

## Full Length Research Paper

# Various macro and micro-morphological features of two species of *Cakile*

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The morphology and anatomy of *Cakile maritima* subsp. *aegyptiaca* and *Cakile arabica* are organized in this work to invent the different characters between the two studied species. The species were collected fresh from Mersa-Matruh in Egypt and Dammam city in Eastern region of Saudi Arabia. The main characteristic to distinguish between the different *Cakile* species is the morphology of the fruit, *C. maritima* was characterized by the occurrence of 2 opposite lateral horns in its fruit, and the absence of this in the other species. In this paper many characteristics other than fruit morphology are noticed to differentiate between them as habit of stem, type of leaf, texture of sepal, seed shape, stem outline, types of cortex, pericycle tissue and number of vascular bundles. These characteristics can be used as tools for identification between the different species belonging to the same genera.

**Key words:** Vegetative part, flowering part, anatomy, *Cakile maritima*, *Cakile arabica*.

## INTRODUCTION

The *Cakile* is one genus in the family Brassicaceae, its species are annual succulent halophyte plants, Clausen et al., (2000). Species of *Cakile* are widely distributed in sandy coasts throughout the world as sandy beach of North Atlantic Ocean, the Baltic, Mediterranean, North and White seas, the Caribbean and Gulf of Mexico and the Great lakes, and is established in Australia, Japan and on the Pacific Coast of North America, one species, *Cakile arabica* Vel. et Bornm is found in deserts of Middle as (Iraq, Kuwait and Saudi Arabia). The number of species of the genus *Cakile* is undefined. Pobedimova (1963) recorded 15 species on the basis of the morphology only. While Rodman (1974) verified seven species: (*Cakile arabica*, *Cakile arctica*, *Cakile constricta*, *Cakile edentula*, *Cakile geniculata*, *Cakile lanceolat*, and

*Cakile maritima*) based on morphological and chemical analysis. Recently Warwick and Sauder (2005) recognized 6 species on the basis of morphological and molecular evidence. In Egypt the genus is represented by one species and one subspecies (*Cakile maritima* Scop. subsp. *aegyptiaca* (Willd.), according to Tackholm (1974) and Boulos (1999). In Saudi Arabia, one species (*Cakile arabica* Vel. et Bornm) is recorded according to Mandaville, (1990) and Chaudhary, (1999).

The *Cakile maritima* and its subspecies are common species of this genus and it is widely distributed throughout the world Barbour, (1972). It is a naturally salt-tolerant plant that shows potential for economical (oilseed), nutrient food and chemotherapeutic utilization (Ksouri et al. 2007).

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Studies on this genus are limited and most of them are on the adaptation of these plant to its environment as, Wright (1927), Ball (1964), Davy et al. (2006), Daniela et al. (2010) and Jianu et al. (2014). Morphological and anatomical studies of the studied species are very scarce Al-Taisan and Gabr, (2017). The main objective for this paper is to prove the presence of any differences between the two studied species.

## MATERIALS AND METHODS

Two species of *Cakile* were collected; *Cakile maritima* Scop. subsp. *aegyptiaca* (Willd.), from the coastal part of Mersa-Matruh in Egypt and *Cakile arabica* Vel. et Bornm, from Al- Rawda area - Dammam city in the Eastern region of Saudi Arabi. The species were collected by the author in March (2015). The species were identified according to the plant key of Tackholm (1974), Mandaville (1990), Boulos (1999) and Chaudhary (1999).

Foliar and floral details were examined with the aid of binocular stereo microscope under incident light and photographs. For anatomical investigation, each specimen was fixed according to Nassar and El-Sahhar, (1998) in F.A.A. (formalin - glacial acetic acid - 70% alcohol) with the ratio of 5: 5: 90 by volume. The stems and leaves (petiole and blade) were hand sectioned; the stems were taken from second internodes. The sections were stained according to Dilcher, (1974) in safranin (1% solution in 50% ethanol) and light green (1% solution in 96% ethanol) then photographed.

## RESULTS

### Morphology

#### *Cakile maritima* Scop. subsp. *aegyptiaca* (Willd.)

The *Cakile maritima* Scop. subsp. *aegyptiaca* is an annual, succulent herb that can grow up to 60 cm. long and glabrous. The stem is decumbent, terete, solid and branched. Internodes are 2-4 cm x 0.2 - 0.4 cm. The leaves are up to 6 cm. long while the lower leaves are oblong-ovate in outline and petiolate. The petiole is glabrous and up to 2.5 cm. long. Blade is 2- 3.5 cm x 1 - 1.5 cm, simple with entire to sinuate-dentate margin and acute apex. The upper leaves are simple and petiolate. The petiole is up to 1.5 cm. long. Blade is 1.5- 2.5 cm. x 0.5 - 1 cm, oblong ovate, dentate with acute apex (Table 1, Plate 1 and 2).

Inflorescence types are raceme. Flower length is 3 - 7 mm. long and pedicellate. Pedicels are glabrous, 2- 4 mm. long and thick. Sepals are glabrous, green- yellow, 2.5 - 4 mm x 1- 1.5 mm and ovate oblong in outline with narrow membranous margin. Petals color is violet-lilac, 4 -6.5 mm x 1- 2.5 mm clawed with obovate limb and obtuse apex. Stamens length is 3-5 mm. long, with glabrous filament and ovate-triangle anthers. Ovary is smooth with inconspicuous style and flattened stigma (Plate 1).

Siliqua is 1.5 - 2 cm x 0.4 - 0.6 cm, ribbed, glabrous,

horned and indehiscent with 2- segmented. The upper segment is longer than the lower with pyramidal shape and one seeded. The lower segment is short, cylindrical with two prominent lateral projections basally and one seeded. Beak length is 2-3 mm long and seedless. Seeds are D-shaped, 2.5-3.5 mm x 1 long, 2 mm wide, brown with sub-terminal hillum and has smooth surface.

#### *Cakile arabica* Vel. et Bornm

The *Cakile arabica* species is an annual, glabrous and succulent herb arising from tap root. The stem is erect, terete, solid and ascending in branch. Internodes are 2 – 4.5 cm x 0.1 - 0.3 cm. Leaves are alternate and pinnate. Lower leaves are oblong-ovate in outline and petiolate. Petiole is glabrous and up to 7.5 cm. long. Blade is 9.5 to 15 cm x 4.5 to 10 cm and pinnately divided into 4 to 7 narrowly linear lobes. The upper leaves are pinnate and petiolate. The petiole is up to 1.7 cm. long, the Blade 4 to 6 cm x 3 to 5.5 cm and ovate with 1-3 lateral lobes.

Inflorescence types are raceme. Flower length is 3 to 7 mm. long and pedicellate. Pedicels are glabrous and thick with 1.5 to 3.5 mm long. Sepals are hairy, green violet, 4 to 5.5 mm x 1 to 1.5 mm and ovate oblong in outline with narrow membranous margin. Petals are violet, 5 to 6.5 mm x 1.5 to 2 mm clawed, limb obovate with obtuse apex. Stamens length is 4.5 to 5.5 mm long with glabrous filament and long ovate anthers. Ovary is smooth with inconspicuous style and flattened stigma.

Siliqua is 1.6 to 2 cm x 0.2 to 0.3 cm, ribbed, glabrous and indehiscent with 2- segment. The upper segment is longer than the lower with pyramidal shaped and is one seeded. The lower segment is short, cylindrical and one seeded. Beak is long and seedless. Seeds are oblong, 3 to 3.5 mm x 0.5 to 1 mm brown with sub-terminal hillum and smooth surfaced (Plate 2).

### Anatomy

#### *Cakile maritima* Scop. subsp. *aegyptiaca* (Willd.)

##### *Stem anatomy*

The outline in cross section is pentagonal. Epidermal cells are radially elongated cells covered with thick and warty cutin. Cortex is wide and consists of 5 - 6 layers of sclerenchyma followed by 1 to 2 layers of polygonal parenchyma. Starch sheath is well defined. Pericycle consists of patches of fibers alternate with parenchymatous cells. Vascular cylinder is composed of 9 to 10 bundles, each with well defined patches of phloem and wide xylem vessels (Plate 3). The medullary rays are wide; 6 to 9 series of thin walled parenchyma cells. Pith is wide, solid and homogenous, consists of round thin cell wall parenchymatous cells. Schizogenous canals are recorded in cortex and pith (Table 2, Plate 3 and 4).

**Table 1.** The main different morphological characters among the two studied species.

Character	Species	
	<i>C. maritime</i> subsp. <i>aegyptiaca</i>	<i>C. arabica</i>
Duration	Annual Herb	Annual Herb
Nature	Succulent	Succulent
Stem habit	Decumbent	Erect
Internode length (cm.)	2-4	2- 4.5
Internode width (cm.)	0.2-0.4	0.1-0.3
Type of Leaf	Simple	Pinnate
Petiole length (cm.)	1.5-2.5	1.7-7.5
Blade length (cm.)	1.5-3.5	4-15
Blade width (cm.)	0.5-1.5	3-10
Color of sepal	Green- yellow	Green violet
Texture of Sepal	Glabrous	Hairy
Color of petal	Violet-lilac	Violet
Shape of stamen	Ovate-triangle	Long ovate
Fruit	Horned	Not horned
Shape of seed	D-shaped	Oblong

**Plate 1.** Different morphological features of *Cakile maritime* subsp. *aegyptiaca* 1-lower leaves; 2- Upper leaves; 3- Flower; 4- Sepal; 5- Petal; 6- Stamen; 7- Fruit; 8- Seed.**Leaf anatomy****Petiole**

The outline in cross section is crescent with two

prominent ridges. Epidermis is composed of radially elongated cell mixed with bulliform cells and covered with thick and warty cutin. Ground tissue is consisted of 4- 6 layers of chlorenchyma tissue found abaxially and in ridges followed by round to irregular thin cell wall



**Plate 2.** Different morphological feature of *Cakile arabica*. 1-lower leaves; 2- Upper leaves;3- Flower;4- Sepal; 5- Petal;6- Stamen;7- Fruit;8- Seed.

**Table 2.** The main different anatomical characters among the two studied species.

Species		<i>C. maritime subsp. aegyptiaca</i>	<i>C. arabica</i>
Characters	outline	Pentagonal	Terete
	Epidermal cell	Radial	Tangential
Stem	Cortex layer	6-8	4-6
	Cortex tissue	sclerenchyma	chlorenchyma
	Pericycle	Fibers + Parenchyma	Parenchyma
	No. of vascular bundles	9-10	15-17
Petiole	Bulliform cell	Present	Absent
	No. of vascular bundles	11	7
Blade	Epidermal cell	Radial	Tangential
	Bulliform cell	Present	Absent
	Mesophyll	Discontinuous	Continuous
	Type of mesophyll	Isobilateral	Centric in rachis – Isobilateral in lobe
	Main vascular bundles	one	11 in rachis- one in lobe

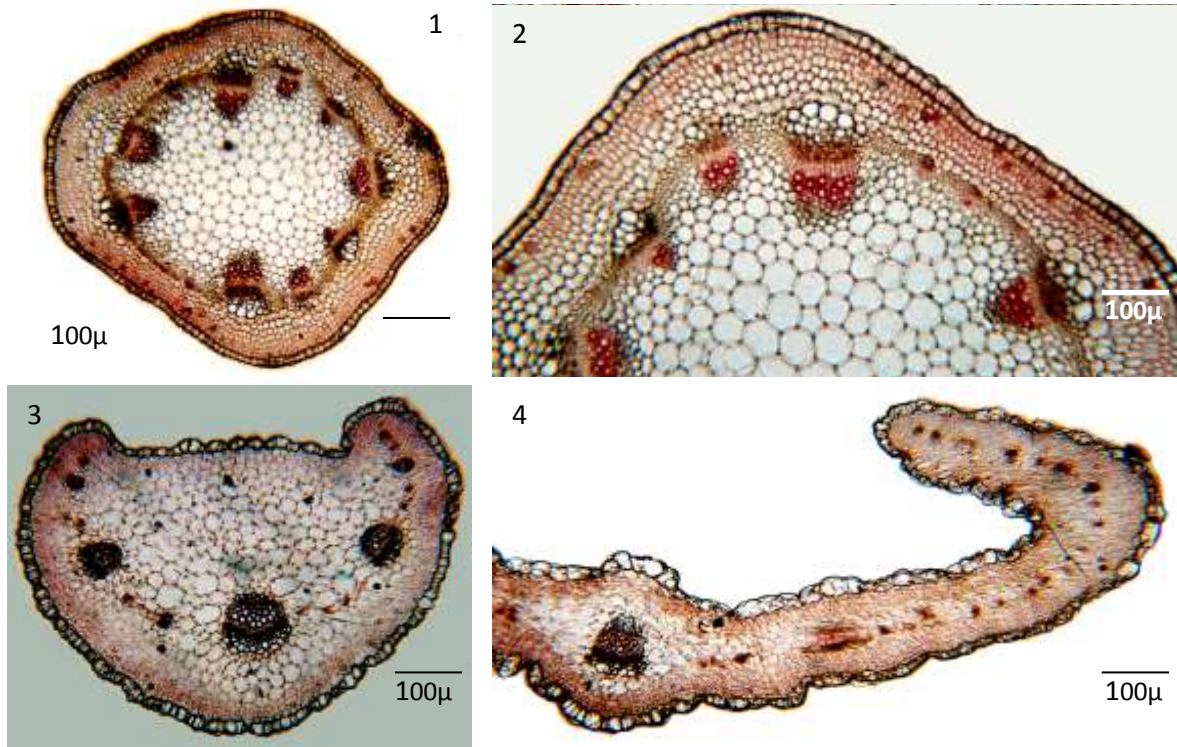
parenchyma cells. Vascular system is 11 bundles arranged in crescent form, one main and 10 (5, 5) small, unequal size in each side. Each bundle has well-defined patches of phloem, wide xylem vessels and surrounded by bundle sheath of wide parenchyma. The vascular bundles are associated with fibers. Schizogenous canals

are present.

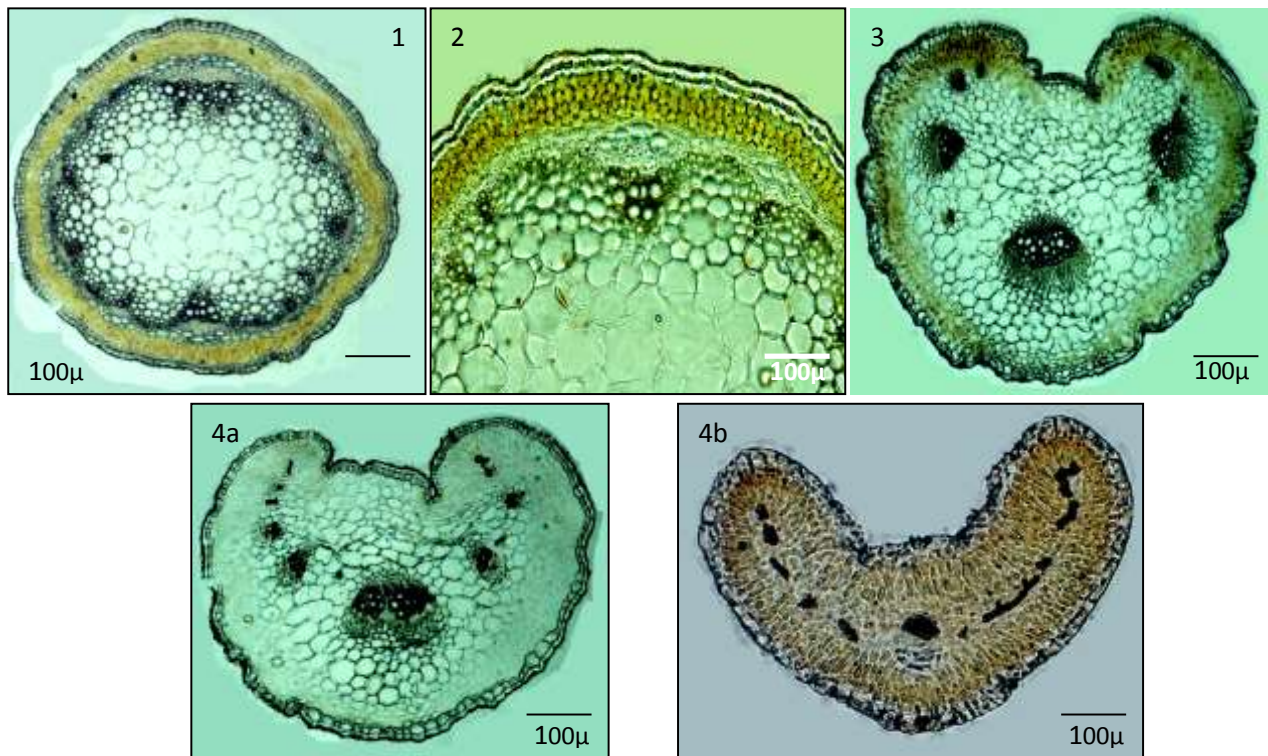
**Blade**

The outline in cross section is in duplicate. Epidermal





**Plate 3.** Different anatomical features of *Cakile maritima* subsp. *Aegyptiaca*. 1- Stem outline; 2- Stem sector; 3- Petiole outline; 4- Blade.



**Plate 4.** Different anatomical feature of *Cakile arabica*. 1- Stem outline; 2- Stem sector; 3- Petiole outline; 4a- Rachis of blade; 4b- Lobe of blade.

cells are radial mixed with bulliform cells covered with thick and warty cutin. The epidermis is interrupted by anisocytic semi depressed stomata. Mesophyll is isobilateral, composed of 4 to 5 layers of short cubic cells of palisade tissue discontinuous adaxially at midrib region followed by one layer of thin cell wall parenchyma cells.

Vascular system is composed of one large main bundle at midrib region and many small bundles in each side at wing region. Each bundle surrounded by bundle sheath of wide parenchyma and associated with fibers.

### ***Cakile arabica* Vel. et Bornm**

#### **Stem anatomy**

The outline in cross section is terete. Epidermal cells are tangentially elongated cells shielded by thick and warty cutin. Cortex consists of 3 to 4 layers of chlorenchyma cells followed by 1 to 2 layers of parenchyma. Pericycle consists of parenchymatous cells. Vascular cylinder is eustele, composed of 15 to 17 bundles; each with will defined patches of phloem and will defined xylem vessels. The medullary rays are wide. Pith is wide and homogenous and consists of thin walled round to polygonal parenchymatous cells. Schizogenous canals are recorded in cortex and pith (Plate 4).

#### **Leaf anatomy**

##### **Petiole**

The outline in cross section is  $\pm$  crescent with two prominent ridges. Epidermis is composed of radially elongated cells covered with thick and warty cutin. Ground tissue is consisted of 3 to 4 layers of chlorenchyma tissue found abaxially and in ridges followed by round to irregular thin cell wall parenchyma cells. Vascular system consists of 7 bundle, one main and 6 (3, 3) subsidiary in each side. Each bundle with well-defined patches of phloem, wide xylem vessels and surrounded by bundle sheath of wide parenchyma cells. The vascular bundles are associated with fibers (sclerenchyma), the number of row of sclerenchyma ranges from 4 to 5 row. Schizogenous canals are present.

##### **Blade- c.1- Rachis**

The outline in cross section is  $\pm$  crescent with two prominent ridges. Epidermis is composed of radially elongated cells mixed with some tangential and covered with thick and warty cutin. Mesophyll is centric, composed of palisade in the form of outer 3-4 layers of

loose cells, followed by parenchyma tissue which is composed of 4 - 6 layers of large thin-walled round to polygonal. The vascular system is in the form of 11 collateral bundles, two (united) main vascular bundles and 9 (5,4) subsidiary schizogenous canal are recorded.

#### **2- Lobe**

The outline in cross section is in duplicate. Epidermal cells are tangential mixed with some radial cells and covered with thick and warty cutin. The epidermis is interrupted by anisocytic, semi depressed stomata. Mesophyll is isobilateral, composed of 3 to 4 layers of long palisade tissue continuous adaxially at midrib region followed by one layer of thin cell wall parenchyma cells. Vascular system is composed of one large main bundle at midrib region and 4-5 small bundles in each side.

**The key:** The studied characters were used in the construction of an indented key to the assorted species.

(i) Decumbent stem, simple leaves, d-shaped seed, pentagonal stem outline, scalarenchyma tissue present in the cortex and the type of the mesophyll is isobilateral..... *Cakile maritima* subsp. *aegyptiaca*.

(ii) Erect stem, pinnate leaves, oblong shaped seed, teret stem outline, scalarenchyma tissue absent in the cortex and the type of the mesophyll is centric..... *Cakile arabica*

### **DISCUSSION**

The *Cakile* fruit is a characteristically shaped, fleshy, usually single-seeded, indehiscent, heteroarthrocarpic siliqua and consists of a proximal capsule that stays attached to the parent, and a deciduous beaked distal capsule that separates easily at the joint when fully ripe (Hall et al. 2006). It has a thick, corky inner tissue that allows it to float on water, allowing it to disperse to great distances, Maun and Payne (1989) and Donohue (1997, 1998a, b).

The main characteristic to distinguish between the different *Cakile* species is the morphology of the fruit, *Cakile maritima* characterized by occurrence of 2 opposite lateral horns in its fruit, and the other species do not have these horns.

This study recorded different morphological and anatomical features between *Cakile maritima* subsp. *aegyptiaca* and *Cakile arabica* beside the different in fruit morphology.

The stem is decumbent and more succulent in *Cakile maritima* subsp. *aegyptiaca*, and erect in *Cakile arabica*. Leaves are simple and small in *Cakile maritima* subsp. *aegyptiaca*, while pinnate and longer in *Cakile arabica*.

Sepals are glabrous and green yellow in *Cakile maritima* subsp. *aegyptiaca*, and hairy and green violet in *Cakile arabica*. Seeds are d-shaped in *Cakile maritima* subsp. *aegyptiaca*, and oblong in *Cakile arabica*. The stem outline pentagonal in *Cakile maritima* subsp. *aegyptiaca*, and terete in *Cakile Arabica*, cortex wide and contain sclerenchyma tissue in *Cakile maritima* subsp. *aegyptiaca*, and consists of chlorenchyma tissue in *Cakile arabica*, the pericycle in *Cakile maritima* subsp. *aegyptiaca* and consists of patches of fibers alternate with parenchyma while consists of parenchyma only in *Cakile arabica*. The stem vascular bundles are little in *Cakile maritima* subsp. *aegyptiaca*, rather than in *Cakile arabica*. Petiole vascular bundles are 11 in *Cakile maritima* subsp. *aegyptiaca*, and 7 in *Cakile arabica*. Bulliform cells are present in the leaves of *Cakile maritima* subsp. *aegyptiaca*, and absent in *Cakile Arabica*. Mesophyll discontinuous in *Cakile maritima* subsp. *aegyptiaca*, while continuous in *Cakile Arabica*, Isobilateral *Cakile maritima* subsp. *aegyptiaca*, while centric and isobilateral in *Cakile Arabica*. The number of vascular bundle in midrib region is one in *Cakile maritima* subsp. *aegyptiaca*, and 11 in the rachis of *Cakile arabica*

## Conclusion

The two species, *Cakile maritima* subsp. *aegyptiaca*, and *Cakile arabica* have different morphological characters such as habit of stem, type of leave, texture of flower (sepal) and seed shape. They also have some different anatomy characters such as, stem outline, tissue of cortex and pericycle, types of mesophyll and number of vascular bundles. The present study recommends that future studies should use these characteristics as a tool for identification of the different species belonging to the same genera.

## CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

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