomum* and *R. refracta*, while it was thin in *P. rhoeas*. The current investigation finds three types of the stomata (i.e., anomocytic, paracytic and hemiparacytic), and the number of stomata on the adaxial epidermis ranged between 22.11 stomata/mm² in *P. rhoeas* and 69.30 stomata/mm² in *P. fugax*; the stomatal index percentage on the adaxial surface was 15.04% in *P. macrostomum* and 4.14% in *P. rhoeas*.

The type of the mesophyll was bifacial (dorsiventral) in structure for the species. Stems gave a good character in separation of the species; shape and size of cortex cells, and the numbers of cortex layers were taxonomically significant. The observations of this study showed six types of trichomes that were non-glandular biserial, triserial or multiserial, unicellular with multicellular short hairs and finally uniseriate long hairs (in *G. grandiflorum*). *P. rhoeas* recognized by found glandular short hairs.

Keywords: Anatomical study, Leaf, North of Iraq, Papaveraceae, Stem.

INTRODUCTION

Papaveraceae (poppy family) is one of the families of Angiosperm and includes 26 - 42 genera and 690 - 800 species in the world (Judd *et al.*, 1999). It is widely distributed in the temperate and subtropical regions of the world, especially the Mediterranean, western, central and eastern Asia and south western parts of America, India, middle Europe and south areas of Scandinavia and Great Britain (Sans *et al.*, 2006; Takhtajan, 2009; Björk, 2019). The Papaveraceae family is divided into four subfamilies based upon critical details of the floral morphology and fruit characteristics. Papaveroideae is the largest subfamily, and *Papaver* is the largest genus within the family (Brezinova *et al.*, 2009). Numerous species of the family

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are valuable ornamentals and pharmaceutically important plants (Sans *et al.*, 2006; Brezinova *et al.*, 2009; Oh *et al.*, 2018).

Previous studies regarding the anatomy of Papaveraceae have been completed by Solereder (1908), Dickson (1935), Metcalfe and Chalk (1950), and the anatomical characteristics of *P. somniferum* Linnaeus (1753) have been investigated by Dickinson and Fairbairn (1975). Furthermore, the anatomical structure of leaves, fruits and laticifers was studied by Esau (1977), Fahn (1990), Batanouny (1992), while Carlquist and Hoekman (1985) studied the anatomical structure of wood in *Romneya* and *Dendromecon*. In addition, the structure of wood in Papaveraceae has been reported by Carlquist and Zona (1988).

Anatomical characteristics of fruits leaves and stems of some species of Papaveraceae studied by Nessler (1992), Azizian and Norani (1997), Lujan *et al.* (2004), Bercu *et al.* (2006), Goetz *et al.* (2009) Rahmatpour *et al.* (2010), (Gupta and Rao, 2012). While some researchers have described morphological and anatomical characteristics of the genera *Fumaria*, *Glaucium* and species of *P. rhoeas* (Rajopadhye and Upadhye, 2011; Bercu, 2012; Lack, 2019; Kilic *et al.*, 2019; Tavakkoli and Assadi, 2019).

The present study aimed to investigate the anatomical characteristics of epidermal surfaces, leaves and stems of seven species of the family Papaveraceae that grow in Iraq, which may be useful in the identification of the species under study.

MATERIALS AND METHODS

In the present study, seven taxa of the Papaveraceae family have been investigated; eight plant specimens from each species were collected from the northern region of Iraq of Sharbazher, Mountain Sulaymaniyah district (MSU), from May 2017 to July 2017. The epidermis was prepared by macerating the leaves in Jeffrey's solution (equal parts of 10% chromium trioxide solution and concentrated nitric acid) and then stained by safranin-glycerin jelly dye. For sectioning, the fresh material of leaves and stems were fixed at least 48 hours in FAA (Formalin- acetic acid- 70% ethyl alcohol, 5:5: 90 ml) and preserved in 70% alcohol, then dehydrated in ethyl alcohol series (70 , 80, 90, 95 and 100 %) and put in paraffin. The samples were sectioned on a rotary microtome and stained by safranin prepared by mixed 1 g from safranin in 100 ml distal water and fast green, which was prepared by mixed 1 g from fast green melted with absolute alcohol, the samples clearing with xylene and then mounted by Canada balsam (Johansen, 1940).

The epidermis characteristics of the samples were examined using a scanning electron microscope. In addition, a light microscope (Olympus CH4) was used, and photographs were taken using a digital camera (type DCE-2). Stomatal index was calculated according to Ditcher (1974). The anatomical terms have been taken from (Radford *et al.*, 1974; Ditcher, 1974). Data of stomatal index for species are presented in Table (1).

RESULTS AND DISCUSSION

The Epidermis

There are usually differences in epidermal cell shapes and dimensions between the adaxial and abaxial surfaces of the leaf as well as among the studied species. The epidermal cells of upper and lower epidermis of leaves are polygonal, oblong, irregular and semi-circular in all species studied. The anticlinal cell walls in the adaxial surface were thicker in *P. fugax*, *H. pendulum*, *P. macrostomum* and *R. refracta*, while it was thin in *P. rhoeas*. The results also showed that the anticlinal cell walls of the abaxial surface were sinuate-strongly undulate in

R. refracta and *P. rhoeas*, and straight – sinuate in the other species. In adaxial surface the anticlinal cell walls were straight – sinuate in most of the species, while it was slightly undulate in *P. rhoeas* (Tab. 1, Pls. 1, 3).

The average of epidermal cells length in the adaxial surface ranged between 154.16 μm in *R. refracta* and 31.73 μm in *P. rhoeas*, while in the abaxial surface, it's ranged between 92.66 μm in *R. refracta* and 66.87 μm in *G. grandiflorum*. A large number of epidermal cells is often recorded on the upper epidermis, ranging between 550.33 cells/ mm^2 in *R. refracta* and 330.41 cells/ mm^2 in *P. macrostomum*, while on the lower epidermis, it ranged between 580.10 cells/ mm^2 in *Papaver fugax* and 390.22 cells/ mm^2 in *R. refracta* (Tab. 1). Scanning electron microscope images showed that stomata were sunken in most of species, and the cuticle was thick in *R. refracta* (Pl. 3).

The guard cells are elliptic shaped on both surfaces (Amphistomatic leaves), and there are three types of stomata of the studied species:

- 1- Anomocytic type (ranunculaceous type): guard cells are surrounded by epidermis cells that have the same shape, size and arrangement.
- 2- Paracytic type: the stomata are surrounded by two subsidiary cells parallel to the of pore and guard cells (Pl.II).
- 3- Hemiparacytic type (Pls. 1-3); the stomata are surrounded by one subsidiary cell, its length parallel to the stoma opening.

Higher lengths of stomata on the adaxial and abaxial surfaces were recorded in *R. refracta*: 46.83 μm and 45.61 μm , respectively (Tab.1, Pls.1, 3). The number of stomata on the adaxial surface ranged between 69.30 stomata/ mm^2 in *Papaver fugax* and 22.11 stomata / mm^2 in *P. rhoeas*, while on the abaxial surface, it was 99 stomata/ mm^2 in *P. rhoeas* and 12 stomata/ mm^2 in *F. bracteausa* (Tab. 1).

Stomatal index percent on the adaxial surface was high in *P. macrostomum* (15.04%) and low in *P. rhoeas* (4.14%), while on the abaxial surface it was high (17.09%) in *P. rhoeas* and low in *P. fugax* (2.81%) (Tab.1); the differences in stomatal complex characteristics indicate differentiation and adaptation to ecological environments (Haraldson, 1978). The presence of epidermal cells with straight-curved anticlinal walls on both adaxial and abaxial surfaces in some species of *Glaucium* genus agrees with the current study (Tavakkoli, 2016).

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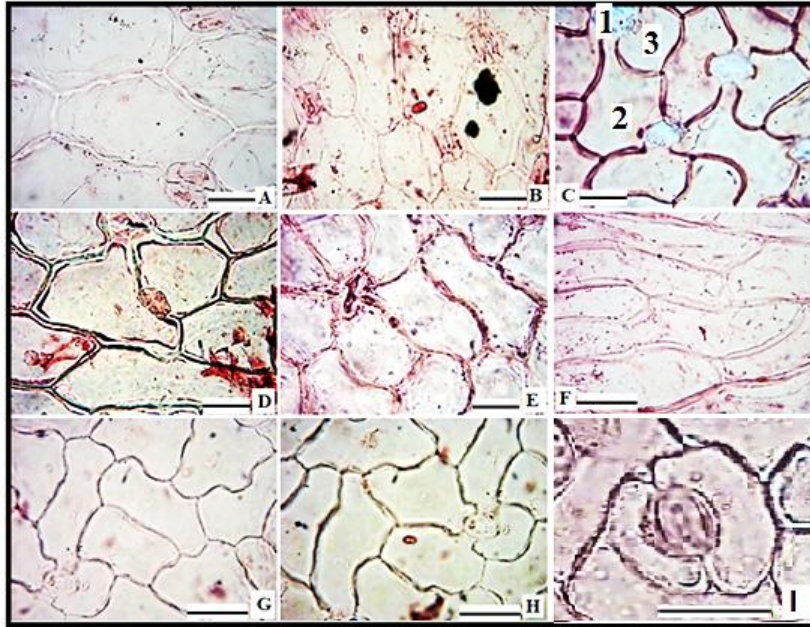


Plate (1): Stomatal complex in adaxial surface of the leaves of Papaveraceae species; (A) *G. grandiflorum*, (B) *H. pendulum*, (C) *P. fugax*, (D-E) *P. macrostomum*, (F) *R. refracta*, (G-H) *P. rhoeas*. (Scale bar 50 μ m).

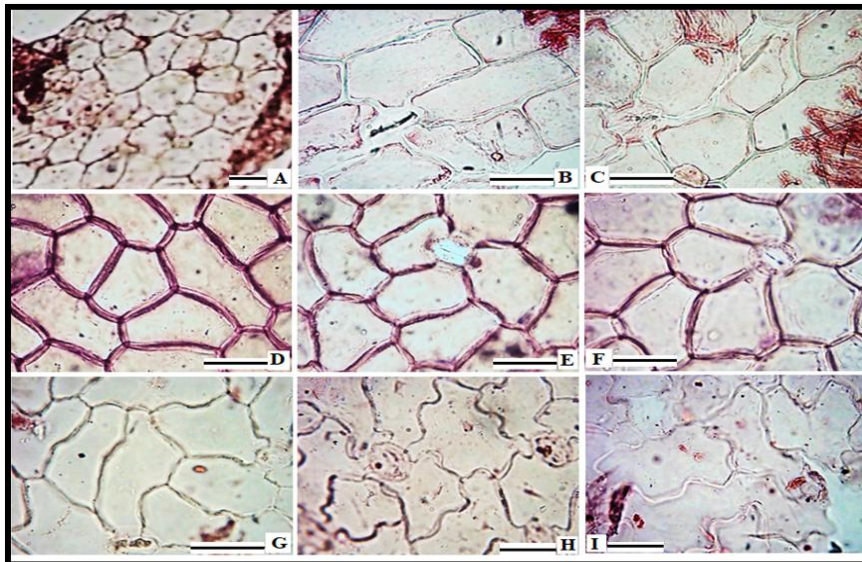


Plate (2): Stomatal complex in abaxial surface of the leaves of Papaveraceae species; (A) *G. grandiflorum*, (B) *H. pendulum*, (C) *P. macrostomum*, (D-F) *P. fugax*, (G-H) *P. rhoeas*, (I) *R. refracta*. (Scale bar: 50 μ m).

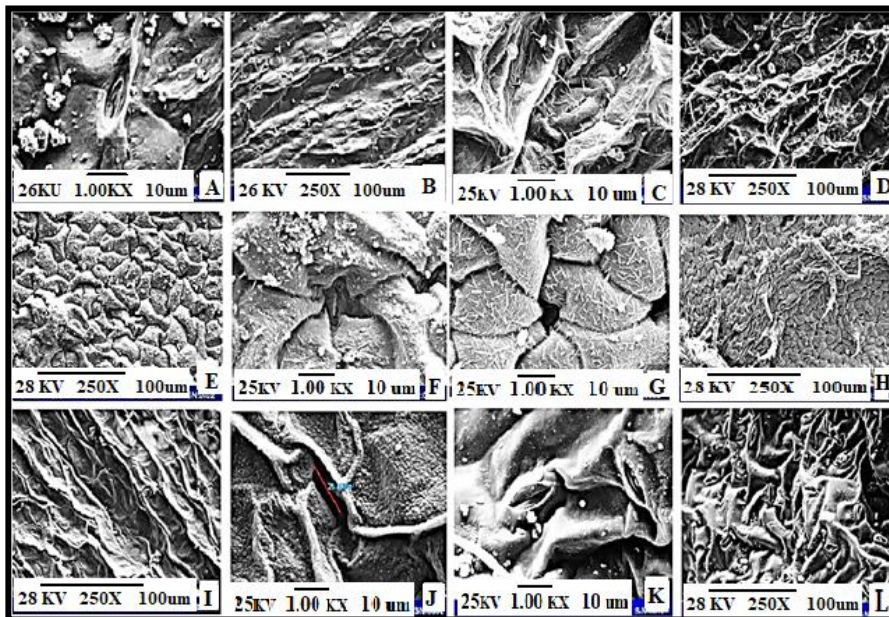


Plate (3): Electromicrographs of stomatal complex of the leaves of Papaveraceae species; (A, B) *G. grandiflorum*, (C, D) *F. bracteosa*, (E, F) *P. fugax*, (G, H) *P. macrostomum*, (I, J) *P. rhoeas*, (K, L) *R. refracta*.

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Table (1): Anatomical dimensions of epidermis in some species of Papaveraceae family.

Species	Epidermal cells (µm)				Guard cells(µm)				Number of Epidermis (µm ²)				Number of Stomata (µm ²)				Stomatal Index	
	Upper epidermis		Lower epidermis		Upper epidermis		Lower epidermis		Adaxial	Abaxial	Adaxial	Abaxial	Adaxial	Abaxial	Adaxial	Abaxial		
<i>F. bracteosa</i>	Length	Width	Length	Width	Length	Width	Length	Width	Adaxial	Abaxial	Adaxial	Abaxial	Adaxial	Abaxial	4.21	2.98		
	(87.5-250) *	(25-62.5)	(45-175)	(25-75)	(37.5-52)	(25-32.60)	(42.5-50)	(25-27.5)	(355-750)	(360-420)	(12-32)	(6-18)						
	154.16	39.37	92.66	43.12	46.83	29.16	45.61	25.83	550.33	390.22	24.22	12						
<i>G. grandiflorum</i>	Length	Width	Length	Width	Length	Width	Length	Width	Adaxial	Abaxial	Adaxial	Abaxial	Adaxial	Abaxial	10.79	11.53		
	(37.5-125)	(37.5-62.5)	(37.5-100)	(37.5-75)	(27.5-36.32)	(27.5-35)	(25-30)	(22.5-30)	(430-720)	(432-600)	(42-82)	(48-78)						
	87.62	52.91	66.87	47.85	33.51	32.66	27.5	25.62	540.23	502.09	65.40	64.80						
<i>H. pendulum</i>	Length	Width	Length	Width	Length	Width	Length	Width	Adaxial	Abaxial	Adaxial	Abaxial	Adaxial	Abaxial	5.59	5.93		
	(45-110)	(35-76)	(62.5-87.5)	(37.5-55)	(27.5-43)	(25-32.5)	(25-30)	(25-30)	(332-510)	(310-420)	(12-30)	(12-30)						
	85.12	54.36	75.12	43.33	32.18	29.63	28.33	26.66	390.10	396	23.10	20						
<i>P. fugeax</i>	Length	Width	Length	Width	Length	Width	Length	Width	Adaxial	Abaxial	Adaxial	Abaxial	Adaxial	Abaxial	11.91	2.81		
	(37.5-112.5)	(30-52.5)	(30-150)	(20-52.5)	(25-37.5)	(12.5-27.5)	(30-40)	(25-37.5)	(474-540)	(480-780)	(48-90)	(6-30)						
	76.32	41.25	78.12	37.22	31.11	20.33	35.93	27.5	512.40	580.10	69.30	16.80						
<i>P. microstomum</i>	Length	Width	Length	Width	Length	Width	Length	Width	Adaxial	Abaxial	Adaxial	Abaxial	Adaxial	Abaxial	15.04	9.93		
	(35.25-100)	(37.50-65.11)	(47.5-102.5)	(36.5-80)	(35-40)	(25-30)	(32.5-50)	(22.5-30)	(232-450)	(240-492)	(48-72)	(36-54)						
	64.36	46.87	75.11	53.33	37.50	28.21	42.52	26.12	330.41	396.23	58.51	43.71						
<i>P. rhoeos</i>	Length	Width	Length	Width	Length	Width	Length	Width	Adaxial	Abaxial	Adaxial	Abaxial	Adaxial	Abaxial	4.14	17.09		
	(20-125)	(25-75)	(37.5-150)	(25-62.5)	(21.71-32.50)	(25-35)	(30-42.5)	(22.5-32.4)	(310-650)	(420-540)	(20-47)	(72-120)						
	31.73	46.66	88.21	41.66	30.50	31.22	40.11	29.32	511.40	480.10	22.11	99						
<i>R. refracta</i>	Length	Width	Length	Width	Length	Width	Length	Width	Adaxial	Abaxial	Adaxial	Abaxial	Adaxial	Abaxial	9.34	12.71		
	(75-137.5)	(25-37.50)	(62.5-112.5)	(30-75)	(37.5-50)	(30-32.5)	(30-40)	(25-37.5)	(320-540)	(320-620)	(18-65)	(33-85)						
	107.58	29.37	87.50	50.42	43.44	31.25	33.75	33.51	476.11	500.35	49.10	72.90						

*The numbers between the brackets represent the minimum and maximum and outside the brackets representing the average

In the cross sections (transverse), on the adaxial and abaxial surfaces, the epidermal cells comprise thin radial walls that are uniseriate, circular, semicircular, rectangular and square-shaped. Epidermis is covered with a thin cuticle and trichomes. The thickness of the lamina was between 330.33 μm in *P. macrostomum* and 188.75 μm in *P. fugax*, while the cuticle thickness ranged between 29.75 μm in *P. macrostomum* and 4.53 μm in *P. rhoeas* (Tab. 2, Pl. 4). The upper epidermal cells are different in terms of shape and size and are composed of big cells recognized in *R. refracta* and *P. macrostomum*.

The mesophyll is bifacial (dorsiventral) in the species and is protected by the cuticle. It consists of 1 to 2 layers of palisade cells under the adaxial epidermis and 1 – 4 layers of spongy tissue under the palisade layer. The thickness of the palisade layer was between 226.33 μm in *G. grandiflorum* and 50.21 μm in *P. fugax*, while the spongy tissue was 201.11 μm in *P. macrostomum* and 95.51 μm in *R.refracta* (Tab.2). The vascular bundle is solitary and surrounded by parenchymatic cells. This result agreed with Metcalfe and Chalk (1950) and Paltinean *et al.* (2015).

In the transverse section of the midrib, the upper surface was flat or slightly curved, and the lower surface was raised in *P. rhoeas*, *R. refracta* and *P. macrostomum* (Pl.4, E, G, I). A thick cuticle was observed on the outer surface of the epidermis. Several laminar layers of collenchyma were recognized under the epidermis. Under the collenchyma, parenchyma and in the central part, vascular bundles could be seen, which were surrounded by sclerenchymatous sheaths (Pl. 4). Epidermal cells were interrupted by the presence of hairs. Midrib was thicker in *P. macrostomum* (688.12 μm) and lower in *H. pendulum* (62.57 μm). Vascular bundle thickness ranged between 146.87 μm in *G. grandiflorum* and 62.75 μm in *P. macrostomum* (Tab. 2).The midrib can be recognized by the large vascular bundle surrounded by parenchyma cells.

Table (2): Measurements of leaves in some species of Papaveraceae family (in micrometer).

Species	Lamina thickness	Cuticle thickness	Palisade layer thickness	Spongy layer thickness	Midrib	
					Thickness of Mid rib	Thickness of vascular bundle
<i>F. bracteosa</i>	(176-400) 242.66	(4-12) 8.21	(150-370.5) 200.83	(120.5-250) 190.25	(382-521) 400.10	(98.61-175) 120.23
<i>G. grandiflorum</i>	(242.5-400) 308.51	(2.5-12.5) 7.25	(188-305) 226.33	(95-210) 133.21	(375- 400) 387.62	(62.5-187.5) 146.87
<i>H. pendulum</i>	(120-320) 260.30	(2.5-7.5) 5.23	(110-226) 175.23	(80-260) 120.60	(49.71-83) 62.57	(50-150) 67.50
<i>P. fugax</i>	(175-200) 188.75	(2.5-7.5) 5.83	(45-62.5) 50.21	(85-143) 100.06	(250-325) 284.37	(50-150) 67.55
<i>P. macrostomum</i>	(250-450) 330.33	(12.5-50) 29.75	(144-360) 215.80	(112-325) 201.11	(400-1140.5) 688.12	(25-125) 62.75
<i>P. rhoeas</i>	(162.5-275) 212.50	(2.5-7.5) 4.53	(119-182) 160.21	(75.6-125) 101.40	(162.5-275) 212.71	(50.25-165) 63.22
<i>R. refracta</i>	(130-245.5) 206.25	(25-32.5) 28.75	(112-210) 123.41	(75-199) 95.51	(210-310) 250.11	(62.75-75) 68.75

*The numbers between the brackets represent the minimum and maximum and outside the brackets representing the average.

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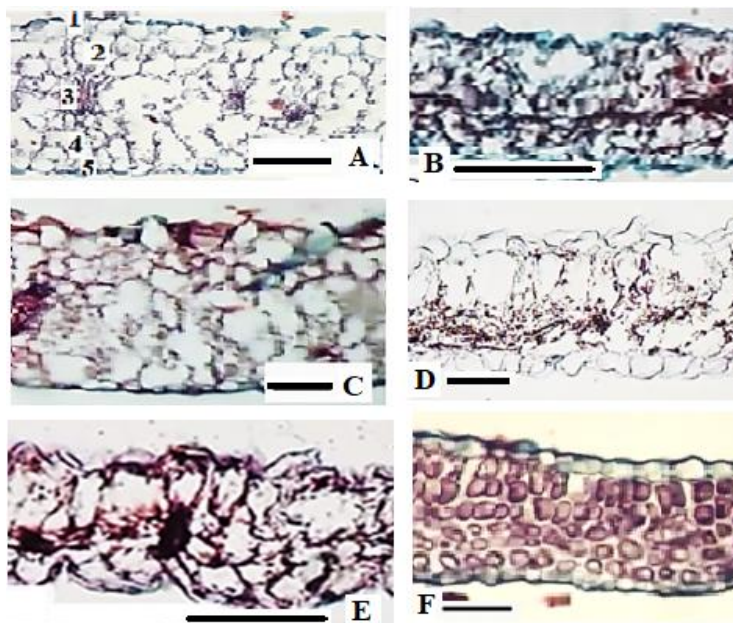


Plate (4): Transverse section of leaf lamina and midrib; (A) *H. pendulum*, (B) *G. grandiflorum*, (C) *P. fugax*, (D) *R. refractan*, (E) *P. rhoeas*, (F) *P. macrostomum*, 1- Upper epidermis 2- Palisade layer 3- Spongy layer 4- Lower epidermis 5- Bascular bundle. (Scale bar: 50 μ m).

Transverse sections of stems

Stems can be used to differentiate the different species; shape, size and the number of cortex layers are taxonomically significant to identify species. Transverse sections of the stem describe a circular shape in *P. macrostomum* and *F. bracteosa*, semicircular in *R. refracta* and *H. pendulum*, ovate or elliptic in *P. rhoeas*, *P. fugax* and *G. grandiflorum*, these findings agree with (Keshavarzi *et al.*, 2011; Chaleshtori and Attar, 2012).

Stems consist of epidermis, cortex, vascular cylinder and pith. The single-layered epidermis is represented by circular, semicircular and irregular cell shapes with slightly thickened radial, external and internal walls. The outer side, that is, the epidermal cells are covered by a cuticle, and the minimum thickness (3.21 μ m) of the cuticle was found in *F. bracteosa*, while the maximum thickness (18.33 μ m) was recorded in *P. fugax* (Tab. 3, Pl. 5). Three types of distinct tissues are recognized in cortex, collenchyma, sclerenchyma and parenchyma. Tubular collenchyma was recorded in all the species and consisted of 3-4 layers below the epidermis.

The cortex is composed of parenchyma cells; it is ranged between 5-12 layers in *P. fugax*, *P. rhoeas* and *F. bracteausa*, while it was 2-8 in other species. All species contained one layer of sclerenchyma tissue, which agreed with Esau (1977) and Bercu (2012). Sclerenchyma layers ranged in thickness between 187.50 μ m in *P. fugax* and 56.25 μ m in *G. grandiflorum*. Most of species at the central part of stem contain the pith, which consists of the cells was spherical and semispherical cells, but the center part of *G. grandiflorum* stem was occupied by a large cavity cell (Pl. 5).

Most of the species contain numerous collateral vascular bundles, while their presence was lower in *F. bracteausa* and *H. pendulum*. Xylem thickness of the wood varied between 225.32µm in *P. fugax* and 131.40 µm in *P. rhoeas*, while phloem was 112.50 µm in *H. pendulum* and 33.33 µm in *F.bracteosa* (Tab.3, Pl.5). The vascular cylinder contains 3- 4 layered sclerenchymatous, and these results are consistent with the description given by Metcalfe and Chalk (1950), Bercu *et al.* (2006), Rahmatpour *et al.* (2010), and Bercu (2012). Laticifer tubes in species could be seen around a vascular bundle and in the cortex, and a sclerenchymatous sheath was recorded in some species of Papaveraceae by Esau (1977), Batanouny (1992), Bercu (2012), and Chaleshtori and Attar (2012). Laticifers with white or yellow latex contain alkaloids in *P. somniferum* (Mahlberg, 1959; Reynold, 1963; Esau and Kosakai, 1975; Dickinson and Fairbairn, 1975). The pith diameter was between 1412.51 µm in *P. rhoeas* and 875.33 µm in *R. refracta* (Tab.3, Pl. 5).

Table (3): Anatomical dimensions of stems of some species of Papaveraceae family (in micrometer).

Species	Stem diameter	Cuticle thickness	Epidermis thickness	Thickness cortex	Phloem thickness	Xylem thickness	Pith diameter
<i>F. bracteosa</i>	(1500-1950)* 1739	(2.5-5) 3.21	(10-17.5) 13.33	(75-100) 87.50	(25-50) 33.33	(100-200) 166.66	(750-1125) 937.50
<i>G. grandiflorum</i>	(1000-1525) 1312.50	(7.5-22) 13.44	(10.5-15) 12.53	(25-200) 56.25	(25-50) 35	(117.5-175) 139.16	(875-1050) 975
<i>H. pendulum</i>	(1300-1950) 1583.33	(2.5-12.5) 7.5	(12.5-22.5) 17.85	(85-220) 123.55	(62.5-150) 112.5	(200-212) 208.33	(750-1050) 900.45
<i>P. fugax</i>	(625-1125) 937.50	(12.5-25) 18.33	(12.5-22.5) 15.35	(78.5-875) 187.50	(25-75) 46.87	(175-250) 225.32	(150-325) 240.25
<i>P. macrostomum</i>	(2000-2750) 2416.66	(2.5-7.5) 5.41	(10-22.5) 12.91	(50-250) 163.21	(100-25) 62.5	(100-200) 150.25	(840-1250) 1000.10
<i>P. rhoeas</i>	(2375-2875) 2593.75	(2.5-10) 4.10	(7.5-17.5) 10.24	(75-200) 125.55	(37.5-50) 43.33	(62.5-250) 131.40	(1250-2250) 1412.51
<i>R. refracta</i>	(1250-1800) 1600.22	(2.5-12.5) 10.22	(7.5-15) 11.25	(100-225) 143.75	(25-75) 42.41	(125-287.5) 185.41	(750-1000) 875.33

*The numbers between the brackets represent the minimum and maximum and outside the brackets representing the average.

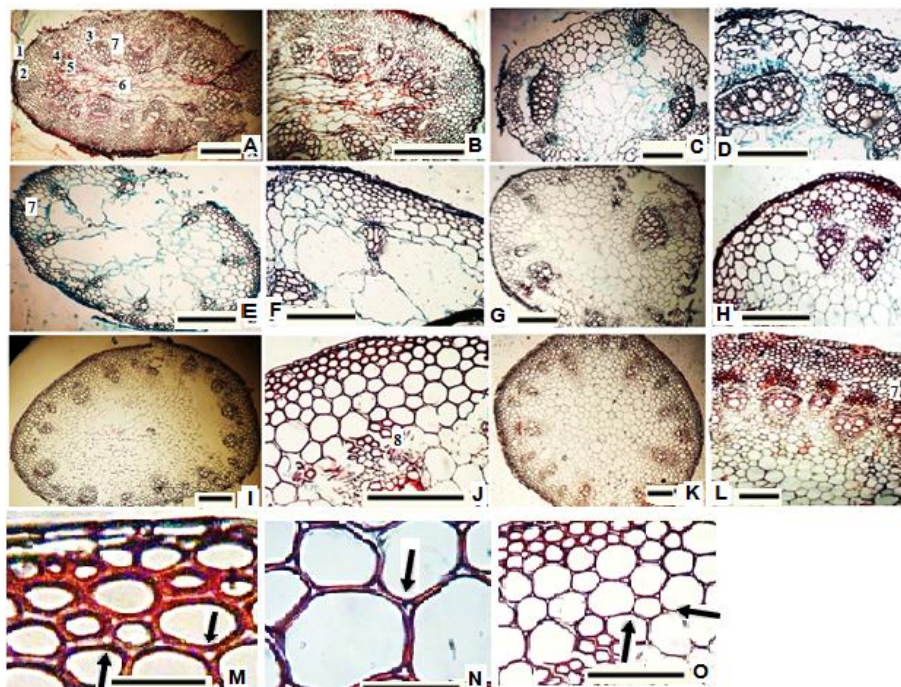


Plate (5): Stem anatomy of some species of Papaveraceae family; (A, B) *P. fugax*, (C, D) *H. pendulum*, (E, F) *G. grandiflorum*, (G, H) *R. refracta*, (I, J) *P. rhoeas*, (K) *F. bracteosa*, (L) *P. macrostomum*, (M) Tubular collenchyma in *R. refracta*, (N, O) Tubular collenchyma in *P. rhoeas*, 1-Epidermis 2- Collenchyma layer 3- Sclerenchyma layer 4- Phloem 5- Xylem 6- Pith 7-Parenchyma layer 8- Laticifer tubes (scale bar 100 μ m).

Trichomes

The current study showed six types of trichomes that present in Papaveraceae species (Pl. 6):

- 1- Non-glandular long biseriate hairs in *P. fugax*, *P. macrostomum* and *R. refracta*.
- 2- Non-glandular long triseriate hairs in *P. fugax*, *P. macrostomum* and *R. refracta*.
- 3- Non-glandular long multiseriate hairs in *P. fugax*, *P. macrostomum* and *R. refracta*.
- 4- Non-glandular long uniseriate (unicellular and multicellular) in *G. grandiflorum*, *F. bracteosa* and *H. pendulum*.
- 5- Non-glandular short hairs unicellular in *P. rhoeas* and *R. refracta*.
- 6- Glandular short hairs multicellular cells in *P. rhoeas*.

The trichome types provided an important diagnostic characteristic for species separation, and the results showed that *P. rhoeas* has five types of hairs, while *G. grandiflorum* have only one type (Pl. 6). Bercu (2012) and Chaleshtori and Attar (2012) reported that the trichomes in Papaveraceae vary in form; they are multiserate or consist of a single row which agrees with the present study. Scanning electronic microscope (SEM) photographs of the trichomes on leaves of Papaveraceae species distributed on the surface and were variable in distribution and long between the species (Pl. 6).

Anatomical study of some species belonging to the Papaveraceae

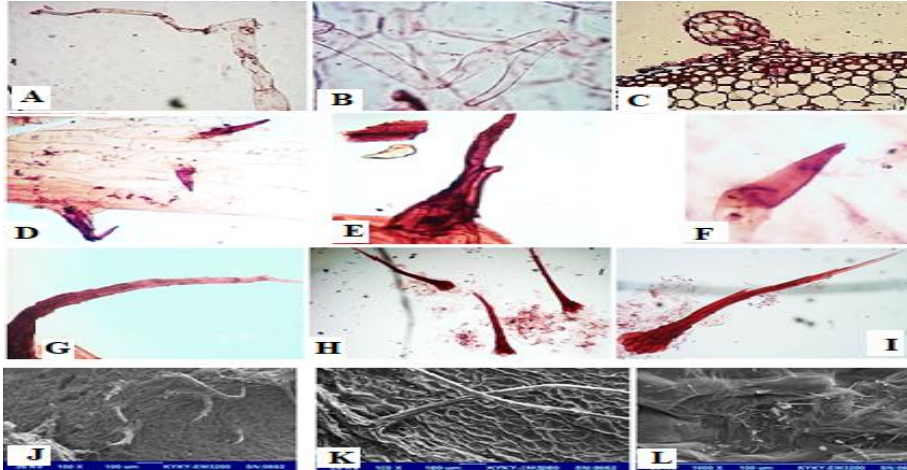


Plate (6): Trichomes in some species of Papaveraceae family; (A, B) Non-glandular long uniseriate *G. grandiflorum*, (C) glandular short hairs multicellular hairs *P. rhoeas*, (D) Non-glandular uniseriate and biseriata *R. refracta*, E, Non-glandular long hairs biseriata *R. refracta*, (F) Non-glandular short hairs unicellular *R. refracta*, (G) Non-glandular long triseriate *P. fugax*, (H, I) Non-glandular long multiseriata hair *P. macrostomum*, (J) Non-glandular long multiseriata hair in *P. fugax*, (K) *F. bracteosa*, (L) *P. rhoeas*. (Scale bar 100 μ m).

The cluster analysis of Papaveraceae species of Iraq based on anatomical characteristics showed in (Diag. 1). A cluster analysis has revealed that *P. fugax*, *P. rhoeas* and *P. macrostomum* are closely related, all these species belongs to the genus *Papaver*. The results showed two major clusters were formed. The first major cluster comprised two subclusters, in the first we found *R. refracta* and *G. grandiflorum*. The second subclustered include the *papaver* species, *F. bracteosa* and *H. pendulum*. *F. bracteosa* and *H. pendulum* was separated alone and other subclustered include three species (*P. fugax*, *P. rhoeas* and *P. macrostomum*). *P. macrostomum* was formed a separate cluster and it was related to *P. fugax* and *P. rhoeas*.

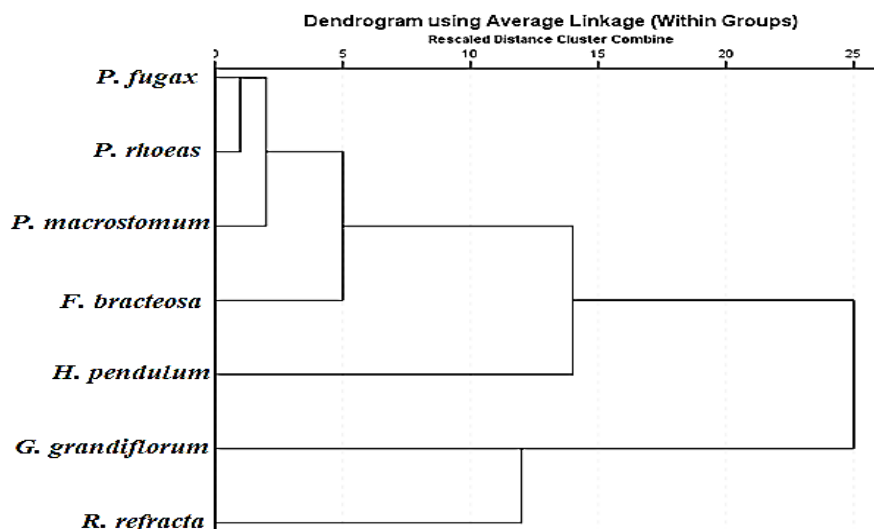


Diagram (1): Dendrogram of some Papaveraceae species in Iraq.

According to the present study, a taxonomic key has been made for the species separation:

- 1-Glandular trichomes present ----- *P. rhoeas*
- Glandular trichomes absent-----2
- 2-Trichomes biseriate or multiseriatehairs -----3
- Trichomes long uniseriatehairs -----5
- 3-Stem shape ovate ----- *P. fugax*
- Stem shape circular or semicircular ----- 4
- 4- Thin anticlinal cell wall of epidermis ----- *R. refracta*
- Thick anticlinal cell wall of epidermis -----*P. macrostomum*
- 5-Stem semicircular or ovate, and vascular bundles less than 15 -----6
- Stem circular, and vascular bundles more than 15 ----- *F. bracteosa*
- 6-Pith contains large cavity cells, number of vascular bundles of stem more than five -----
- *G. grandiflorum*
- Pith contains regular cells, number of vascular bundles of stem less five ----- *H. pendulum*

CONCLUSION

In the presence of variation in the leaf's mesophyll, number and arrangement of the vascular bundles, thickness of epidermis appeared to be a good diagnostic characteristic for the species separation, as well as the midrib characteristics. The species *G. grandiflorum* contained a large cavity in the central part of the stems section. The cortex of the stem showed significant differences in the species *P. fugax*.

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دراسة الصفات التشريحية لبعض الأنواع من العائلة الخشخاشية Papaveraceae في العراق

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تاريخ الاستلام: ٢٠١٩/٠٥/٢٣. تاريخ القبول: ٢٠١٩/٠٧/٢٩. تاريخ النشر: ٢٠١٩/١٢/٢٦

الخلاصة

درست الصفات التشريحية لأوراق وسيقان سبعة أنواع تعود الى خمسة اجناس من العائلة الخشخاشية وهي:

Fumaria bracteosa Pomel, 1875 و *Glaucium grandiflorum* Boissier & A. Huet, 1856 و *Hypecoum pendulum* Linnaeus, 1753 و *Papaver fugax* Poirlet, 1804 و *Papaver macrostomum* Boissier & A. Huet, 1867 و *Papaver rhoeas* Linnaeus, 1753 و *Roemeria refracta* de Candolle, 1821.

أوضحت النتائج أن جدران الخلايا المماسية للسطح العلوي للورقة أكثر سمكاً في الأنواع *H.* و *P. fugax* و *P. macrostomum* و *P. rhoeas* و *R. refracta* ولكنها كانت رقيقة في النوع *P. rhoeas*؛ كما تبين وجود ثلاث طرز من المعقدات الثغرية (الطرز الشاذ Anomocytic type والطرز المتوازي Paracytic type والطرز شبه المتوازي Hemiparacytic type). تباينت الأنواع في عدد الثغور على سطح البشرة فقد سجل ادناها 22.11 ثغراً/ملم^٢ في النوع *P. rhoeas* وأعلاها في النوع *P. fugax* (69.30) ثغراً/ملم^٢. أما الدليل الثغري فكان أعلاه في النوع *P. macrostomum* (15.04%) وأدنى قيمة سجلت في النوع *P. rhoeas* (4.14%).

تبين من خلال الدراسة أن النسيج المتوسط السائد في الأنواع المدروسة هو الثنائي الجانب Bifacial (dorsiventral)؛ أما السيقان فقد أعطت أهمية تصنيفية معتبرة في فصل الأنواع عن بعضها من خلال شكلها وحجمها وعدد طبقات القشرة؛ لوحظ من الدراسة وجود ست أنواع من الشعيرات: الشعيرات الغير غدية الثنائية والثلاثية والمتعددة الصفوف، فضلاً عن وجود الشعيرات القصيرة الوحيدة والمتعددة الخلايا، كما أمكن ملاحظة الشعيرات الطويلة وحيدة الصف والتي تميزت بوجودها في النوع *G. grandiflorum* وتميز النوع *P. rhoeas* بوجود الشعيرات الغدية القصيرة.