https://doi.org/10.46344/JBINO.2021.v010i01.13

FLORAL TAXONOMICAL INVESTIGATION WITHIN PAPAVERACEAE *S.L.*

Wafaa K.Taia

Alexandria University-Faculty of Science-Botany Department *Alexandria- EGYPT

ABSTRACT

Twenty seven species belonging to eight genera have been investigated in this study. These species covered the three restricted families, Papaveraceae, Fumariaceae and Hypecoaceae. The floral characters have been examined carefully, and the herbarium sheets, flowers, stigma, fruits and pollen grains have been photographed. The results indicated that the flower arrangement and symmetry, stamen number, presence of style, shape of stigma, and type of fruits as well as pollen grain characters all together proved new taxonomic division of the Papaveraceae *s.l.*. This investigation supports the separation of the Fumariaceae with two tribes from both the papaveraceae and Hypecoaceae. Meanwhile, the position of the Hypecoaceae, as subfamily level, under the Papaveraceae is more acceptable. Floral morphological key has been constructed as well as phenogram show the relations between these taxa using SYSTAT12 program. A correlation analysis of nineteen most important characters has been investigated using SPSS program and three identification keys have been constructed.

Key words: Fagoniaceae-Floral-Hypecoaceae-Papaveraceae-Taxonomy

Introduction

Floral characters have been used in many systems of classification since Tournefort (1656-1708). Tournefort recognized two grades of genera based on the form and size of flowers and fruits. This view has been accepted by Linnaeus (1737), but he used the androecium characters to construct his sexual system of angiosperm classification. Stearn (1961b) arranged the plant characters in a priori consideration as follows: embryo, stamens and pistils, followed by the perianth and fruits. The flowers exhibit an amazing variety of sizes, shapes, colors, arrangements, scents, rewards, and sexual systems. Small *et al.* (1981) used the petal arrangement, venation and staminal tube variations in distinguishing members of tribe Trigonelleae, *Medicago*, *Trigonella*, and *Melilotus*. They referred these variations as an adaptation to outcross pollinations. A recent opinion by Kay *et al.* (2006) concerning the importance of floral characters is their influence in speciation and extinction of many species. Thus floral morphology recently applied in the taxonomic decisions in many taxa (ex. Kong and Hong, 2018; Nam and Chung, 2018; Vasconcelos *et al.*, 2019 & Taia *et al.*, 2020).

Dahlgren (1980), Kadereit (1993) and Lidén (1993a) recognized Papaveraceae *s. s.* with the combination of Fumariaceae including *Hypecoum* L. and Fumariaceae including *Pteridophyllum* Siebold & Zucc., and *Hypecoum*. Hutchinson (1921), Cronquist (1981) and Wang *et. al.* (2009) recognized two subfamilies within Papaveraceae *s. l.*: Fumarioideae (DC) Endl. (including *Pteridophyllum* and *Hypecoum*) and Papaveroideae Eaton. Cronquist (1981), Takhtajan (1987), Dahlgren (1989) and Kubitzki (1993) suggested major segregation of Fumariaceae from Papaveraceae.

Members of family Papaveraceae *s.l.* have great variations in their floral characters. These variations have been used in their segregation and identifications of certain taxa by Günther (1975a). He found two types of inflorescence; monotelic or amphitelic synflorescences; within the papaveraceae *s.s.* which are of important value in the classification of the genera. Xuan and Chuang (1993) considered the papaveraceae from the most primitive families within the Angiosperm. They used the floral characters, especially the number of carpels and their status in dividing the family into three subfamilies and eight tribes and their importance in the phylogenetic trend. Molecular investigations done by Cronquist (1981) recognized the Fumariaceae as a separate family, despite their close phylogenetic relationship to the Papaveraceae *s.s*. The three families may be treated as subfamilies. The Angiosperm Phylogeny Group II (2003) and III (2009) favor the recognition of Papaveraceae *s. l.*, but retain the option of recognizing Pteridophyllaceae and Fumariaceae (including *Hypecoum*) as separate families. In APG III (2009) the Papaveraceae has three taxa, these taxa have been separated into different families: the Papaveraceae *s. s.*, the Fumariaceae and the Pteridophyllaceae. While the APG IV (2016) treated the

Papaveroideae and Fumarioideae (including *Hypecoum)* as a subfamilies under family Papaveraceae in order Ranunculales. Nowadays most of the authors are treating Fumariaceae as a subfamily of Papaveraceae.

The Papaveraceae *s.s.* comprises 43 genera and 820 species worldwide, mostly distributed in north temperate and tropical regions (Mabberley, 2008). Fumariaceae *s.s.* family previously treated as a small family of about 19 genus and 400 species (Lidén, 1986) occurring mainly in North America, Europe, Asia and Africa. The family Hypecoaceae includes the single genus *Hypecoum* with about 15 living species distributed from the Mediterranean region through central Asia to northern China (Mabberley, 1987). *Hypecoum* is thought to be closely related to the Papaveraceae and is frequently placed within the Fumariaceae (e.g., Cronquist 1981 Lidén 1993).

In Egypt the family Papaveraceae *s.s.* is represented by 13 species classified under four genera; *Papaver* L., *Argemone* L., *Roemeria* Medik. And *Glaucium* Mill. (Täckholm, 1974 and Boulos, 1999). According to Täckholm (1974), the family Fumariaceae represented by one genus *Fumaria* L. containing 8 species, while according to Boulos (1999) the Fumariaceae merged with Hypecoaceae and represented by 15 species distributed in two genera, *Fumaria* L. and *Hypecoum* L. This work aims to clarify the relationship between the three closely related families; Papaveraceae, Fumariaceae and Hypecoaceae; by investigating the floral characters within 24 species.

Materials and Methods

This work has been done on 27 species representing eight genera collected from field trips and different herbaria in Egypt (table 1). From three to ten sheets or fresh individuals were examined in each species, as availability. Fresh specimens collected from Borg El Arab, King Mariut and Al Omayed region in the western Mediterranean coastal strips during March and April 2017, 2018 by the author, have been subjected in this study. The flowers have been examined and dissected by Stereomicroscope. The specimens were identified by the aid of student's flora of Egypt Täckholm (1974) and Boulos (1999) and confirmation of nomenclature has been done according to the sites indicated in table 1. All the information about the studied taxa is summarized in table 1, abbreviation of the herbaria in which the specimens located are as follows: Alexandria (ALEX) and Cairo (CAI).

Data analyses

The studied characters have been subjected to data analyses using SPSS program to investigate nineteen, most variable characters (Apendix 1) have been subjected to SYSTAT13 program to evaluate the relations between the studied taxa, as well as correlation analysis between these characters have been investigated using SPSS program.

Results

The results of the studied taxa summarized in tables 2, 3, 4 & 5. The flowers of the studied species are either solitary in Papaveraceae *s.s.* and *Hypecoum* species, or aggregated in definite inflorescences in *Fumaria* species. The length of the inflorescences within the *Fumaria* species varied from 1.3 cm in *F. bracteosa* to 3.4 cm in *F.judaica*, with different width from 1 mm in both *F.*

gaillardotii and *F.microstachys* to 6 mm in *F. bracteosa, F.judaica* and *F.parviflora*. All the flowers are bracteated and pedicellated with bracts either shorter or longer than the pedicels (table 2). The calyx in all the studied species consists of two sepals, which are deciduous in the Papaveraceae *s.s* species. The sepal surface is enriched by sharp spines in *Argemone Mexicana* only, while they are hairy in all the other species belonging to Papaveraceae *s.s.*except *P.decaisnei* the sepals are glabrous. In both the Fumariaceae and Hypecoaceae the sepals are glabrous, except *F.microstachys* they are hairy. The corolla consists of four delicate and colorful petals, which are actinomorphic in the papaveraceae taxa and zygomorphic in both Fumariaceae and Hypecoaceae (table 2).

The gynaecium within the studied species varied greatly in their characters. The number of united carpels differs within the Papaveraceae taxa, they are 5 in *Argemone Mexicana,* 2 in *Eschscholzia* sp., from 5-12 in *Papaver* sp. and 4 in *Roemeria hybrida.* In both the Fumariaceae and Hypecoaceae there are two united carpels only. The style absent in the Papaveraceae species, except in *Eschscholzia* species, while in both the Fumariaceae and the Hypecoaceae the style present. The stigmas are mostly sessile, with rounded lobes or disc- shape in the Papaveraceae, except *Eschscholzia* and *Glaucium* they are either lobed or biforked. The ovary takes different shapes between the studied species. It is globose in both *Argemone* and *Glaucium* with spiny wall in the former and glbrous in the later. The ovary is linear and glabrous in *Eschscholzia* species. In *Papaver* sp. it is rectangular and glabrous, while in *Roemeria* it is rectangular and enriched by multicellular uniseriate hairs (table 3). In both Fumariaceae and Hypecoaceae taxa, the ovary is globose and glabrous, except in *F.gaillardotii*, the wall covered by multicellular uniserriate hairs, and *F.microstachys*, the wall covered by multicellular glandular hairs. In *F.parviflora*, the ovary is globose and ridged (table 3).

The fruit characters are more obvious within the studied taxa. Mostly the capsules are dry dehiscent capsules opened by either valves or pores within the Papaveraceae species. In the Fumariaceae, only the genus *Dicentra* has Capsule fruits opened by valves, while in the genus *Fumaria* the fruits are dry indehiscent nuts. In *Hypecoum* species, the fruits are siliquose articulated. The fruit shape varied according to the ovary shape, from linear, slightly elongated, oblong or globose with different lengths and widths (table 4). The fruit surfaces are either spiny in *A.mexicana*, mostly glabrous or ornamented with multicellular uniserriate hairs in moderate density except in *F. microstachys* they are woolly (table 4).

The androecium has great variations in both stamen number and pollen grain characters as viewed in table 5. In Papaveraceae taxa the number of stamens varied from 10 to numerous, while in the Fumariaceae they are six only and three in the Hypecoaceae. The pollen morphological characters show great variation between the three restricted families. They are stenopalynous within the Papaveraceae and Fumariaceae species i.e. have different shapes, aperture number and type as well as exine ornamentations.

They are varied from the suboblate, peroblate, spheroidal to the subprolate with three, four to six apertures. The apertures are colpate, colporoidate or colporate and in some *Fumaria* species the pollen grains have porate aperture. Their exine ornamentation varied from the reticulate to the tectate echinate or scabrate (table 5). The pollen grains of the Hypecoaceae; are eurypalynous i.e. having more similar characters. They are spheroidal, with one or two colpi and tectate echinate exine (table 5).

Data analyses

The results of the data analyses have been summarized in tables 6 and 7. Table 6 shows the mean, standard error, standard deviation, sample variance, range (19-2=17), minimum reading, maximum reading, summation of the data and count of the studied taxa (=27 investigated species) of the nineteen most variable characters. While table 7 shows the correlation between these characters. The most obvious results obtained are the number of flower per inflorescence is highly correlated with the symmetry of the flowers, presence of style and fruit shape. The symmetry of the flowers is positively correlated with type of fruits and pollen grain characters and negatively correlated with the number of stamen, in the same time the number of stamens is negatively correlated with the presence of style. In the same time the stigma shape is highly correlated with the fruit shape, and the fruit shape is highly correlated with both ovary shape and pollen aperture type as well as the ovary shape is highly correlated with the fruit surface.

The clustering analysis of the nineteen most variable characters (Apendix 1) grouped that the studied taxa into two categories, I & II. The first category (I) include all the Fumariaceae and Hypecoaceae species, while the second category (II) include all the Papaveraceae species. Each of these two categories is subdivided into two divisions within the first category (A & B) and three divisions in the second category (A, B & C). Group I A has all the *Fagonia* species, except *F.microstachys* which came in group I B with the *Dicentra* and *Hypecoum* species. Group II A has the *Eshscholzia* species only, while group II B has the two *Glaucium* species and finally group II C gather the *Argemone* with the *Papaver* and *Romeria* species (Fig.1).

A-Key to the three families Papaveraceae, Fumariaceae & Hypecoaceae

1-Flowers solitary

1.1-Flowers actinomorphic Papaveraceae

1.2-Flowers zygomorphic Hypecoaceae

1-Flowers arranged in inflorescences Fumariaceae

B-Key to the studied genera

1-Flowers solitary

1.2.1-Bract spiny *Argemone mexicana*

1.2.2-Bract glabrous *Papaver & Eschcholzia*

1.2.3-Bract hairy

1.2.3.1-Flowers actinomorphic *Roemeria &Glaucium*

1.2.3.2-Flowers zygomorphic *Hypecoum*

1-Flowers in inflorescences composed from 5-7 flowers

1.2.1-Bract glabrous *Dicentra formosa*

1.2.2-Bract hairy *Fagonia microstachys*

1-Flowers in inflorescences composed from 8-18 flowers

1.2.1-Bract glabrous, Bract/pedicel shorter

Fagonia gaillordii, F.judaica, F.officinalis

1.2.2-Bract glabrous, Bract/pedicel longer

F.bracteosa, F.densiflora, F.parviflora

C-Key to the nearby genera and species

1-Flowers solitary actinomorphic, bract glabrous

1.2-Stigma sessile *Papaver* sp.

1.2.1-Stigma discoid, 5 in number

1.2.1.1-Fruit obovate *P.argemone*

1.2.1.2-Fruit oblong *P.decaiseneii*

1.2.2-Stigma discoid, 7 in number

1.2.1-Fruit glabrous *P.pumile*

1.2.2-Fruit hairy *P.hybridum*

1.2.3-Stigma discoid, 10 in number *P.dubium*

1.2.4-Stigma discoid, 12 in number *P.rhoeas*

1.2-Stigma subtended by long style *Eschscholzia* sp.

1.2.1-Stamens 10-12

1.2.1.1-Calyx sparsely hairy *E.lobii*

1.2.1.2-Calyx densely hairy *E.minutifolia*

1.2.2-Stamens 12

1.2.2.1-Calyx hairy *E.caespitosa*

1.2.2.2-Calyx glabrous *E.californica & E.glyptosperma*

1.2.3-Stamen 12-16 *E.lemmonii*

1-Flowers solitary actinomorphic, bract hairy

1.2-Fruit length from 65-13 cm. *Glaucium* sp.

1.2-Fruit length never exceed 5.8 cm *Roemeria hybrid*

1-Flower solitary, zygomorphic ***Hypecoum*** **Sp.**

1-Flowers aggregated in cyme inflorescences

1.2-Number of flowers 5-7

1.2.1-Bract glabrous ***Dicentra Formosa***

1.2.2-Bract hairy ***Fagonia microstachys***

1.2-Number of flowers 8-18

1.2.1-Bract/pedicel shorter

1.2.1.1-Pollen aperture tricolpate ***F.gaillordii***

1.2.1.2-Pollen aperture pentaporate ***F.judaica***

1.2.1.3-Pollen aperture hexaporate ***F.officinalis***

1.2.2-Bract/pedicel longer

1.2.2.1-Pollen aperture hexaporate

1.2.2.1.1-Pollen grain spherical ***F.densiflora***

1.2.2.1.2-Pollen grain spherical ***F.bracteosa & F.parviflora***

Discussion

The flower, which is the basic reproductive organ of all angiosperms, is incomparably more diverse than equivalent structures found in any other group of organisms (Barrett 2002). Accordingly, flowers give the taxonomic key to all groups of angiosperm. Floral characters are the most important tool in taxonomic decisions since Linnaeus (1737). Floral characters such as the type and position of inflorescence, flowers and associated structures such as structure of perianth, floral symmetry, the number, size, shape and union of floral leaves in each whorl, types of androecium, stamens numbers and pollen grains, gynoecium and carpel characters, fruits and ovules, beside characters of bracts, bracteoles and pedicels are very important from the taxonomic point of view. These characters are more stable than the external vegetative ones and considered from the most important characters in taxonomic decisions.

The Papaveraceae *senso lato* comprise the three families, Papaveraceae , Fumariaceae and Hypecoaceae, has diverse floral features which make it interesting to reevaluate it and considered in the taxonomy of the group. For that, this work has been done in order to clarify the relations between the studied taxa according to their variations in floral characters. Hidalgo and Gleisberg (2010) gave clear description of the Papaveraceae floral structures which varied between the main divisions of the three restricted families and even between the genera. From the result obtained the Papaveraceae *s.s.* is the only ones with actinomorphic flowers emerged solely and not aggregated in inflorescences. The symmetry of the flowers is the first observable character to recognize members of the papaveraceae from the two other families. From the correlation analyses of the obtained characters, the number of flower per inflorescence is highly correlated with the symmetry of the flowers as well as the presence of style and fruit shape. Meanwhile the symmetry of the flowers is positively correlated with type of fruits and pollen grain characters and negatively correlated with the number of stamen. These characters are obviously identified members of the Fumariaceae. The number of flowers / inflorescence divided the Fumariaceae into two categories; *F.microstachys* and *Dicentra Formosa* having from 5 to 7 flowers, and the rest of the studied taxa have from 8 to 18 flowers. This division coincides with Lidén (1986) who proposed two tribes within the Fumariaceae, Corydaleae Rchb. and Fumarieae.

The position of the Hypecoaceae as separate family is confusing, Lidén (1986) considered the genus *Hypecoum* L. at subfamily level within family Papaveraceae *s.l.* but in his later work (1993) he treated Fumariaceae as an separate family and maintained *Hypecoum* as a subfamily within Fumariaceae (Lidén, 1993). The result obtained shows that the *Hypecoum* species have floral characters similar to those within Papaveraceae members, the only things share the Fumariaceae on are the zygomorphic flowers and the number of stamens. Thus it is logic to put the Hypecoaceae as subfamily level under the Papaveraceae. Wang *et al*. (2009) found that *Hypecoum* was a sister clade of *Pteridophyllum* Siebold & Zucc. which had been considered the earliest-diverging lineage of Papaveraceae *s.l*., and that both genera were related to the Fumarioideae taxa. Our results prefer the separation of the Fumariaceae as separate family as mentioned before by Cronquist (1981).

The floral characters of the studied taxa within the Papaveraceae *s.s* support the position of genus *Eschscholzia* has its characteristic features which might enables it to be upgraded to the subfamily level; Eschscholzioidea; as mentioned by Ernst (1962a & b), Layka (1976), Heslop-Harison & Shivana (1977), Mabry (1973), Kadereit (1993), Kadereit *et al.*(1994) , Bruckner (2000) and Taia (2008 & 2009). The data obtained from the fruit characters support the separation of the *Eschscholzia* from both the *Papaver* and *Hypecoum* and each of them will be in separate subfamily, Eschscholzioidea, Papaveroideae and Hypecoideae. This classification support that obtained by Hoot *et al.* (1997). While the separation of the genus *Hypecoum*, as proposed by Hoot *et al.* (2015), in another family is not supported as all the studied genera form related groups.

Palynological results show that the Papaveroideae taxa have either echinate or reticulate exine sculpture, while those belonging to the Fumaroideae have scabrate or smooth exine sculpture. Shapes of the pollen grains differs between the Papaveroideae and Fumaroidea as well, in addition to the type of aperture which varied from the colpate to colporoidateto the porate with different numbers (table 5).

From this results, we can construct phylogenetic trend within the studied taxa as the Papaveroideae considered the most primitive, then the Hypecoideae and last with the Fumaroideae. Within the Papaveroideae *Roemeria* is the most primitive genus, then *Glaucium* and *Papaver* and the *Argemone* is the most advanced one. Within the three families genus *Dicentra* considered the more advanced one, as it has zygomorphic flowers arranged in inflorescences with closed corolla, capsule fruits and scabrate exine surface and this coincide Berg (1969) and Stern (1970).

Scheme towards the advanced taxa

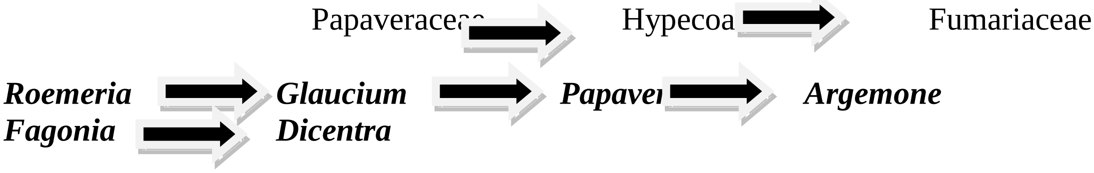


Table 1 Collection data of the studied taxa

IK= Index Kewenses, IPNI= International Plant Name Index, Sp.Pl.= Species Plantarum, WCSP is an international collaborative programme that provides the latest peer reviewed and published opinions on the accepted scientific names and synonyms of selected plant families.

No	Family	Genus	Species	Localities	Source	Confirmation of nomenclature
1	Papaveraceae A.Juss.	*Argemone L.*	*A.mexicana.* L.	Sinai (Saint catrein) The road of Nile, Helwan	CAI	-- Sp. Pl. 2 1753 (IPNI). -- Sp. Pl. 1: 508. 1753 [1 May 1753] (GCI). -- Sp. Pl. 1: 508. 1753 [1 May 1753] (IK).
2		*Eschscholzia* Cham	*E. caespitosa* Benth.	Napa County, California	ALEX	WCSP, 2012, 23-3.
3			*E. californica* Cham	Solano, Yolo, Marin Counties, California	ALEX	WCSP,2012, 23-3.
4			*E. glyptosperma* Greene	Inyo County, California	ALEX	WCSP, 2012,23-3. Bull. Calif. Acad. Sci. 1(3): 70 1885. IPNI: http://ipni.org/urn:lsid:ipni.org:names:672773.
5			*E. lemmonii* Greene	San Luis Obispo County, California	ALEX	WCSP,2012, 23-3.
6			*E. lobii* Greene	Solano County, California	ALEX	WCSP,2012, 23-3.
7			*E. minutifolia* S.Wattson	Inyo County, California	ALEX	WCSP,2012, 23-3.
8		*Glaucium* Adans	*G.arabicum* Fres.	Sinai	ALEX	WCSP,2012, 23-3.
9			*G. corniculatum.* (L.) Rudolph.	King maruit (Fresh Sp.)	ALEX	- Fl. Londin. (Curtis) vi. t. 32. (IK). - Florae Jenensis Plantas 1781 (APNI).
10		*Papaver* L.	*P.argemone* L.	King Mariut (Fresh Sp.)	ALEX	WCSP,2012, 23-3.
11			*P. decaisneii.* Hochst & Steud.	Sinai	CAI	Monogr. Papaver 26. 1839 [2 Oct 1839] (IK)
12			*P. dubium.* L.	Borg El Arab (Fresh Sp.)	ALEX	- Species Plantarum 2 1753 (APNI). - Fl. Napol. 4: 306. 1830 (IK). - Sp. Pl. 2: 1196. 1753 [1 May 1753] (IK). - Deutschl. Fl. (Sturm), ed. 2. 6: 12. 1902 (IK).
13			*P.humile.* Fedde	Borg El Arab (Fresh Sp.)	ALEX	-- Bull. Herb. Boissier Ser. II. v. 446. (IK).
14			*P.hybridum.* L.	Borg El Arab (Fresh Sp.)	ALEX.	- Sp. Pl. 1: 506. 1753 [1 May 1753] (IK). - Species Plantarum 2 1753 (IPNI). - Fl. Friburg. 3: 979. 1829 (IK).
15			*P.rhoeas.* L.	Borg El Arab (Fresh Sp.)	ALEX	- Sp. Pl. 1: 507. 1753 [1 May 1753] (IK). - Species Plantarum 2 1753 (APNI). - Sp. Pl. 1: 507. 1753 [1 May 1753] (GCI). - Reise Russ. Reich. 3(2): 546. 1776 (IK).
16		*Roemeria* Medic.	*R. hybrida.* (L). Dc.	Baheig Borg El Arab road (Fresh Sp.)	ALEX	- Regni Vegetabilis Systema Naturale 2 1821 (IPNI). - Abh. Königl. Böhm. Ges. Wiss. ser. 5, 3: 438. 1845 [Jul-Dec 1845] ; Bot. Bemerk. (C. Presl): 8. [Jan-Apr 1846](IK). - Syst. Nat. [Candolle] 2: 92. 1821 [late May 1821] (IK).
17	Fumariaceae	*Dicentra* Benth.	*D.formosa* (Haw)Walp.	Placer County, California)	ALEX	WCSP, 2012, 23-3.
18		*Fumaria* L.	*F. bracteosa.* Pomel.	Borg El Arab (Fresh Sp.)	ALEX	Nouv. Mat. Fl. Atl. 239. 1874 (IK).
19			*F. densiflora.* Dc.	Borg El Arab (Fresh Sp.)	ALEX	- Catalogus Plantarum Horti Botanici Monspeliensis 1813 (APNI). - Cat. Pl. Horti Monsp. 113. 1813 [Feb-Mar

27						1813] (IK). - Consp. Fl. Eur. 1: 27. 1878 [Sep 1878] (IK). - Syst. Nat. [Candolle] 2: 137. 1821 [late May 1821] (IK).
20			*F. gaillardotii.* Boiss.	Lake Mariut(Fresh Sp.)	ALEX	- Fl. Orient. [Boissier] 1: 139. 1867 [Apr-Jun 1867] (IK).
21			*F.judaica.* Boiss.	Faculty garden (Fresh Sp.)	ALEX	-- Diagn. Pl. Orient. ser. 1, 8: 15. 1849 [Jan-Feb 1849] (IK).
22			*F. microstachys.* Hausskn.	Mersa Matrouh (`Agiba) (Fresh Sp.)	ALEX	-- Flora 56: 552. 1873 (IK).
23			*F. officinalis.* L.	Mersa Matrouh (Fresh Sp.)	ALEX	-- Bull. Soc. Imp. Naturalistes Moscou vi. (1833) 247. (IK). *Fumaria officinalis* L. -- Sp. Pl. 2: 700. 1753 [1 May 1753] (GCI). -- Nouv. Fl. 22Pélop. 45. 1838 (IK). -- Nova Acta Regiae Soc. Sci. Upsal. Ser. III, ii. (1856-58) 275. (IK). . -- Sp. Pl. 2: 700. 1753 [1 May 1753] (IK). -- Fl. Ind. (N. L. Burman) Prodr. Fl. Cap.: 20. 1768 [1 Mar-6 Apr 1768] (IK). -- Hist. Nat. Iles Canaries (Phytogr.) i. 53. (IK). *Fumaria officinalis* L. -- Species Plantarum 2 1753 (APNI).
24			*F. parviflora.* Lam.	Mersa Matruh (Fresh Sp.)	ALEX	-- Fl. Graec. Prodr. 2(1): 50. 1813 (IK). *Fumaria parviflora* Wight & Arn. -- Prodr. Fl. Ind. Orient. 1: 18. 1834 [10 Oct 1834] (IK). – Encyclop die Methodique, Botanique 2 1786 (APNI). -- Encycl. [J. Lamarck & al.] 2(2): 567. 1788 [14 Apr 1788] (IK).
25	*Hypecoaceae*	*Hypecoum*	*H. aegyptiacum.* (Forssk.) Asch. & Schweinf.	Borg El Arab (Fresh Sp.)	ALEX	- Mém. Inst. Égypt. 2: 37. 1887 (IK).
26			*Parviflorum* L.	Sinai	ALEX	WCSP, 2012, 23-3.
27			*H.pendulum.* L.	El Kome ElAkhdar Island	TAN	- Sp. Pl. 1: 124. 1753 [1 May 1753] (IK). - Hist. Pl. Pyrenées 76. 1813 (IK). - Sp. Pl. 2 1753 (APNI).

Table 2 Flower characters within the studied taxa

Abreviations: Infl.=Inflorescence, L.=Length, W.=Width, Col.=Colour, Gl=Glabrous, Sym.=Symmetry, Act.=Actinomorphic, Zyg=Zygomorphic

No.	Character Species	No. of flowers	Infl L. (cm)	Infl W.(cm)	Bract /Pedicel	Calyx		Corolla	
						Col.	Surface	Color	Sym.
1	*A. mexicana.*	1	____	____	Shorter	Gr	Spiny	Yellow	Act.
2	*E. caespitosa*	1	____	____	Shorter	Gr	Hairy	Yellow	Act..
3	*E. californica*	1	____	____	Shorter	Gr	Gl	Yellow	Act..
4	*E. glyptosperma*	1	____	____	Shorter	Gr	Gl.	Yellow	Act.
5	*E. lemmonii*	1	____	____	Shorter	Gr	Hairy	Yellow	Act.
6	*E. lobii*	1	____	____	Shorter	Gr	Hairy	Yellow	Act.
7	*E. minutifolia*	1	____	____	Shorter	Gr	Densely hairy	Red	Act.
8	*G. . arabicum*	1	____	____	Shorter	Gr	Hairy	Red	Act.

9	*G. . corniculatum.*	1	____	____	Shorter	Gr	Densely hairy	Red	Act.
10	*P.argemone*	1	____	____	Shorter	Gr	Gl	Red	Act.
11	*P.decaisneii.*	1	____	____	Shorter	Gr	Gl	Orange	Act.
12	*P.dubium.*	1	____	____	Shorter	Gr	Hairy	Orange	Act.
13	*P.humile.*	1	____	____	Shorter	Gr	Hairy	Red	Act.
14	*P.hybridum.*	1	____	____	Shorter	Gr	Hairy	Red	Act.
15	*P.rhoeas.*	1	____	____	Shorter	Gr	Hairy	Red	Act.
16	*R.hybrida.*	1	____	____	Shorter	Gr	Hairy	Purple	Act.
17	*D. Formosa*	4-7 (6± 1.3)	1.3-1.8 (1.66 ± 1.3)	0.5-0.7 (0.55± 0.12)	Longer	Gr	Gl	Cream	Zyg.
18	*F.bracteosa.*	15 – 19 (17 ± 1.3)	1.3 – 2.9 (2.8 ± 0.53)	0.3 – 0.6 (0.45 ± 0.12)	Longer	Col	Gl	Pink	Zyg.
19	*F.densiflora.*	14 – 22 (18 ± 2.5)	1.2 – 2.8 (1.85 ± 0.55)	0.2 – 0.5 (0.34 ± 0.13)	Longer	Col	Gl	Pink	Zyg.
20	*F.gaillardotii.*	10 – 18 (14 ± 3.1)	2.6 – 2.8 (2.7 ± 0.08)	0.1 – 0.3 (0.2 ± 0.079)	Shorter	Col	Gl	Pink	Zyg.
21	*F.judaica.*	8 – 18 (12 ± 3)	1.6 – 3.4 (2.27 ± 0.62)	0.35 – 0.65 (0.47 ± 0.1)	Shorter	Col	Gl	White	Zyg.
22	*F.microstachys.*	5 – 7 (6 ± 1)	0.9 – 1.2 (1 ± 0.13)	0.1 – 0.2 (0.15 ± 0.05)	Longer	Col	Hairy	Pink	Zyg.
23	*F.officinalis.*	10 – 18 (14 ± 2.6)	2.13 – 2.32 (2.2 ± 0.068)	0.38 – 0.44 (0.4 ± 0.031)	Shorter	Col	Gl	Pink	Zyg.
24	*F.parviflora.*	14 – 18 (16± 1.58)	2.6 – 2.8 (2.7 ± 0.08)	0.5 – 0.6 (0.55 ± 0.038)	Longer	Col	Gl	White	Zyg.
25	*H.aegyptiacum*	1	____	____	Shorter	Gr	Gl	Yellow	Zyg.
26	*H. parviflorum*	1	____	____	Shorter	Gr	Gl	Yellow	Zyg.
27	*H. pendulum.*	1	____	____	Shorter	Gr	Gl	Yellow	Zyg.

Table 3 Ovary characters of the studied taxa

No.	Character Species	Style	Stigma		Shape	Surface	Trichome type
			No.	Shape			
1	*A. mexicana.*	Absent	5	Lobed	Globose	Spiny	Spines
2	*E. caespitosa*	Present	2	Lobed	Linear	Gl.	---
3	*E. californica*	Present	2	Biforked	Linear	Gl.	---
4	*E. glyptosperma*	Present	2	Lobed	Linear	Gl.	---
5	*E. lemmonii*	Present	2	Lobed	Linear	Gl.	---
6	*E. lobii*	Present	2	Lobed	Linear	Gl.	---
7	*E. minutifolia*	Present	2	Lobed	Linear	Gl.	---
8	*G.arabicum*	Absent	2	Lobed	Linear	Hairy	MU
9	*G.corniculatum.*	Absent	2	Lobed	Linear	Hairy	MU
10	*P.argemone*	Absent	5	Discoid	Rectangular	Gl.	---

11	***P.decaisneii.***	**Absent**	**5**	**Discoid**	**Rectangular**	**Gl.**	**---**
12	***P.dubium.***	**Absent**	**10**	**Discoid**	**Rectangular**	**Gl.**	**---**
13	***P.humile.***	**Absent**	**7**	**Lobed**	**Rectangular**	**Gl.**	**---**
14	***P.hybridum.***	**Absent**	**7**	**Lobed**	**Rectangular**	**Gl.**	**---**
15	***P.rhoeas.***	**Absent**	**12**	**Discoid**	**Rectangular**	**Gl.**	**---**
16	***R.hybrida.***	**Absent**	**4**	**Pointed**	**Rectangular**	**Hairy**	**MU**
17	***D. Formosa.***	**Present**	**2**	**Biforked**	**Globose**	**Gl.**	**---**
18	***F.bracteosa.***	**Present**	**2**	**Biforked**	**Globose**	**Gl.**	**---**
19	***F.densiflora.***	**Present**	**2**	**Biforked**	**Globose**	**Gl.**	**---**
20	***F.gaillardotii.***	**Present**	**2**	**Biforked**	**Globose**	**Hairy**	**MU**
21	***F.judaica.***	**Present**	**2**	**Biforked**	**Globose**	**Gl.**	**---**
22	***F.microstachys.***	**Present**	**2**	**Biforked**	**Clobose**	**Hairy**	**MG**
23	***F.officinalis.***	**Present**	**2**	**Biforked**	**Globose**	**Gl.**	**---**
24	***F.parviflora.***	**Present**	**2**	**Biforked**	**Ridged**	**Gl.**	**---**
25	***H.aegyptiacum***	**Present**	**2**	**Lobed**	**Linear**	**Gl.**	**---**
26	***H. parviflorum***	**Present**	**2**	**Lobed**	**Linear**	**Gl.**	**---**
27	***H. pendulum.***	**Present**	**2**	**Lobed**	**Linear**	**Gl.**	**---**

Table 4 Fruit characters of the studied taxa

No.	**Character Species**	**Fruit Type**	**Fruit shape**	**Fruit surface**	**Fruit length (cm)**	**Fruit width (cm)**
1	***A. mexicana.***	**Capsule op. by valve**	**Oblong**	**Spiny**	**2.5 – 5.2 (3.8 ± 1.11)**	**1.1-2.0 (1.5 ± 0.11)**
2	***E. caespitosa***	**Capsule op. by valve**	**Linear**	**Glabrous**	**3.8-5.2 4.6±0.87)(**	**0.8-1.4 (1.1±0.33)**
3	***E. californica***	**Capsule op. by valve**	**Linear**	**Glabrous**	**4.8-6.2 5.2±0.82)(**	**0.5-1.1 (0.6±0.21)**
4	***E. glyptosperma***	**Capsule op. by valve**	**Linear**	**Glabrous**	**4.8-5.4 5.1±0.62)(**	**0.5-1.0 (0.9±0.33)**
5	***E. lemmonii***	**Capsule op. by valve**	**Linear**	**Glabrous**	**3.8-4.8 4.5±0.62)(**	**0.6-1.0 (0.9±0.33)**
6	***E. lobii***	**Capsule op. by valve**	**Linear**	**Glabrous**	**4.6-5.6 5.1±0.62)(**	**0.5-1.0 (0.9±0.33)**
7	***E. minutifolia***	**Capsule op. by valve**	**Linear**	**Glabrous**	**4.8-5.4 4.9±0.62)(**	**0.5-1.0 (0.9±0.33)**
8	***G arabicum.***	**Capsule op. by valve**	**Linear**	**Hairy**	**8.5-12.5 (11.5± 1.5)**	**0.25 – 0.4 (0.32 ± 0.07)**
9	***G.corniculatum .***	**Capsule op. by valve**	**Linear**	**Hairy**	**5.9 – 13.3 (8.32 ± 3)**	**0.2 – 0.4 (0.28 ± 0.07)**
10	***P.argemone***	**Capsule op. by pores**	**obovate**	**Glabrous**	**1.2-2.2 (1.82 ± 0.13)**	**0.3-0.8 (0.45 ± 0.016)**

11	***P.decaisneii.***	**Capsule op. by pores**	**Oblong**	**Glabrous**	**0.8 – 1.8 (1.36 ± 0.43)**	**0.4 – 0.8 (0.6 ± 0.15)**
12	***P.dubium.***	**Capsule op. by pores**	**Oblong**	**Glabrous**	**0.8 – 1.1 (0.93 ± 0.12)**	**0.4 – 0.5 (0.45 ± 0.036)**
13	***P.humile.***	**Capsule op. by pores**	**Oblong**	**Glabrous**	**0.9 – 1.3 (1.1 ± 0.16)**	**0.4 – 0.7 (0.54 ± 0.11)**
14	***P.hybridum.***	**Capsule op. by pores**	**Oblong**	**Hairy**	**1.2 – 1.5 (1.32 ± 0.13)**	**0.6 – 0.8 (0.71 ± 0.1)**
15	***P.rhoeas.***	**Capsule op. by pores**	**Oblong**	**Glabrous**	**1.2 – 1.5 (1.36 ± 0.11)**	**0.5 – 0.7 (0.62 ± 0.083)**
16	***R.hybrida.***	**Capsule op. by valves**	**Linear**	**Hairy**	**3.8 – 5.7 (4.54 ± 0.87)**	**0.15 – 0.3 (0.21 ± 0.05)**
17	***D. Formosa.***	**Capsule op.by valves**	**Linear**	**Hairy**	**2.4-4.7 (3.5± 0.85)**	**0.5-0.8 (0.6± 0.14)**
18	***F.bracteosa.***	**Nut**	**Globose**	**Glabrous**	**0.15 – 0.2 (0.17 ±0.02)**	**0.15 – 0.2 (0.17 ± 0.02)**
19	***F.densiflora.***	**Nut**	**Globose**	**Glabrous**	**0.1 – 0.22 (0.15 ± 0.05)**	**0.1 – 0.22 (0.15 ± 0.05)**
20	***F.gaillardotii.***	**Nut**	**Globose**	**Hairy**	**0.25 – 0.35 (0.3 ± 0.04)**	**0.25 – 0.35 (0.3 ± 0.04)**
21	***F.judaica.***	**Nut**	**Globose**	**Glabrous**	**0.15 – 0.28 (0.23 ± 0.04)**	**0.15 – 0.28 (0.23 ± 0.04)**
22	***F.microstachys.***	**Nut**	**Globose**	**Hairy**	**0.48 – 0.64 (0.55 ± 0.67)**	**0.38 – 0.52 (0.4 ± 0.08)**
23	***F.officinalis.***	**Nut**	**Globose**	**Glabrous**	**0.28 – 0.32 (0.3 ± 0.15)**	**0.28 – 0.32 (0.3 ± 0.15)**
24	***F.parviflora.***	**Nut**	**Globose**	**Glabrous**	**0.17 – 0.22 (0.19 ± 0.018)**	**0.17 – 0.22 (0.19 ± 0.018)**
25	***H.aegyptiacum***	**Siliquose, articulated**	**Linear**	**Glabrous**	**1.2 – 4.2 (2.52 ± 1.08)**	**0.2 – 0.4 (0.3 ± 0.288)**
	H. parviflorum	**Siliquose, articulated**	**Linear**	**Glabrous**	**1.8-3.7 (2.8± 1.37)**	**1.2-2.8 (2. 5 ± 0.14)**
	H. pendulum.	**Siliquose, articulated**	**Linear**	**Glabrous**	**2 – 5.6 (3.6 ± 1.37)**	**1.2 – 3.3 (2.25 ± 0.14)**

Table 5 Stamen and pollen grain characters of the studied taxa

No.	Character Species	No.of stamens	Pollen Shape	Aperture		Exine Ornamentation
				Type	Number	

1	***A. mexicana.***	**Many**	**Peroblate**	**Colporate**	**3**	**Retic.**
2	***E. caespitosa***	**12**	**Peroblate**	**Colpate**	**4-6**	**Retic.**
3	***E. californica***	**12**	**Peroblate**	**Colpate**	**4-6**	**Retic.**
4	***E. glyptosperma***	**12**	**Peroblate**	**Colpate**	**4-6**	**Retic.**
5	***E. lemmonii***	**12-16**	**Peroblate**	**Colpate**	**4-6**	**Retic.**
6	***E. lobii***	**10-12**	**Peroblate**	**Colpate**	**4-6**	**Retic.**
7	***E. minutifolia***	**10-12**	**Peroblate**	**Colpate**	**4-6**	**Retic.**
8	***G. arabicum***	**Many**	**Subprolate**	**Colporoid ate**	**3**	**Retic**
9	***G. corniculatum.***	**Many**	**Subprolate**	**Colporoid ate**	**3**	**Retic**
10	***P. argemone***	**Many**	**Perprolate**	**Colpate**	**3**	**Echinate**
11	***P. decaisneii.***	**Many**	**Perprolate**	**Colpate**	**3**	**Echinate**
12	***P. dubium.***	**Many**	**Peroblate**	**Colpate**	**3**	**Scabrate**
13	***P. humile.***	**Many**	**Perprolate**	**Colpate**	**3**	**Echinate**
14	***P.hybridum.***	**Many**	**Subprolate**	**Colporoid ate**	**3**	**Echinate**
15	***P. rhoeas.***	**Many**	**Perprolate**	**Colpate**	**3**	**Echinate**
16	***R. hybrida.***	**Many**	**Spheroidal**	**Colporoid ate**	**4**	**Echinate**
17	***D. Formosa.***	**6**	**Subprolate**	**Colpate**	**3**	**Scabrate**
18	***F. bracteosa.***	**6**	**Subprolate**	**Porate**	**6**	**Rugate**
19	***F .densiflora.***	**6**	**Spheroidal**	**Porate**	**6**	**Rugate**
20	***F.gaillardotii.***	**6**	**Subprolate**	**Colporate**	**3**	**Psilate**
21	***F.judaica.***	**6**	**spheroidal**	**Porate**	**8**	**Rugate**
22	***F.microstachys.***	**6**	**Spheroidal**	**Colporate**	**3**	**Psilate**
23	***F.officinalis.***	**6**	**Peroblate**	**Porate**	**6**	**Rugate**
24	***F.parviflora.***	**6**	**Subprolate**	**Porate**	**6**	**Rugate**
25	***H.aegyptiacum***	**3**	**Spheroidal**	**Colpate**	**3**	**Echinate**
26	***H. parviflorum***	**3**	**Spheroidal**	**Colpate**	**3**	**Echinate**
27	***H. pendulum.***	**3**	**Spheroidal**	**Colpate**	**3**	**Ecchinate**

Table 6 Statistical values of the nineteen most variable characters mentioned below

1= No.of flowers/Inflorescence	**2= Flower symmetry**	**3= Bract/Pedicel**	**4= Calyx surface**
5=Style presency	**6=Number of stigma**	**7=Stigma shape**	**8=Ovary shape**
9=Ovary surface	**10=Fruit type**	**11=Fruit shape**	**12=Fruit surface**
13=Fruit length	**14=Fruit width**	**15=Stamen number**	**16=Pollen shape**

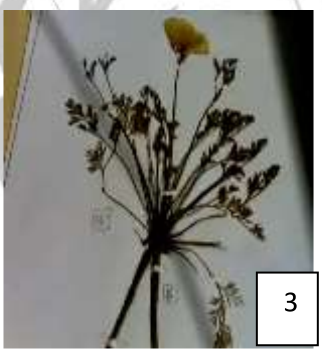
	Mean	Standard error	Standard deviation	Sample variance	Range	Mini.	Max.	Sum	Count
1	4.52	1.16	6.03	36.34	17	1	18	122	27
2	1.41	0.09	0.50	0.25	1	1	2	38	27
3	1.85	0.08	0.40	0.16	1	1	2	32	27
4	1.96	0.21	1.09	1.20	3	1	4	53	27
5	1.59	0.09	0.50	0.25	1	1	2	43	27
6	3.44	0.52	2.69	7.26	10	2	12	93	27
7	2.60	0.15	0.8	0.64	3	1	4	70	27
8	1.96	0.18	0.94	0.88	3	1	4	53	27
9	1.4	0.15	0.80	0.64	2	1	3	38	27
10	2.11	0.20	1.05	1.10	3	1	4	57	27
11	2.26	0.25	1.32	1.74	3	1	4	61	27
12	1.56	0.17	0.89	0.79	2	1	3	42	27
13	2.96	0.53	2.74	7.51	11.3	0.2	11.5	79.8	27
14	0.7	0.12	0.60	0.34	2.3	0.2	2.5	18.8	27
15	12.12	1.29	6.71	45.00	17	3	20	329	27
16	3.41	0.21	1.08	1.17	3	2	5	92	27
17	1.93	0.23	1.21	1.46	3	1	4	52	27
18	4.33	0.31	1.61	2.62	5	3	8	117	27
19	3.00	0.33	1.71	2.92	4	1	5	81	27

17=Aperture type	18=Aperture number	19=Exine ornamentation

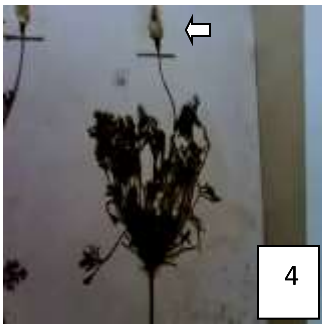
Table 7 Correlation between the nineteen most variable characters, grey cells= highly +ve correlated, blue cells=+ve correlation, pink cells=-ve correlation,redcells= highly –ve correlation, white cells=no correlation

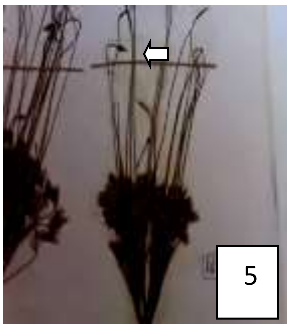
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	1																		
2	0.72	1																	
3	0.65	0.58	1																
4	0.48	0.61	0.25	1															
5	0.49	0.69	0.40	0.52	1														
6	0.33	0.45	0.25	0.33	0.66	1													
7	0.31	0.14	0.26	0.33	0.05	0.41	1												

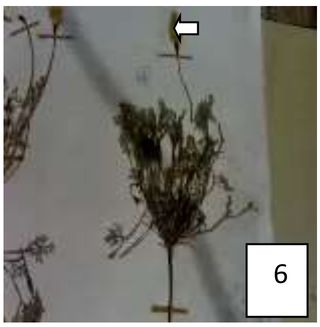
8	**0.77**	**0.53**	**0.64**	**0.34**	**0.13**	**0.07**	**0.44**	**1**											
9	**0.02**	**0.05**	**0.01**	**0.28**	**0.24**	**0.16**	**0.27**	**0.07**	**1**										
10	**0.45**	**0.79**	**0.23**	**0.50**	**0.38**	**0.10**	**0.12**	**0.32**	**0.10**	**1**									
11	**0.73**	**0.42**	**0.42**	**0.23**	**0.05**	**0.24**	**0.54**	**0.85**	**0.01**	**0.42**	**1**								
12	**0.05**	**0.01**	**0.13**	**0.26**	**0.25**	**0.08**	**0.26**	**0.16**	**0.81**	**0.19**	**0.03**	**1**							
13	**0.56**	**0.51**	**0.36**	**0.34**	**0.24**	**0.27**	**0.53**	**0.68**	**0.39**	**0.61**	**0.78**	**0.30**	**1**						
14	**0.46**	**0.03**	**0.31**	**0.02**	**0.12**	**0.07**	**0.33**	**0.46**	**0.27**	**0.09**	**0.45**	**0.26**	**0.19**	**1**					
15	**0.56**	**0.88**	**0.45**	**0.34**	**0.89**	**0.65**	**0.04**	**0.21**	**0.22**	**0.63**	**0.12**	**0.21**	**0.34**	**0.17**	**1**				
16	**0.21**	**1.02**	**0.09**	**0.15**	**0.39**	**0.45**	**0.56**	**0.39**	**0.02**	**0.26**	**0.46**	**0.12**	**0.36**	**0.41**	**0.26**	**1**			
17	**0.87**	**5.62**	**0.51**	**0.29**	**0.27**	**0.27**	**0.13**	**0.78**	**0.23**	**0.37**	**0.76**	**0.15**	**0.42**	**0.45**	**0.34**	**0.14**	**1**		
18	**0.44**	**1.12**	**0.14**	**0.12**	**0.51**	**0.44**	**0.07**	**0.08**	**0.38**	**0.11**	**0.10**	**0.48**	**0.09**	**0.16**	**0.36**	**0.45**	**0.37**	**1**	
19	**0.05**	**2.25**	**0.0**	**0.25**	**0.23**	**0.48**	**0.25**	**0.17**	**0.28**	**0.59**	**0.17**	**0.10**	**0.51**	**0.05**	**0.03**	**0.58**	**0.15**	**0.47**	**1**



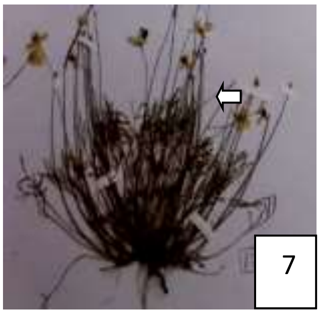
A.mexicana ***E.californica*** ***E. caespitosa***



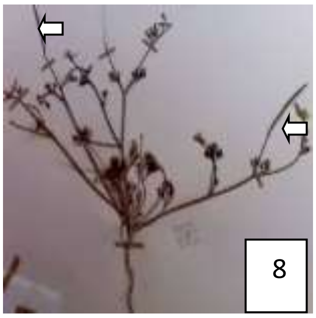




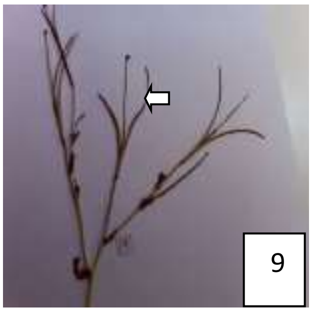
E. glyptosperma ***E. glyptosperma*** ***E. lemmonii***



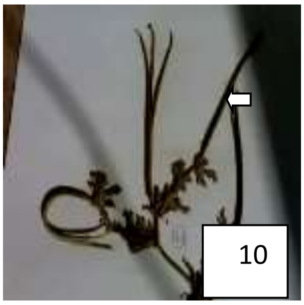
E. lobii



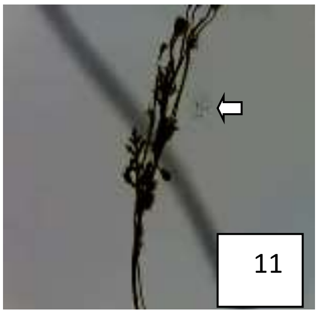
E. minutifolia



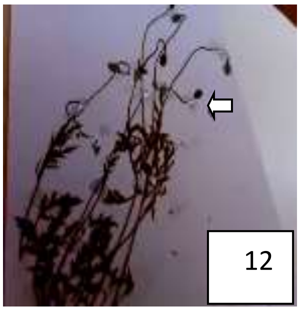
G. arabicum



G.corniculatum

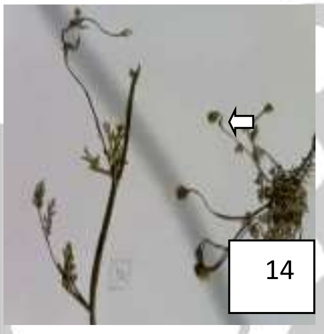


P.argemone

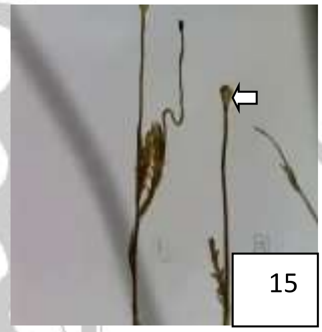


P. decaisneii

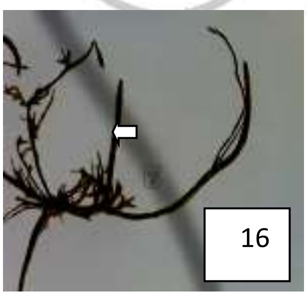
P. dubium



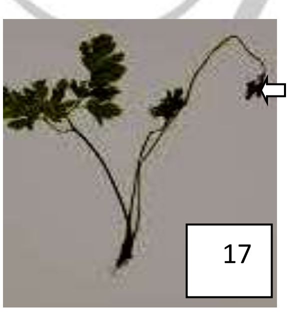
P. hybridum



P. rhoes

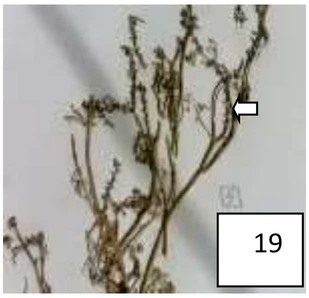


R. hybrid

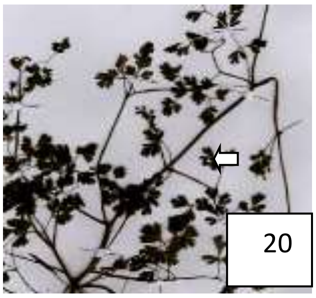


D. Formosa

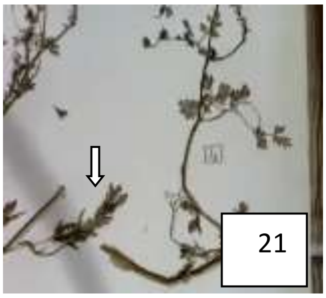
F. bracteosa



F. densiflora

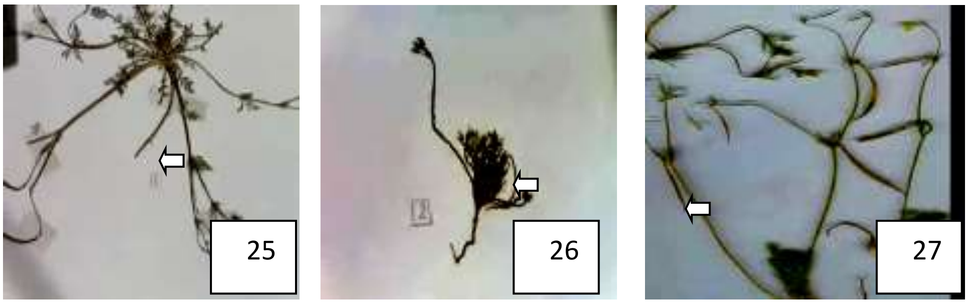


F. gaillordotii



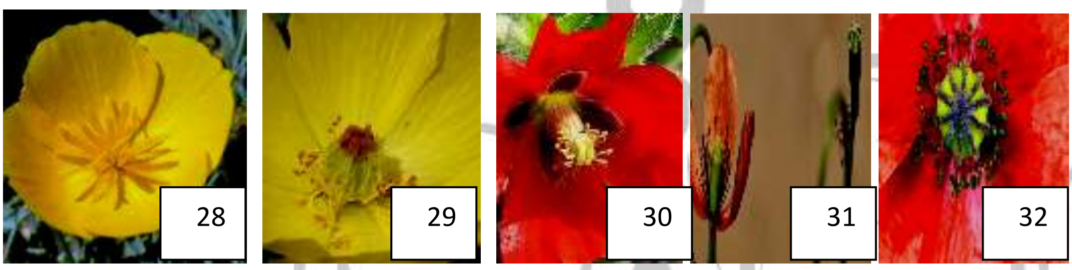
F. judaica

F. microstachs *F. officinalis* *F. parviflora*

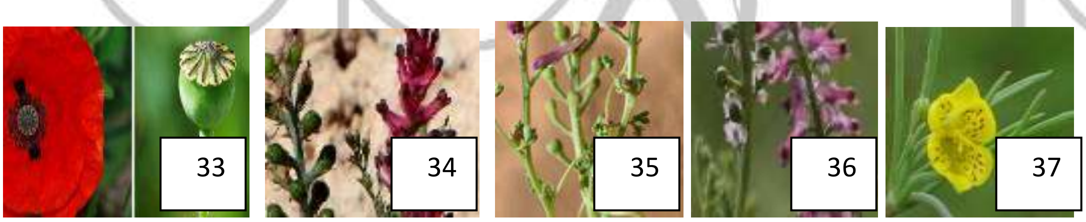


H. aegyptiacum *H. parviflorum* *H. pedulum*

Photographs of herbarium sheets show general appearance and fruits. Arrows indicate to fruit.

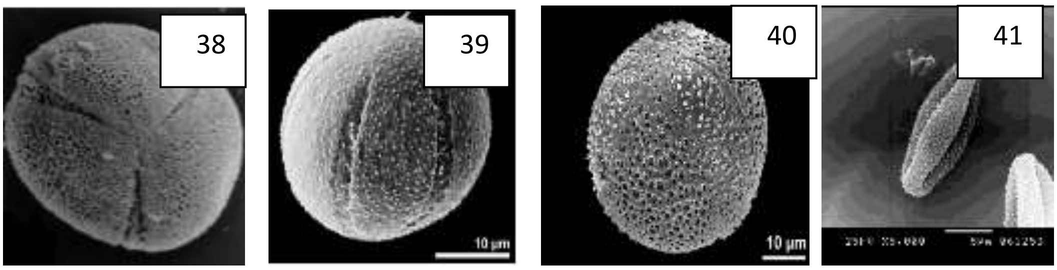


A. mexicana *E. caespitosa* *P. humile* *P. dubium*

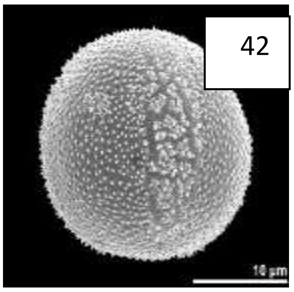


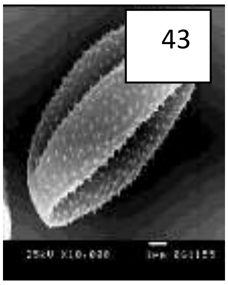
P. rhoes *F.*
densiflora *F. officinalis* *F.parviflora* *H.aegyptiacum*

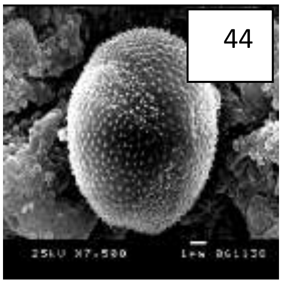
Photographs of selected flowers showing different stigma and fruit types

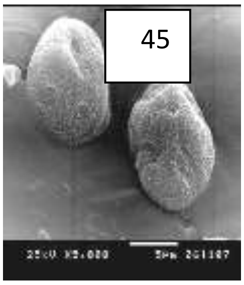


A. mexicana *E. californica* *G .corniculatum* *P.decaisneii*

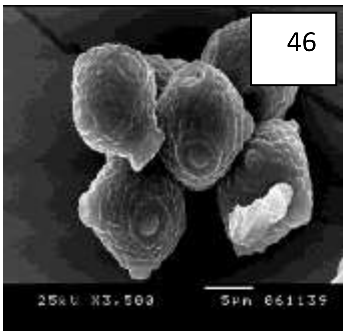


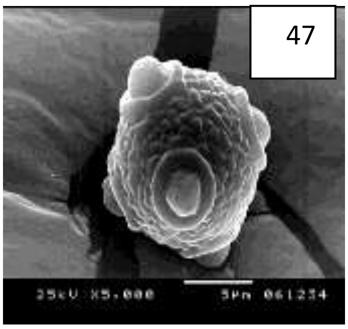


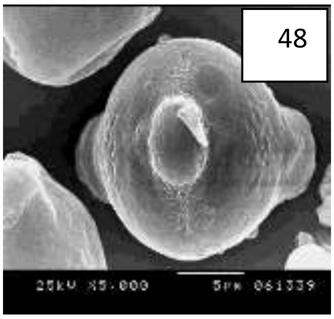




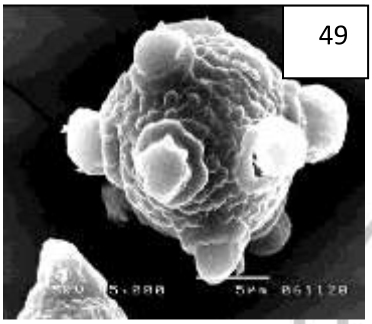
P.dubium *P.humile* *P.hybridum* *Roemeria*

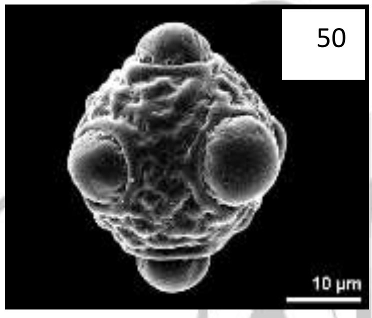


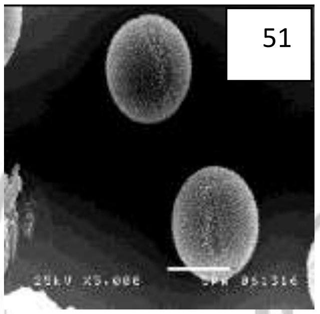




F.bracteosa *F.densiflora* *F.gaillardotii*





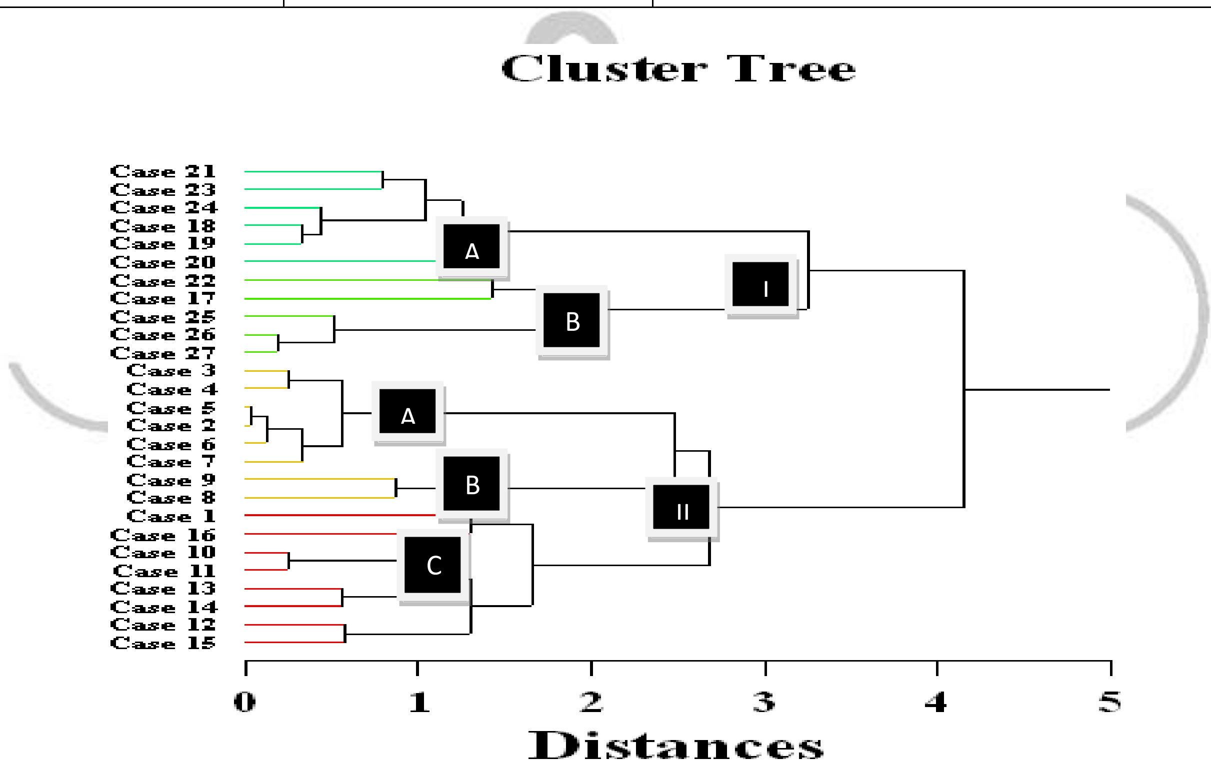


F.bracteosa judaica *F.officinalis* *H.aegyptiacum*

Apendix 1 Characters subjected to SYSTAT 13 clustering analysis

No.	Character	State	Possibilities
1	No.of flowers/Inflorescence	Continuous	
2	Flower symmetry	Binary	1=Actinomorphic, 2=Zygomorphic
3	Bract/Pedicel	Binary	1=shorter, 2=Longer
4	Calyx surface	Multistate qualitative ordered (MQO)	1=Glabrous, 2=Spiny, 3=Hairy, 4=Densely hairy
5	Style	Binary	1=Absent, 2= Present
6	Stigma number	Continuous	
7	Stigma shape	Multistate qualitative unordered (MQUO)	1=Pointed, 2=lobed, 3=Biforked, 4=Discoid
8	Ovary shape	Multistate qualitative unordered (MQUO)	1=Linear, 2=Rectangular, 3=Globose, 4=Riged
9	Ovary surface	Multistate qualitative ordered (MQO)	1=Glabrous, 2=Spiny, 3=Hairy

10	**Fruit type**	**Multistate qualitative unordered (MQUO)**	**1=Capsule opened by valves, 2=Capsule opened by pores, 3=Nut, 4=Soliquose**
11	**Fruit shape**	**Multistate qualitative unordered (MQUO)**	**1=Linear, 2=Obovate, 3=Oblong, 4=Globose**
12	**Fruit surface**	**Multistate qualitative ordered (MQO)**	**1=Glabrous, 2=Spiny, 3=Hairy**
13	**Fruit length**	**Continuous**	
14	**Fruit width**	**Continuous**	
15	**Stamen number**	**Continuous**	
16	**Pollen grain shape**	**Multistate qualitative ordered (MQO)**	**1=Suboblate, 2=Peroblate, 3=Spheroidal, 4=Subprolate, 5=Prolate**
17	**Aperture type**	**Multistate qualitative ordered (MQO)**	**1=Colpate,2=Colporoidate, 3=Colporate, 4=Porate**
18	**Aperture number**	**Continuous**	
19	**Exine ornamentation**	**Multistate qualitative ordered (MQO)**	**1=Reticulate, 2=Psilate, 3=Rugate, 4=Scabrate, 5=Echinate.**



Phenogram showing the grouping of the studied taxa

References

APG I. 1998. An ordinal classification for the families of flowering plants.Ann. Missouri Bot. Gard. (Missouri Botanical Garden Press) **85 (4):** 531–553.

APG II. 2003. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG II. Bot. j. Linn. Soc. **141 (4)**: 399–436.

APG III. 2009. "An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IIIBot. j. Linn. Soc**. 161 (2)**: 399–436.

APG IV. 2016. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV. Botanical Journal of the Linnean Society.**181 (1)**: 1–20.

Barrett S.CH. 2002 .The evolution of plant sexual diversity. Nature Reviews,Genetics **3**: 274-284.

Behnke H.D. & Barthlott W. 1983. New Evidence from the Ultrastructural and Miccromorphological Fields in Angiosperm Classification. Nordic Journal of Botany **3**:43-66.

Benson L.D. 1979. Plant Classification. Ed.2. D.C. Health, Lexington, Mass.

Berg, R. Y. 1969. Adaptation and evolution in Dicentra (Fumariaceae), with special reference to seed, fruit, and dispersal mechanism. Nytt Mag. Bot. **16(1)**: 49-75.

Blagowestschenski**, A.W. 1955**. Die biochemischen Grundlagen des Evolution sprozesses der Pflanzen. Akademie-Verlag, Berlin.

Boulos, L. 1999. Flora of Egypt.Vol.1. (Azollaceae-Oxalidaceae), Al Hadara publishing, Cairo, Egypt. : 116 – 122.

Bruckner C. 2000. Clarification of the carpel number in Papaverales, Capparales, and Berberidaceae. Botanical Review **66 (2)**: 155-304.

Cronquist, A. 1981. An integrated system of classification of flowering plants. Copyright © Columbia University press. Usadoconpermiso de la editorial.

Dahlgren, R. M. T. 1980. A revised system of classification of the angiosperms. Botanical Journal of the Linnean Society **80**: 91–124.

Dahlgren, G. 1989.The last Dahlgrenogram, system of classification of the dicotyledons. In Tan, K., (Ed.): Plant taxonomy, phytogeography and related subjects, pp. 249-260. Edinburgh: Edinburgh University Press.

Ernst, W.R.1962a. A comparative morphology of the Papaveraceae. Ph.D. desertation, Standford University.

Ernst, W. 1962b. The genera of Papveraceae and Fumariaceae in the southeastern united states. J. Ar-nold Arbor. **43**:315-343.

Günther, K. F. 1975. Beitrfige zur Morphologie und Verbreitung der Papaveraceae. 1. Teil: Inflo-reszenzmorphologie der Papaveraceae; Wuchs- form der Chelidonieae. Flora **164**: 185-234.

Heslop-Harrison, Y. & Shivana, K.P. 1977. The receptive Surface of the Angiosperm Stigma. Annals of Botany (London) **41**: 1233-1258.

Hidalgo,O. & Gleisberg, S. 2010. Evolution of Reproductive Morphology in the Papaveraceae s.l.(Papaveraceae and Fumariaceae, Ranunculales). International Journal of Plant Developmental Biology, Global Science Books. 76-85.

Hoot, S. B., Kadereit, J. W., Blattner, F. R., Jork, K. B., Schwarzbach, A. E. & Crane, P. R. 1997. Data congruence and phylogeny of the Papaveraceaes.l.based on four data sets: atpB and rbcL sequences, trnK restriction sites, and morphological characters. Systematic Botany **22**: 575-590.

Hoot, S. B., Wefferling, K. & Wulff, J. 2015. Phylogeny and Character Evolution of Papaveraceae s. l. (Ranunculales) Systematic Botany **40 (2):**474-488·

Hutchinson, J. 1921. The genera of Fumariaceaeand their distribution. - Bull. Mise. Inf., Royal Bot. Gardens, Kew **3:** 97-115.

Kadereit, J.W. 1993. Papaveraceae in: K. Kubitzi et al.(eds.) The families and genera of vascular plants. Berlin **2.**

Kadereit, J. W., Blattner, F. R., Jork, K. & Schwarzbach, A. 1994. Phylogenetic analysis of the Papaveraceaes.l. (including Fumariaceae, Hypecoaceae, and Pteridophyllum).BotanischeJahrbücherfürSystematik und Pflanzengeographie **116**: 361-390.

Kay, K.M., Vaelckel,C., yang, J.Y., Hufford, K.M., Kaska, D.D. & Hodges, S. 2006. Floral characters and species diversification. Genetic Diversity of St Helena Wahlenbergia Project. Chapter **17** Pp 311- 325.

Kubitzki, K. 1993. Families and genera of vascular plants. - Berlin: Springer.

Kong, M.-J. & Hong, S.-P. 2018. The taxonomic consideration of floral morphology in the Persicaria sect. Cephalophil on (Polygonaceae). Korean J. Pl. Taxon. **48(3)**: 185-194.

Lidén , M. 1986 . Synopsis of Fumarioideae (Papaveraceae) with a monograph of the tribu Fumarieae. Opera Botanica **88** : 1 – 133 .

Layka, S. 1976. Les methods modernes de la palynologie appliqués a l`etude des Papaverales. Dissertation, Montpellier, C.N.R.S.A.O. **12**.535.

Lidén , M. 1993a . Fumariaceae. In: K. Kubitzki, J. G. Rohwer, and V. Bittrich [eds.], The families and genera of vascular plants, vol. **2**: Florewing plants, dicotyledons: Magnoliid, hamamelid, and caryophyllid families, 310 – 318. Springer-Verlag, Heidelberg, Germany.

Lidén , M. ,Fukuhara, T., Rylander, J., & Oxelman, B.. 1997 . Phylogeny and classifi cation of Fumariaceae, with emphasis on Dicentra s.l., based on the plastid gene rps16 intron. Plant

Systematics and Evolution **206** : 411 – 420

Linnaeus, C. 1753. Species Plantarum. Stockholm: Laurentii Salvii.

Mabberley, D. J. 1987.The plant book. - Cambridge: Cambridge University Press. Mal, D. H., 1980. ZurBedeutung von Relikten in der Florengeschichte. - In VENT, W., (Ed.): 100 Jahre Arboretum 1879-1979, pp. 281-307. - Berlin.

Mabberley, D. J. 2008.Mabberley's plant-book.A portable dictionary of plants, their classification and uses. Cambridge: Cambridge University Press.

Mabry, T.J. 1973. Is the order Centrospermae monophyletic? In G. Bendz and J. Santesson (Eds.), Chemistry in botanical clasification, 275-285. Academic Press, New York, USA.

Nam, B-M & Chung, G.Y. 2018. Taxonomic implications of floral morphology in the subfamily Asclepiadoideae (Apocynaceae s.l.) in Korea. Korean J. Pl. Taxon. **48(3)**: 172-184.

Small, E.; Crompton, C.V. & Brookes, B.S. 1981. The taxonomic value of floral characters in tribe Trigonelleae (Leguminosae), with special reference to Medicago. Canad. J. Bot. **59 (9)**: 1578-1598.

Stearn, W.T. 1961b. Botanicalgarden and botanical literature in the eighteenth century. Catalogues of botanical booksin the collection of Rachel McMasters Miller Hunt, 2: xlii-cxl.

Stern, K. R. 1970. Pollen aperture variation and phylogeny in Dicentra. Madroño **20**: 354-359.

Tackholm, V. 1974. Student`s Flora of Egypt. 2nd. Ed. Cairo University, Cooperative Printing Company, Beirut.

Taia, W. K. 2008. Systematic Review of the Papaveracea Adans. and Status of Some Genera. By the Egyptian society of environmental sciences. Catrina **3 (1)**: 1 -10.

Taia, W. K. 2009. Review Article of the Papaveracea Adans. and Status of the Egyptian and Saudi Genera. JKAU: Sci., **21(1)**: 145-159.

Taia, W. K., & Sheha, M. A. 2003. Systematic Study within the Papaverales (Papaveraceae and Fumariaceae). Bulletin of Pure and Appllied Sciences **22 B (2)**: 75-93.

Taia, W .K., Shehata, A. A., El-Shamy, I .M. & Ibrahim, M .M. 2020. Biosystematic studies for some Egyptian Amaranthus L. taxa and their significance in their identification. Taeckholmia **40**: 85-99.

Takhtajan, A. 1987.SystemaMagnoliophytorum. - Leningrad: Nauka

Tournefort, J.P De 1656-1708. Herbarium J.P. de Tournefort Muséum National d'Histoire Naturelle, Laboratoire de Phanérogamie, Paris.

Vasconcelos, T.N.C.; Prenner, G. & Lucas, E.J. 2019. A Systematic Overview of the Floral Diversity in Myrteae (Myrtaceae)," Systematic Botany **44(3)**: 570-591.

Wang, W.A., Lu, A.M., Ren, Y., Endress, M.E., & Chen, D. 2009. Phylogeny and classification of Ranunculales: Evidence from four molecular loci and morphological data. Perspectives in Plant Ecology, Evolution and Systematics **11** : 81 – 110 .

Xuan, Z. & Chuang, H. 1993. The taxonomic and evolution and distribution of Papaveraceae.- Acta Bot. Yunnanica **15 (2)**: 137-148.