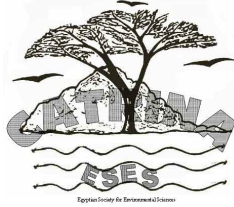


Systematic Review of the *Papaveraceae* Adans. and Status of Some Genera

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ABSTRACT

This work deals with the systematic relations of family *Papaveraceae* according to the new data derived from molecular analysis. An overall view has been given to elucidate the taxonomic position of the family within the basal eudicots. Characteristic features of all the group has been given with clear view of the general features of the family and its taxonomic divisions. Complete list of the genera, as listed by Royal Botanical Gardens in Kew has been added with summary of the recent phylogenetic relationships of the family and its genera. Leaf and fruit morphological variations of 14 species belonging to *Papaveraceae* s.s., 7 species belonging to *Fumariaceae* s.s. and two species from *Hypocoaceae* s.s. have been studied to assess the new classification of the *Papaveraceae* s.l. with complete description of their morphological variations and their position according to the new classification of the family.

Keywords: Eudicots, Magnoliopsida, *Papaveraceae*, Phylogeny, *Ranunculales*, Taxonomy.

Taxonomic Status of the *Papaveraceae* s.l.

The status of family *Papaveraceae* s.l. has been faced with numerous opinions. Before the extensive ribosomal and DNA sequences researches concerning the phylogeny of the taxonomic taxa, the family has been considered by Wettstein (1935) as one of the *Rhoeadales* families. Later, Melchior (1964), Tamura (1974), Benson (1979) and Tutin *et al.* (1993) renamed the order *Rhoeadales* by *Papaverales* s.l. with four suborders; *Papaverinae*, *Capparinae*, *Tovarianae* and *Moringanae*. The family was found to be closely related to the *Brassicaceae*, *Capparidaceae*, *Resedaceae*, *Tovariaceae* and *Moringaceae* (Blagowestschenski, 1955, Hegnauer, 1961 and Gershenzon and Mabry, 1983). The position of these families in the same order is due to flower characters, such as regular and hypogynous flowers, anthers arranged in several whorls and the carpels are syncarpous and possess two to many parietal ovules. Norris (1941) considered the *Papaveraceae* s.l. closely related to both the *Fumariaceae* and *Brassicaceae* and they all evolved from the same origin according to torus anatomy and nectary characteristics.

Family *Papaveraceae* Adans. nom.cons. s.l. which is a north temperate, mostly herbaceous family consisting of 23 genera and about 250 species (Heywood, 1993), Newly recorded species raises the number of genera to 35 as compared with the list given by Royal Botanical Gardens, in Kew, 2006. The family has three synonyms; *Chelidoniaceae* Martinov., *Echscholziaceae* Ser. and *Platystemonaceae* (Rchb.ex Spatch) Lilja. According to Cronquist System (1981), family *Papaveraceae* s.l. is classified under subclass *Magnoliidae* together with the *Magnoliaceae*, *Nymphaeaceae* and *Ranunculaceae*. This subclass is characterized by well developed flowers with separated perianth or calyx and corolla, the stamens are numerous and gynoecium is apocarpous. In *Papaveraceae* gynoecium is paracarpous. According to South West Virginia flora, the *Magnoliidae* comprises nine families; *Magnoliaceae*, *Annonaceae*, *Lauraceae*,

Ranunculaceae, *Papaveraceae*, *Fumariaceae*, *Berberidaceae*, *Menispermaceae*, and *Aristolochiaceae*. The family is closely related to the *Fumariaceae* which often included within it (Norris, 1941, Fohne, 1962, Kolbe, 1978, Behnke and Barthlott, 1983 Chase *et al.*, 1993; Taia and Sheha, 2003). Meanwhile, the family has close affinity to members of *Ranunculales* with the only differences that gynoecium is paracarpous and the presence of secretory idioblasts or laticifers in the *Papaveraceae* s.l., and both families are considered as primitive families. Parker (1982) separated the *Papaveraceae* as an order *Papaverales* while the *Ranunculaceae* as order *Ranunculales* and both orders under subclass *Magnoliidae*, class *Magnoliopsida*. This class refers to a small group containing *Papaveraceae*, *Ranunculaceae* and *Berberidaceae* as sister group to Monocots. Based on the recent work on molecular analysis, done by Hoot *et al.* (1999), the *Papaveraceae* s.l. is considered as one of the families belonging to order *Ranunculales* and they up graded the order *Ranunculales* from *Magnoliidae* to the base of the Eudicots, which is in close association with the Monocots.

Phylogenetic Opinions within the Family

Cronquist (1981) considered the *Ranunculales* as one of the woody magnoliids because their flowers have free parts that are sometimes spirally arranged. Cronquist (1981) suggested that the connection to the woody magnoliids was via *Illiciaceae* (ANITA grade; Qui *et al.*, 1999) due to the presence of triaperturate pollen grains in both groups. Spichiger and Savolainen (1997) pointed to the similarities between the *Ranunculales* and *Papaverales* with the monocots as they share many features such as imperfect vessels; inaperturate or uniaperturate pollen grains (or derived types). Recent works based on molecular analysis considered the *Ranunculales* as a monophyletic group (Fig. 1) (Chase *et al.*, 1993, Drinnan *et al.*, 1994, Hoot and Crane 1995, Soltis *et al.*, 1997, Kallersjo *et al.*, 1998,

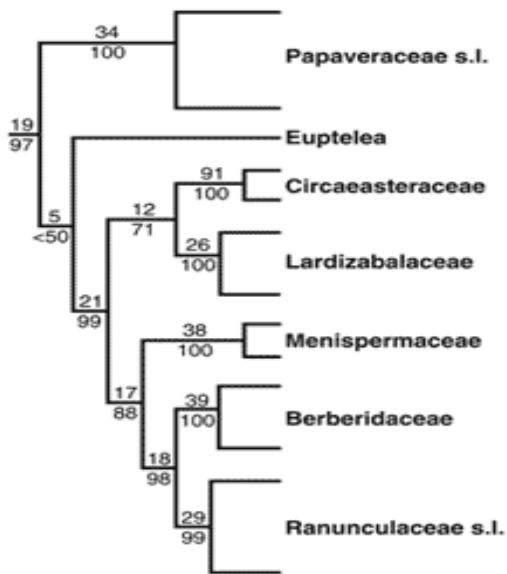


Figure (1): Phylogeny of the *Ranunculales*, showing relative positions of the major families within this order (Tree adapted from Hoot *et al.*, 1999). Numbers above lines indicate the number of nucleotide changes supporting each branch. Number below the branches is the percentage of times that the branch was recovered in 1000 bootstrap replications.

Hoot *et al.*, 1999). Hilu *et al.* (2003), Kim *et al.* (2004) and Worberg *et al.* (2006) supported the close association of the *Papaveraceae* s.l. with the *Fumariaceae* then with the *Eupteleaceae* and the three families are in close relation with the rest of the *Ranunculales* families.

Despite the relations between the *Papaveraceae* s.l. genera are still obscure, due to the lack of fossils records for that group and their geographical distribution. Kadereit *et al.* (1994) found that the genera *Papaver* L., *Meconopsis* Vig., *Stylomecon* G.Taylor and *Roemeria* Medik. Belonging to *Papaveraceae* s.str. subfamily *Papaveroideae* are morphologically similar. In the mean time Schwarzbach & Kadereit (1995) reported that these genera form a monophyletic clade on the basis of molecular analysis. Kadereit *et al.* (1997), on the basis of molecular data concluded that (1) Asian *Meconopsis* is not a monophyletic group, but paraphyletic in relation to *Papaver* s.l. including *M.cambrica*, *Stylomecon* and *Roemeria*; (2) both *Roemeria* and *Stylomecon* are nested with *Papaver* s.l., *Roemeria* is sister group to *Papaver* sect. *Argemonidium* and *Stylomecon* to *papaver californicum*; and (3) the position of *M.cambrica* within *papaver* s.l. (incl. *Stylomecon* and *Roemeria*) allows the arise of it from within *Papaver* s.l. in parallel to Asian *Meconopsis* and in this case the genus *Papaver* will be monophyletic – or *M. cambrica* can be regarded as an original although disjunct *Meconopsis*, in this case the entire genus *Meconopsis* would be paraphyletic in relation to *Papaver* s.l. – or both *Meconopsis* and *Papaver* s.l. are polyphyletic.

General Features of the Family

The family has plants in different varieties of life forms and morphological characters. They are herbs or sub-shrubs, shrubs, or even small trees (*Dendromecon rigida*), annuals, biennials, or perennials. Plants have tap roots or rhizomes with leafy or naked erect or spreading stems. Leaves are basal and/or cauline, alternate to opposite or whorled, simple ex-stipulate petiolate or sessile with entire blade or lobed in pinnate, subpalmate, or palmate orders of lobes. In *Argemone* the leaves are dissected with spiny margins. The leaves are mostly glabrous, except few species covered with ramified or glandular hairs with smooth walls. Stomata are either diacytic or anomocytic with isodiametric or elongated epidermal cells (Heywood, 1993).

The family has variety of flower arrangements, forms and colors, but all are bracteate, radially symmetric, pedicellate or sessile; receptacle sometimes expanded and forming cup or ring beneath calyx (in *Eschscholzia*, *Meconella* and *Platystemon*). The flowers are either solitary or arranged in groups which are either terminal or axillary. The inflorescences are either cymose or racemose, umbelliform or corymbiform. Flowers are sometimes perigynous; sepals two or three, ob-ovate, distinct or connate always caducous. Petals are distinct, colored and ob-ovate, usually four or more, sometimes absent. Stamens are numerous in many whorls, sometimes 4-15 in *Meconella* and *Canbya*, with bilocular anthers (Kiger, 1996). Pollen grains appear spheroidal or sub prolate, medium sized, usually with tricolpate apertures. In some species such as *Papaver argemone*, *Argemone mexicana*, and *Roemeria hybrida*, pollen grains are polyporate (Taia and Sheha, 2003).

Pistil is 1, 2 to many (22) united carpels with one or two locules, sometimes multilocular by placental intrusion, placenta two or more in parietal position. Style is usually one or absent with sessile stigma. Stigma lobes are 2 to many in circular disc or radiating ones. Fruits are capsules dehiscent by pores, valves or dissociating and breaking transversely into one seeded segments (only in *Platystemon*). Seeds are always many small, sometimes arillate or carunculate with different colors varies from white to black or different shades of brown.

Classification of the Family

The *Papaveraceae* s.l. is subdivided into three subfamilies by Hoot *et al.*, 1997; *Pteridophylloideae*, *Papaveroideae*, and *Fumarioideae*. Ernst (1962), Layka (1976), Heslop-Harison and Shivana (1977), Mabry (1973), Kaderreit (1993), Kaderreit *et al.* (1994) and Bruckner (2000) divided the family into four subfamilies; *Chelidonoideae*, *Eschscholzioideae*, *Papaveroideae* and *Platystemonoideae*. *Fumarioideae* and *Pteridophylloideae* were separated in new families, *Fumariaceae*, and *Pteridophyllaceae*, and the four tribes under subfamily *Papaveroideae* have been graded up to the rank of subfamilies. This division is based mainly on gynoecium morphology and indumentum's characters

but the evolutionary relationships within the subfamilies remain ambiguous as well as the relations between the genera. Hoot *et al.* (1999) on the basis of molecular data found that the genera *Corydalis* and *Hypecoum* belonging to the *Fumarioideae* are closely related and they supported their separation in the new family *Fumariaceae*. The same to the genus *Pteridophyllum*, is better to be treated as a separate family *Pteridophyllaceae*, while the rest of the genera are better to be subdivided into three subfamilies (Fig. 2). They are *Adlumia* Raf ex DC., *Arctomecon* Torr. & Frem. *Argemone* L., *Bocconia* L., *Canbya* Parry ex A. Gray, *Capnoides* Mill., *Ceratocapnos* Durieu, *Chelidonium* L., *Cryptocapnos* Rech.F., *Cysticapnos* Mill., *Dactylicapnos* Wall., *Dendromecon* Benth., *Dicentra* Borkh. Ex Benth., *Dicranostigma* Hook.f. & Thomson, *Discocapnos* Cham. & Schltld., *Eomecon* Hance, *Eschscholzia* Cham., *Glaucium* Mill., *Hesperomecon* Greene, *Hunnemannia* Sweet, *Hylomecon* Maxim., *Hypecoum* L., *Macleaya* R.Br., *Meconella* Nutt., *Meconopsis* R. Vig., *Papaver* L., *Platycapnos* (DC.) Bernh., *Platystemon* Benth., *Pteridophyllum* Siebold & Zucc., *Roemeria* Medik., *Romneya* Harv., *Rupicapnos* Pomel, *Sanguinaria* L., *Stylomecon* G.Taylor, *Stylophorum* Nutt. And *Trigonocapnos* Schltr. Some of these genera contain one species only which is endemic to certain localities, while others like *Papaver*, *Argemone*, *Glaucium*, *Meconella*, *Meconopsis*, *Eschscholzia*, *Dendromecon*, *Chelidonium* and *Roemeria* are more abundant and well known.

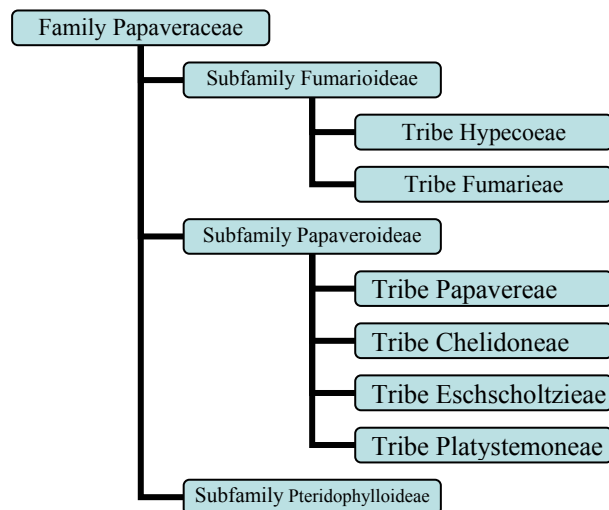


Figure (2): Family *Papaveraceae* Classification according to Hoot *et al.* (1997).

According to Täckholm (1974), the Egyptian *Papaveraceae* s.s. comprises four native genera *Papaver*, *Argemone*, *Roemeria* and *Glaucium* and one introduced genus; *Eschscholzia*. These genera are narrowly distributed, in Egypt they are mainly Mediterranean annual species. Genus *Papaver* has seven species: *P. argemone* L., *P. decaisnei* Hochst &

St., *P. hybridum* L., *P. mexicana* L., *P. polytrichum* Boiss, *P. somniferum* L. and *P. rhoeas* L.. While genus *Glaucium* has four species; *G. arabicum* Fres, *G. corniculatum* L., *G. Flavum* Crantz, and *G. grandiflorum* Boiss & Huet. The other two genera are represented only by one species each, *Argemone mexicana* L. and *Roemeria hybridica* Medic. while family *Fumariaceae* has one genus; *Fumaria* with eight species in Egypt. These are *F. bracteosa* Pomel, *F. capreolata* L., *F. densiflora* DC., *F. gaillardotii* Boiss., *F. judaica* Boiss. *F. microstachys* Kral., *F. officinalis* L., and *F. parviflora* Lam. Moreover genus *Hypecoum* L. is separated in a distinct monogeneric family *Hypecoaceae* with eight species which show relation to the *Fumariaceae* (Täckholm, 1974).

MATERIALS AND METHODS

Herbarium specimens allocated at Alexandria University Herbarium (AUH) have been examined carefully to clarify leaf and fruit morphological variations within the genera. List of the examined specimens, their collectors and localities are given in table 1. The studied taxa include some species from USA and France and represent seven genera and 23 species. Leaf and fruit morphological measurements (in cm.) and descriptions are summarized in table (2). Photographs of selected species to clarify the differences in leaf and fruit characters have been also given (plate 1).

RESULTS AND DISCUSSION

The careful examinations of the herbarium sheets showed that the three families; *Papaveraceae*, *Fumariaceae* and *Hypecoaceae*, are closely related. In all the studied taxa, the leaves are simple, radical or cauline, petiolated with long petioles except in few species; *G. arabicum*, *R. hybrida*, *F. microstachys*, and *H. pendulum*; the leaves are sessile. The genera *Fumaria*, *Dicentra* and *Hypecoum* have glabrous plants, while the genera *Roemeria*, *Papaver*, *Glaucium* and *Eschscholzia* plants are covered by long multicellular, uniseriate hairs and the fruits are supported, as well, by long hairs. The leaves are crowded at the base of the plants even in plants with cauline leaves. In *Eschscholzia* species, the leaf blades are either very finely dissected or finely dissected and appears as being in tufts. The genera *Glaucium*, *Papaver* and *Dicentra* have pinnatifid or slightly lacerus leaf blades. Species of *Fumaria* have alternate or laxus; soft and pendulous without fixed arrangement; leaves and very finely dissected leaf blades.

Stigma and fruit shapes are very important in the differentiation of the species, as all the *Eschscholzia* and *Roemeria* species have pointed stigmas, with very short style and linear fruits. *Glaucium* species have capitate, rounded stigmas with very short style and linear fruits.

In the three genera the fruits are siliqua, but *Eschscholzia* has glabrous ones while the latter two have hairy fruits. *Papaver* species have capitate, sessile

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Table (1): Studied taxa and their collectors and localities.

TAXA	COLLECTOR	LOCALITY
<i>Papaveraceae s.s.</i> <i>1-Eschscholzia</i> <i>E. caespitosa</i> Benth.	Peta C. Lewis 4 (16/4/1967)	Napa County, California
<i>E. californica</i> Cham	Linda Miller 11 (16/4/1967) Loise Krozek 12 (22/4/1965) Jean Addicott 16	Solano County, California Yolo County, California Marin County, California
<i>E. glyptosperma</i> Greene	June McCaskill 280 (30/4/1954)	Inyo County, California
<i>E. lemmonii</i> Greene	J.M. Tucker 2351 (19/4/1952)	San Luis Obispo County, California
<i>E. lobii</i> Greene	Anne Harrison 15 (2/4/1962)	Solano County, California
<i>E. minutifolia</i> S. Wats.	E.M. Gifford (27/4/1950) J. McCaskill 241 (29/4/1954)	Inyo County, California Inyo County, California
<i>2-Glaucium</i> <i>G. arabicum</i> Fresen	L. Boulos (24/6/2005)	Southern Sinai, St.Katherine, Egypt
<i>G. corniculatum</i> (L.)J.H.	S. Kamal (4/5/2003) S. Rashad (19/3/1948) S. Zedan (11/5/1989)	Khorshid, Egypt King Mariut, Egypt Wadi Habes, Egypt
<i>3-Papaver</i> <i>P. argemone</i> L.	Mohamed Aid (11/4/2003)	Burg El-Arab, Egypt
<i>P. decaisnei</i> Hochst & St.	Ayyad <i>et al.</i> (21/3/1989) S. Zedan (1/4/2003)	Mersa Matruh-Siwa Road, Egypt Burg El-Arab, Egypt
<i>P. dubium</i> L.	Ayyad <i>et al.</i> (21/3/1989) Ayyad <i>et al.</i> (21/3/1989) S. Zedan (1/4/2003)	Mersa Matruh-Siwa Road, Egypt Gara Oasis, Egypt Burg El-Arab, Egypt
<i>P. hybridum</i> L.	A.Fakhry. (23/3/1992) S. Zedan (1/5/2001) S. Zedan (1/4/2003) L.Boulos (16/2/1979) T.M.Tadros (26/3/1952)	Burg El-Arab, Egypt Burg El-Arab, Egypt Burg-ElArab, Egypt El-Hammam, Egypt Mersa-Matruh, Egypt
<i>P. rhoeas</i> L.	L. Bidak (1/4/2002) L. Bidak (24/4/2002) 4 th year students (11/4/1993) Ayyad (21/3/1989) G. El-Ghazaly 43 (29/2/1980) L. Boulos (26/4/1979) M. Rezk (10/4/1982) M. Rezk (21/4/1982) M. Rezk (19/3/1982) Tadros (4/1949)	Abu Seer, Egypt Burg El Arab, Egypt Burg El-Arab, Egypt Siwa, Egypt Mersa Matruh, Egypt Mersa Matruh, Egypt Noubaria, Egypt El-Bouseily, Egypt Burg El-Arab, Egypt Burg El-Arab, Egypt
<i>4-Roemeria</i> <i>R. hybrida</i> (L.) DC.	Ayyad (22/3/1976) L.Boulos (16/2/1979) L.Boulos (8/3/1979) M. Rezk (28/3/1992) M. Rezk (3/1993) G. El-Ghazaly (29/2/1980)	Burg El Arab, Egypt El-Hammam, Egypt Burg El Arab, Egypt Rasheed, Egypt El-Bousily, Egypt Mersa Matruh, Egypt
<i>Fumariaceae</i> <i>5-Dicentra</i> <i>D. Formosa</i> Walp.	Gurdev Khush 22 (10/5/1959)	Placer County, California
<i>6-Fumaria</i> <i>F. bracteosa</i> Pomel	A. Fakhry (23/3/1992) S. Zedan (3/3/1989) R. Saad (25/3/1988) R. Saad (23/3/1988) Ayyad (19/3/1989) Ayyad (3/1992) Ayyad (24/3/1986) Ayyad (21/3/1989) B. Bakr (2/1986)	Burg El-Arab, Egypt Burg El-Arab, Egypt Burg El-Arab, Egypt Rasheed, Egypt Mersa Matruh-Siwa Road Mersa Matruh-Siwa Road Mersa Matruh- Alexandria Road Bier nesf El-Ein, Siwa, Egypt Mersa Matruh, Egypt
<i>F. densiflora</i> DC	L. Boulos (9/3/1979) L. Boulos (26/4/1979) L. Boulos (29/2/1980) M. Rezk (21/4/1982) M. Rezk (10/4/1982) 4 th year students (19/3/1982) 4 th year students (19/3/1982)	Burg El Arab, Egypt Mariut, Egypt Matruh, Obayed, Egypt El- Bouseily, Egypt Burg El Arab, Egypt Burg El Arab, Egypt El-Hammam, Egypt.
<i>F. judaica</i> Boiss	Tadros (5/4/1945) Tadros (4/1949) S. El Dareer (19/3/1999) L. Boulos (5/4/1979)	Smouha, Alexandria, Egypt Moharrem Bey, Alexandria, Egypt Moharrem Bey, Alexandria, Egypt El Ma'amura, Alexandria, Egypt

	S. Kamal (16/4/1993)	Mersa Matruh, Egypt
<i>F. microstachys</i> Kral	S. Zedan (12/5/1989)	Agiba, Matruh, Egypt
<i>F. officinalis</i> L.	Tadros (13/3/1948)	Boutonnet, Montpellier, France
<i>F. parviflora</i> Lam	Tadros (3/1945)	Matruh, Egypt
<i>Hypecoaceae</i> <i>Hypecoum</i> <i>H. aegyptiacum</i> Forssk.	Tadros (18/2/1945) Tadros (15/3/1945) G. El-Ghazaly 375 (2/4/1982) S. Zedan (14/3/1988) I. Abdel Megid (24/1/1989) B. Abdel Aziz	Burg El Arab, Egypt Burg El Arab, Egypt El-Omayed, Egypt El-Omayed, Egypt El Hammam, Egypt Burg El Arab, Egypt
<i>H. pendulum</i> L.	G. El-Ghazaly 287 (31/3/1981)	St. Katherine, Sinai, Egypt

Table (2): Leaf and fruit variations within the studied taxa.

TAXA	Plant Hairs	Petiole Length	Leaf Insertion	Leaf			Stigma	Fruit		
				Shape	margin	Arrang.		Shape	Length	Type
<i>Eschscholzia</i>	Hairy	6-8	Radical	V.F.D.	Entire	Basal	Pointed	Linear	3-3.5	Silique
<i>E. caespitosa</i>										
<i>E. californica</i>	Hairy	6-14	Radical	F. D.	Entire	Basal	Pointed	Linear	4-5.5	Silique
<i>E. glyptosperma</i>	Hairy	2.5-3	Radical	F. D.	Entire	Basal	Pointed	Linear	2-6	Silique
<i>E. lemmonii</i>	Hairy	4-6	Radical	F. D.	Entire	Basal	Pointed	Linear	2-4.5	Silique
<i>E. lobii</i>	Hairy	3-5	Radical	V.F.D.	Entire	Basal	Pointed	Linear	3-4	Silique
<i>E. minutifolia</i>	Hairy	1-3	Radical	F. D.	Entire	Basal	Pointed	Linear	3.5-3.8	Silique
<i>Glaucium</i>	Hairy	0-1	Cauline	pinnatifid	Entire	Alternate	Capitate	Linear	10-11	Hairy
<i>G. arabicum</i>										Silique
<i>G. corniculatum</i>	Hairy	0-5	Cauline	Pinnatifid	Entire	Alternate	Capitate	Linear	3-6	Hairy
										Silique
<i>Papaver</i>	Hairy	3-7	Cauline	Pinnatifid	Entire	Alternate	Capitate	Rect.	1-15	H.Cap./P
<i>P. argemone</i>										
<i>P. decaisnei</i>	Hairy	3-3.5	Cauline	Pinnatifid	Dentate	Alternate	Capitate	Rect.	1-1.2	H.Cap./P
<i>P. dubium</i>	Hairy	2-3.5	Cauline	Pinnatifid	Dentate	Basal	Capitate	Rect.	0.5-0.7	H.Cap./P
<i>P. hybridum</i>	Hairy	1-1.5	Cauline	Pinnatifid	Dentate	Alternate	Capitate	Rect.	0.4-0.7	H.Caps./T
<i>P. rhoeas</i>	Hairy	1.5-3.5	Cauline	Pinnatifid	Dentate	Alternate	Capitate	Rect.	1-1.2	H.Cap./P
<i>Roemeria</i>	Hairy	0-0.5	Radical	F. D.	Dentate	Basal	Pointed	Linear	4-5	Hairy
<i>R. hybrida</i>										Silique
<i>Dicentra</i>	Glab.	1-2	Radical	Pinnatifid	Entire	Basal	Biforked	Glob.	0.3-0.4	Nut
<i>D. Formosa</i>										
<i>Fumaria</i>	Glab.	1.5-2	Cauline	V.F.D.	Entire	Alternate	Biforked	Glob.	0.1-0.2	Nut
<i>F. bracteosa</i>										
<i>F. densiflora</i>	Glab.	1-1.5	Cauline	V.F.D.	Entire	Alternate	Biforked	Glob.	0.1	Nut.
<i>F. judaica</i>	Glab.	1.3-2	Cauline	Pinnatifid	Dentate	Laxus	Biforked	Glob.	0.2-0.5	Nut
<i>F. microstachys</i>	Glab.	0	Cauline	F. D.	Entire	Laxus	Biforked	Glob.	0.3-0.5	Nut
<i>F. officinalis</i>	Glab.	1-1.8	Cauline	F. D.	Entire	Alternate	Biforked	Linear	0.3-0.5	Silique
<i>F. parviflora</i>	Glab.	1-1.5	Cauline	V.F.D.	Entire	Alternate	Biforked	Linear	0.3-0.5	Silique.
<i>Hypecoum</i>	Glab.	2-3	Radical	Pinnatifid	Dentate	Basal	Biforked	Linear	3-4	Silique
<i>H. aegyptiacum</i>										
<i>H. pendulum</i>	Glab.	0	Radical	V.F.D.	Entire	Basal	Pointed	Linear	2-3	Silique

Key to table 2: Glab.= Glabrous; Arrang.= arrangement; V.F.D.= very finely dissected; F. D.= finely dissected; Rect.= rectangular; Glob.= Globular; H.Caps./P= hairy capsule open by pores; H.Cap./T= hairy capsule open by teeth

stigmas which ramify in a rosette like appearance over rectangular hairy capsules. These capsules opened by pores or by teeth. Species of *Fumaria* have biforked stigmas, small glabrous fruits and either globular nutlets or short linear siliques. *Hypecoum* species have either pointed or biforked stigmas over very short styles and linear siliques.

From the above mentioned results, it is obvious that the three families are closely related in their morphological criteria and their combination as one family is more acceptable. In spite of the differences of the stigmas, fruit shapes and types, but these differences are not enough to separate them in different families, especially if the molecular data and other tools of taxonomy showed clear similarities between them as mentioned above. The Studied species of *Fumaria*,

Dicentra and *Hypecoum* showed glabrous plants with both sessile or short petioled leaves and very finely dissected leaf blades. Their fruits are either nuts or glabrous silique with biforked stigmas and short styles. These genera form a homogenous group and are acceptable as being subfamily *Fumarioideae* as proposed by Hoot *et al.* (1997). The separation of the genus *Hypecoum*, as proposed by Hoot *et al.* (1999), in another family is not supported as all the studied genera from related groups.

Genera of subfamily *Papaveroideae* are hairy plants with very long petioles, except in *Glaucium* species the leaves are sessile or with very short petioles. The leaf blades are either pinnatifid, very finely or finely dissected. The fruits are either glabrous or hairy siliques or capsules which opened by teeth or pores and ended



Plate (1): Photographs of selected herbarium sheets show differences in leaves and fruits. Arrows indicate to fruit.

with sessile capitate or pointed stigmas with short styles. These genera form another homogenous group which can be divided into two tribes; one contains the *Papaver* species only and the second contain *Glaucium*, *Roemeria* and *Eschscholzia*. This classification in partial agreement with Hoot *et al.* (1997), but separate the genus *Roemeria* from the genus *Papaver*. The results obtained showed that genus *Eschscholzia* has its characteristic features which might enables it to be upgraded to the subfamily level; *Eschscholzioidae*; as mentioned by Ernst (1962), Layka (1976), Heslop-Harrison and Shivana (1977), Mabry (1973), Kaderreit (1993), Kaderreit *et al.* (1994) and Bruckner (2000) but the species studied still have great similarities with the other *Papaveroideae* genera.

REFERENCES

- BEHNKE, H.D., AND W. BARTHOLOTT. 1983. New Evidence from the Ultrastructural and Micromorphological Fields in Angiosperm Classification. *Nordic Journal of Botany* **3**: 43-66.
- BENSON, L.D. 1979. *Plant Classification*. Ed.2. D.C. Heath, Lexington, Mass.
- BLAGOWESTSCHENSKI, A.W. 1955. *Die biochemischen Grundlagen des Evolutionsprozesses der Pflanzen*. Akademie-Verlag, Berlin.
- BRUCKNER, C. 2000. Clarification of the carpel number in Papaverales, Capparales, and Berberidaceae. *Botanical Review* **66(2)**: 155-304.
- CHASE, M.W., D.E. SOLTIS, R.G. OLMSTEAD, D. MORGAN, D.H. LES, B.D. MISHLER, M.R. DUVALL, R.A. PRINCE, H.G. HILLS, Y.L. QUI, K.A. KRONG, J.H. RETTIG, E. CONTI, J.D. PALMER, J.R. MANHAT, K.J. SYSTEMA, H.J. MICHAELS, W.J. KRESS, K.G. KAROL, W.D. CLARK, M. HEDREN, B.S. GAUT, R.K. JANSEN, K.J. KIM, C.F. WIMPEE, J.F. SMITH, G.F. FURNIER, S.H. STRAUSS, Q.Y. XIANG, G.M. PLUNKETT, P.S. SOLTIS, S.M. SWENSEN, S.E. WILLIAMS, P.A. GADEK, C.J. QUINN, L.E. EGUIARTE, E. COLENBERG, G.H. LEARN JR, S.W. GRAHAM, S.C.H. BARETT, S. DAYANANDAN, AND V.A. ALBERT. 1993. Phylogenetics of seed plants: An analysis of nucleotide sequences from the plastid gene *rbcL*. *Annals of the Missouri Botanical Gardens* **80**: 528-580.
- CRONQUIST, A. 1981. *An integrated system of classification of flowering plants*. Columbia University Press, New York, USA.
- DRINNAN, A.N., P.R. CRANE, AND S.B. HOOT. 1994. Patterns of floral evolution in the early diversification of non-magnoliid dicotylons (eudicots). *Plant Systematics and Evolution (Supplement)* **8**: 93-122.
- ERNST, W.R. 1962. *A comparative morphology of the Papaveraceae*. Ph.D. desertation, Stanford University.
- FOHNE, D. 1962. *Das Verhaltenin von Vergleichender Serobotanik zu Vergleichender Phytochemie*, Dargestelt Anserologischen Untersuchungen in Bereich der Rhoeadales. *Plant Medic. (Stuttgard)* **10**: 283-297.
- GERSHENZON, J., AND T.J. MABRY. 1983. Secondary metabolites and the higher classification of angiosperms. *Nordic Journal of Botany* **3**: 5-34.
- HEGNAUER, R. 1961. *Die Gliederung der Rhoeadales sensu Wettstein in Lichte der Inhaltsstoffe*. *Plant Medic (Stuttgard)* **10**: 283-297.
- HESLOP-HARRISON, Y., AND K.P. SHIVANA. 1977. The receptive Surface of the Angiosperm Stigma. *Annals of Botany (London)* **41**: 1233-1258.
- HEYWOOD, V.H. 1993. *Flowering plants of the world*. Andromeda Oxford Ltd.
- HILU, K.W., T. BORSCH, AND K. MULLER *ET AL.* (16 CO-AUTHORS). 2003. Angiosperm phylogeny based on *matK* sequence information. *American Journal of Botany* **90**: 1758-1776.
- HOOT, S.B., AND P.R. CRANE. 1995. Interfamilial relationships in the Ranunculidae based on molecular systematics. *Plant Systematics and Evolution (Supplemen)* **9**: 119-131.
- HOOT, S.B., J.W. KADEREIT, F.R. BLATTNER, K.B. JORK, A.E. SCHWARZBACH, AND P.R. CRANE. 1997. Data congruence and phylogeny of the Papaveraceae s.l. based on four data sets: *atpB* and *rbcL* sequences, *trnK* restriction sites, and morphological characters. *Systematic Botany* **22**: 575-590.
- HOOT, S.B., S. MAGALLON, AND P.R. CRANE. 1999. Phylogeny of basal eudicots based on three molecular data sets: *atpB*, *rbcL* and *18S* nuclear ribosomal DNA sequences. *Annals of the Missouri Botanical Garden* **86**: 1-32.
- KADEREIT, J.W. 1993. Papaveraceae In: K. Kubitzki *et al.*, (Eds.) *the Families and Genera of Vascular Plants Berlin* **2**.
- KADEREIT, J.W., A.E. SCHWARZBACH, AND K.B. JORK. 1997. The phylogeny of *Papaver* s.l. (Papaveraceae): polyphyly or monophyly?. *Plant Systematics and Evolution* **204**: 75-98.
- KADEREIT, J.W., F.R. BLATTNER, K. JORK, AND A. SCHWARZBACH. 1994. Phylogenetic analysis of the Papaveraceae s.l. (including Fumariaceae, Hypocoaceae, and Pteridophyllum). *Botanische Jahrbücher für Systematik und Pflanzengeographie* **116**: 361-390.
- KALLERSJO, M., J.S. FARRIS, M.W. CHASE, B. BREMER, M.F. FAY, C.J. HUMPHRIES, G. PETERSEN, O. SEBERG, AND K. BREMER. 1998. Simultaneous parsimony jackknife analysis of 2538 *rbcL* DNA sequences reveals support for major clades of green plants, land plants and flowering plants. *Plant Systematics and Evolution* **213**: 259-287.
- KIGER, R.W. 1996. *Papaveraceae in Flora of North America Family Treatments: Magnoliidae*. James L.Reveal, Lectures Notes- FNA Magnoliidae Treatment – Spring 1998 in www.eflora.org.

- KÖLBE, K.P. 1978. Serologische Beitrag zur Systematik der Capparales. *Botanical Jahrbuch Systematik* **99**: 468-489.
- LAYKA, S. 1976. Les methods modernes de la palynologie appliqués a l'étude des Papaverales. Dissertation, Montpellier, C.N.R.S.A.O. 12.535.
- MABRY, T.J. 1973. Is the order Centrospermae monophyletic? In G. Bendz and J. Santesson (Eds.), *Chemistry in botanical classification*, 275-285. Academic Press, New York, USA.
- MELCHIOR, H. 1964. A. Engler's Syllabus der Pflanzenfamilien. Ed.12 Gebruder Borntraeger, Berlin- Nikolassee.
- NORRIS, T. 1941. Torus anatomy and nectary characteristics as phylogenetic criteria in the Rhoadales. *American Journal of Botany* **28**: 101-113.
- PARKER, S.P. (ED.). 1982. *Synopsis and classification of living organisms*. McGraw-Hill Book Company **1** and **2**.
- QUI, Y.L., M.W. CHASE, S.B. HOOT, E. CONTI, P.R. CRANE, K.J. SYSTEMA, AND C.R. PARKS. 1998. Phylogenetics of the Hamamelidae and their allies: Parsimony analyses of nucleotide sequences of the plastid gene *rbcL*. *International Journal of Plant Science* **159**: 891-905.
- SCHWARZBACH, A.E., AND J.W. KADEREIT. 1995. Rapid radiation of North American desert genera of the Papaveraceae: evidence from restriction site mapping of PCR-amplified chloroplast DNA fragments. In Jensen U & Kadereit JW (eds.): *Systematics and Evolution of Ranunculiflorae.- Plant Systematics and Evolution. Suppl.* **9**: 159-170.
- SOLTIS, D.E., P.S. SOLTIS, D.L. NICKRENT, L.A. JOHNSON, W.H. HAHN, S.B. HOOT, J.A. SWEERE, P.K. KUZOFF, A. KRON, M.W. CHASE, S.M. SWENSEN, E.A. ZIMMER, S.M. CHAW, L.J. GILLESPIE, W.J. KRESS, AND K.J. SYTSMA. 1997. Angiosperm phylogeny inferred from 18Sr DNA, *rbcL* and *atpB* sequences. *Botanical Journal of the Linnean Society* **133**: 381-461.
- SPICHTIGER, R., AND V. SAVOLAINEN. 1997. Present state of Angiospermae phylogeny. *Candollea* **52**: 435-455.
- TÄCKHOLM, V. 1974. *Student's Flora of Egypt*. 2nd. Ed. Cairo University, Cooperative Printing Company, Beirut.
- TAMURA, M. 1974. *Phylogeny and classification of the angiosperms*. Sanseido, Tokyo.
- TAIA, W.K., AND M.A. SHEHA. 2003. Systematic Study within the Papaverales (Papaveraceae and Fumariaceae). *Bulletin of Pure and Applied Sciences* **22B(2)**: 75-93.
- TUTIN, T.G., N.A. BURGESS, A.O. CHATER, J.R. EDMONDSON, V.H. HEYWOOD, D.M. MOORE, D.H. VALENTINE, S.M. WALTER, AND D.A. WEBB EDS. 1993. *Flora Europaea. Ed. 2 Psilotaceae to Platanaceae*. Cambridge University Press, Cambridge, England **1**.
- WETTSTEIN, R. 1935. *Handbook der systematischen Botanik. Ed. 4*. Franz Deuticke, Leipzig, Vienna.
- WORBE, A., D. QUANDT, A.M. BARMISKE, K.W. HITER, AND T. BORSCH. 2006. Phylogeny of basal eudicots: Insights from non-coding and rapidly evolving DNA. *Organisms, Diversity and Evolution* (in press).

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دراسة مرجعية للوضع التقسيمي للفصيلة الخشخاشية وتوضيح وضع بعض الأجناس تبعاً للنظم التقسيمية الحديثة

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هذه الدراسة شملت مسح كامل للمراجع والدراسات الحديثة التي تناولت الأجناس المختلفة التابعة للفصيلة الخشخاشية في العالم . وبالتالي فقد تم دراسة عينات معشبية لأربعة عشر نوعاً يمثلوا تحت الفصيلة الخشخاشية، سبعة أنواع يمثلوا تحت الفصيلة الفيومارية ونوعان يمثلوا تحت الفصيلة الهيبوكوية. وهدفت هذه الدراسة إلى معرفة مدى تجانس هذه الأنواع وهل الإختلافات الشكلية المدروسة ستؤدى إلى تدعيم الآراء التي ترى فصل هذه الأنواع فى فصائل منفصلة أم تدعم الآراء التي تعضد ضم هذه الأنواع فى فصيلة واحده.

كما تم مراجعة الآراء المختلفة الحديثة التي تناولت الأجناس المختلفة التابعة للفصيلة الخشخاشية فى العالم وأوضاع هذه الأجناس التصنيفية على أساس الدلائل المتحصل عليها من تحليلات الحامض النووى والبروتينات المختلفة. كما تناولت الدراسة توضيح وضع الفصيلة الخشخاشية بالنسبة للفصائل المجاورة والآراء حول العلاقة بينها وبين كل من الفصائل الفيومارية والهيبوكويه والشقيقية .

والنتائج التي تحصلنا عليها وجدنا أن كل تلك الأنواع ذات صفات متقاربة، بالرغم من وجود بعض الإختلافات، وتدعم الآراء التي تنادى بضم هذه الأنواع تحت فصيلة واحدة. فصفات الشكل الخارجى للأوراق متقاربة حيث كل الأنواع ذات أوراق بسيطة مفصصة ذات أعناق متفاوتة فى الطول أو جالسة وهى إما أوراق جذرية تخرج من قاعدة الساق أو مرتبة على الساق بشكل متبادل أو مهدول حول الساق. الثمار تفاوتت فى الطول ولكنها كانت من نوع الخردله المزودة بشعيرات طويلة أو ملساء بينما فى بعض أنواع جنس الفيوماريا فالثمار كانت بندقه وفى جنس الخشخاش الثمار كانت علبة متفتحة إما بثقوب أو أسنان.