

THE SEED ATLAS OF PAKISTAN-. PAPAVERACEAE

RUBINA ABID,* AFSHEEN ATHER AND M. QAISER

Department of Botany University of Karachi, Karachi, Pakistan

*Corresponding author's e-mail: rubinaku@yahoo.com

Abstract

Numerical analysis based on seed morphological characters of 14 taxa belonging to the family Papaveraceae is carried out. Seed macro and micro morphological characters were found useful to strengthen the taxonomic decisions and trace out the phylogenetic relationship within the family Papaveraceae.

Key words: Seed morphology, Papaveraceae, Numerical analysis, Pakistan.

Introduction

The family Papaveraceae comprises 43 genera and 820 species mostly distributed in north temperate and tropical regions (Mabberley, 2008). In Pakistan the family is represented by 14 species distributed in 6 genera viz., *Argemone* L., *Eschscholtzia* Cham., *Glaucium* Mill., *Hypocoum* L., *Papaver* L. and *Roemeria* Medic (Jafri & Qaiser, 1974). Previously seed morphological studies were not only used as an additional taxonomic tool but also to predict the evolutionary relationship of the taxa at various levels (Elisens & Tomb, 1983; Qaiser, 1987; Hufford, 1995; Akbari & Azizian, 2006; Ather *et al.*, 2009; Rajbhandary & Shrestha, 2010; Kanwal *et al.*, 2012; Abid *et al.*, 2013). While, concerning to the seeds of the family Papaveraceae seed coat were found very useful for the systematic delimitation (Clark & Jernstedt, 1978; Berggren, 1981; Debnath & Nayar, 1986; Cresson & Schneider, 1988; Sulaiman *et al.*, 1995; Bojnans & Fargasova, 2007). However, from the last few years a considerable work has been done on the family Papaveraceae to determine the phylogenetic affinities between the taxa (Sulaiman *et al.*, 1995; Kadereit *et al.*, 1994; Hoot *et al.*, 1997; Loconte *et al.*, 1995; Hoot & Crane, 1995). Presently numerical analysis based on the seed morphological characters is carried out to provide the strength to the taxonomic decisions and to trace

out the phylogenetic relationship of the taxa within the family Papaveraceae from Pakistan.

Materials and Methods

Mature and healthy seeds of 14 taxa of the family Papaveraceae were collected from herbarium specimens. Mostly 10 plants/species and 10 seeds/plant were studied (Appendix-I) and examined under stereomicroscope (Nikon XN Model), compound microscope (Nikon type 102) and scanning electron microscope (JSM-6380A). For scanning electron microscopy dry seeds were directly mounted on metallic stub using double adhesive tape and coated with gold for a period of 6 minutes in sputtering chamber and observed under SEM. The terminology used is in accordance to Lawrence (1970), Radford (1974) and Stearn (1983) with slight modifications. Numerical analysis was carried out by Hierarchical clustering using the Euclidean distance index with the computer package (IBM SPSS Statistics Vol.19). Each taxon was treated as an operational taxonomic unit (OUT). Macro and micro morphological characters of seeds viz., size, shape, colour, surface patterns were used. Characters were recorded as presence or absence and coded as 1 or 0 respectively. The average values of the quantitative characters viz., seed length and breadth were directly used (Tables 1-3).

Appendix-I. List of voucher specimens.

S. No.	Taxa	Collector, number and herbarium
1.	<i>Argemone mexicana</i>	S. I. Ali 1 (KUH); Saida Qaiser <i>et al.</i> 333(KUH);Tahir Ali & Tufail Ahmed 1842 (KUH); S. Abedin 7551 (KUH); S. I. Ali <i>et al.</i> 2268 (KUH).
2.	<i>Eschscholtzia californica</i>	S. Abedin & M. Qaiser 9810 (KUH).
3.	<i>Glaucium elegans</i>	A. Ghafoor & S. Omer 3009, 3262 (KUH).
4.	<i>G. fimbrilligerum</i>	Haider Ali 2477, 4389 (KUH); A. Ghafoor & S. Omer 3326 (KUH); A. Ghafoor & R. Yusuf 1504 (KUH); Jan Alam & Saleem 3752 (KUH).
5.	<i>Hypocoum pendulum</i> var. <i>parviflorum</i>	Jan Alam & Jahangir Gabol 2505 (KUH); Jafri & Akbar 1917 (KUH); Tahir Ali & G. R. Sarwar 2717 (KUH).
6.	<i>H. pendulum</i> var. <i>pendulum</i>	Jan Alam & Jahangir Gabol 2620 (KUH); A. Ghafoor & R. Yusuf 1139, 1290 (KUH).
7.	<i>Papaver decaisnei</i>	A. Ghafoor & S. Omer 1722, 3379 (KUH); Jan Alam & Saleem 3589, 3618 (KUH); A. Ghafoor & R. Yousuf 1293 (KUH); M. Qaiser & S. Abedin 6267(KUH); Jan Alam <i>et al.</i> 2547 (KUH).
8.	<i>P. hybridum</i>	K. A. MALik 1212 (KUH).
9.	<i>P. nudicaule</i>	S. W. Khan <i>et al.</i> 352 (KUH); Jan Alam <i>et al.</i> 1543 (KUH).
10.	<i>P. pavoninum</i>	S. Omer & A. Ghafoor 1721, 3318 (KUH); A. Ghafoor & R. Yusuf 1574 (KUH); Jan Alam & Saleem s. n. (KUH); M. Qaiser & A. Ghafoor 1899 (KUH); Tahir Ali & G. R. Sarwar 2690 (KUH).
11.	<i>P. somniferum</i>	K. A. MALik & M. Qaiser 507 (KUH).
12.	<i>Roemeria hybrida</i> ssp. <i>dodecandra</i>	Jan Alam & Saleem 3588, 3755 (KUH).
13.	<i>R. hybrida</i> ssp. <i>hybrida</i>	Jafri & Akbar 1862 (KUH); A. Ghafoor & S. M. Goodman 5168 (KUH).
14.	<i>R. refracta</i>	M. Qaiser 5889 (KUH).

Table 1. Seed morphological characters of the family Papaveraceae.

Name of taxa	Size (mm)		Angular or Non-angular	Compressed or Non-compressed	Shape	Apex	Base	Colour	Surface	Hilum
	Length	Breadth								
<i>Argemone mexicana</i>	1.5-2	1.2-1.5	Non-angular	Non compressed	Broadly obovate	Rounded	Beaked	Dark brown-reddish brown	Reticulate, cells angular, entire walls	Basal
<i>Eschscholzia californica</i>	1.5-1.8	1.5	Non-angular	Non compressed	Globose	Rounded	Slightly truncate	Yellowish brown	Reticulate, cells angular, entire walls	Basal
<i>Glaucium elegans</i>	1.8	1	Angular	Non compressed	Obliquely obovate	Truncate	Oblique	Yellow	Reticulate, cells angular, ruminant walls	Lateral
<i>G. fimbriigerum</i>	1.5	1	Angular	Non compressed	Obliquely oblong	Truncate	Truncate	Blackish brown	Reticulate, cells angular, ruminant walls	Lateral
<i>Hypercicon pendulum</i> var. <i>parviflorum</i>	2	2	Angular	Compressed	Reniform	Truncate	Truncate	Orange brown	Inermis	Laterally central
<i>H. pendulum</i> var. <i>pendulum</i>	2-2.5	2	Angular	Compressed	Obliquely ovate	Oblique	Truncate	Creamy-light brown	Cubical verucate	Basal
<i>Papaver decaisnei</i>	0.8-1	0.5-0.8	Non-angular	Non compressed	Reniform	Rounded	Rounded	Brown-dusty brown	Reticulate, cells non angular, ruminant walls	Laterally central
<i>P. hybridum</i>	0.5	0.2	Non-angular	Non compressed	Reniform	Rounded	Rounded	Light brown	Reticulate, cells angular, ruminant walls	Laterally central
<i>P. nudicaule</i>	0.5	0.2	Non-angular	Non compressed	Reniform-elliptic pyriform	Rounded	Rounded	Orange brown	Irregularly reticulate, cells angular, entire walls	Laterally central
<i>P. pavoninum</i>	1	0.2	Non-angular	Non compressed	Reniform	Rounded	Rounded	Greenish brown-greyish green	Reticulate, cells non angular, ruminant walls	Laterally central
<i>P. somniferum</i>	1	1	Non-angular	Non compressed	Reniform	Rounded	Rounded	Whitish yellow-yellowish brown	Reticulate, cells angular, entire walls	Laterally central
<i>Roemeria hybrida</i> ssp. <i>dodecandra</i>	1	0.5	Non-angular	Non compressed	Reniform	Rounded	Rounded	Grayish brown	Reticulate, cells non angular, entire walls	Laterally central
<i>R. hybrida</i> ssp. <i>hybrida</i>	1	0.8	Non-angular	Non compressed	Reniform	Rounded	Rounded	Light green	Reticulate, cells angular, entire walls	Laterally central
<i>R. refracta</i>	1	1	Non-angular	Non compressed	Reniform	Rounded	Rounded	Creamy	Reticulate, cells non angular, entire walls	Laterally central

Table 2. List of characters, scored for cluster analysis for taxa of the family Papaveraceae listed in Table 1.

Character description	
1.	Length (mm)
2.	Breadth (mm)
Shape	
3.	Angular: absent (0), present (1)
4.	Non angular: absent (0), present (1)
5.	Compressed: absent (0), present (1)
6.	Non compressed: absent (0), present (1)
7.	Broadly obovate: absent (0), present (1)
8.	Obliquely obovate: absent (0), present (1)
9.	Obliquely ovate: absent (0), present (1)
10.	Obliquely oblong: absent (0), present (1)
11.	Reniform: absent (0), present (1)
12.	Globose: absent (0), present (1)
Apex	
13.	Rounded: absent (0), present (1)
14.	Oblique: absent (0), present (1)
15.	Truncate: absent (0), present (1)
Base	
16.	Rounded: absent (0), present (1)
17.	Oblique: absent (0), present (1)
18.	Truncate: absent (0), present (1)
19.	Beaked: absent (0), present (1)
Colours	
20.	Dark brown: absent (0), present (1)

21.	Light brown: absent (0), present (1)
22.	Yellowish brown: absent (0), present (1)
23.	Orange brown: absent (0), present (1)
24.	Blackish brown: absent (0), present (1)
25.	Reddish brown: absent (0), present (1)
26.	Dusty brown: absent (0), present (1)
27.	Grayish brown: absent (0), present (1)
28.	Greenish brown: absent (0), present (1)
29.	Greyish green: absent (0), present (1)
30.	Light green: absent (0), present (1)
31.	Yellow: absent (0), present (1)
32.	Whitish yellow: absent (0), present (1)
33.	Creamy: absent (0), present (1)
Surface	
34.	Reticulate, cells angular: absent (0), present (1)
35.	Reticulate, cells non angular: absent (0), present (1)
36.	Ruminate walls: absent (0), present (1)
37.	Entire walls: absent (0), present (1)
38.	Inermis: absent (0), present (1)
39.	Cubical verrucate: absent (0), present (1)
Hilum	
40.	Basal: absent (0), present (1)
41.	Lateral: absent (0), present (1)
42.	Laterally central: absent (0), present (1)

Observations**General seed characters of the family Papaveraceae:**

Seeds 0.5-2.5 x 0.2-2mm, angular or non-angular, compressed or non-compressed, reniform, broadly obovate, obliquely obovate, obliquely ovate, obliquely oblong or globose, apex rounded, oblique or truncate, base rounded, oblique, beaked or truncate, creamy, light brown, dark brown, dusty brown, reddish brown, blackish

brown, orange brown, yellowish brown, greenish brown, greyish brown, yellow, whitish yellow or green, surface inermis, cubical verrucate, reticulate or irregularly reticulate with angular or non-angular cells and with ruminate or entire walls, hilum basal, lateral or laterally central (Table 1; Plates. 1-2; Figs. 1-5).

Represented by 6 genera viz., *Argemone* L., *Eschscholtzia* Cham., *Glaucium* Mill., *Hypecoum* L., *Papaver* L., *Roemeria* Medic.

Key to the genera

- 1 + Seeds angular 2
- Seeds non-angular 3
- 2 + Seeds non-compressed, surface reticulate *Glaucium*
- Seed compressed, surface inermis or cubical verrucate *Hypecoum*
- 3 + Seeds broadly obovate or globose 2
- Seeds reniform and elliptic pyriform 5
- 4 + Seeds broadly obovate, dark brown-reddish brown, base beaked *Argemone*
- Seeds globose, yellowish brown, base truncate *Eschscholtzia*
- 5 + Seeds white-yellow, yellowish brown, light brown, dusty brown, orange brown, greenish brown-greyish green *Papaver*
- Seeds grayish brown, light green or creamy *Roemeria*

***Argemone* L.**

Seeds 1.5-2x1.2-1.5mm, non-angular, non-compressed, broadly obovate, apex rounded, base oblique, dark brown-reddish brown, surface reticulate with angular cells, entire walls, hilum basal (Table 1; Plate 1 A-B).

Represented by a single species viz., *Argemone mexicana* L.

***Eschscholtzia* Cham.**

Seeds 1.5x1.5mm, non-angular, non-compressed, globose, apex rounded, base slightly truncate, yellowish

brown, surface reticulate with angular cells, entire walls, hilum basal (Table 1; Plate 1 C-D).

Represented by a single species viz., *Eschscholtzia californica* Cham.

***Glaucium* Mill.**

Seeds 1.5-1.8x1mm, angular, non-compressed, obliquely obovate or obliquely oblong, apex truncate, base truncate or oblique, yellow or blackish brown, surface reticulate with angular cells, ruminate walls, hilum lateral (Table 1; Plate 1 E-I).

Represented by 2 species viz., *Glaucium elegans* Fisch. & Mey., *G. fimbrilligerum* (Trautv.) Boiss.

Table 3. Data matrix of Papaveraceae scored for 42 characters present in table 2.

Name of taxa	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
<i>Argemone mexicana</i>	2	2	0	1	0	1	1	0	0	0	0	0	1	0	0	0	1	0	1	0	0
<i>Eschscholtzia californica</i>	2	2	0	1	0	1	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0
<i>Glaucium elegans</i>	2	1	1	0	0	1	0	1	0	0	0	0	0	0	1	0	1	0	0	0	1
<i>G. fimbriigerum</i>	2	1	1	0	0	1	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0
<i>Hypecoum pendulum</i> var. <i>parviflorum</i>	2	2	1	0	1	0	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0
<i>H. pendulum</i> var. <i>pendulum</i>	3	2	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1
<i>Papaver decaisnei</i>	1	1	0	1	0	1	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0
<i>P. hybridum</i>	1	0	0	1	0	1	0	0	0	0	1	0	1	0	0	1	0	0	0	0	1
<i>P. nudicaule</i>	1	0	0	1	0	1	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0
<i>P. pavoninum</i>	1	0	0	1	0	1	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0
<i>P. somniferum</i>	1	1	0	1	0	1	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0
<i>Roemeria hybrida</i> ssp. <i>dodecandra</i>	1	1	0	1	0	1	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0
<i>R. hybrida</i> ssp. <i>hybrida</i>	1	1	0	1	0	1	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0
<i>R. refracta</i>	1	1	0	1	0	1	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0
Name of taxa	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
<i>Argemone mexicana</i>	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0
<i>Eschscholtzia californica</i>	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0
<i>Glaucium elegans</i>	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0	1	0
<i>G. fimbriigerum</i>	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	1	0
<i>Hypecoum pendulum</i> var. <i>parviflorum</i>	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
<i>H. pendulum</i> var. <i>pendulum</i>	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0
<i>Papaver decaisnei</i>	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1
<i>P. hybridum</i>	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
<i>P. nudicaule</i>	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1
<i>P. pavoninum</i>	0	0	0	0	0	0	1	1	0	0	0	0	0	1	1	0	0	0	0	0	1
<i>P. somniferum</i>	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	1
<i>Roemeria hybrida</i> ssp. <i>dodecandra</i>	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0	1
<i>R. hybrida</i> ssp. <i>hybrida</i>	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	0	1
<i>R. refracta</i>	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	1

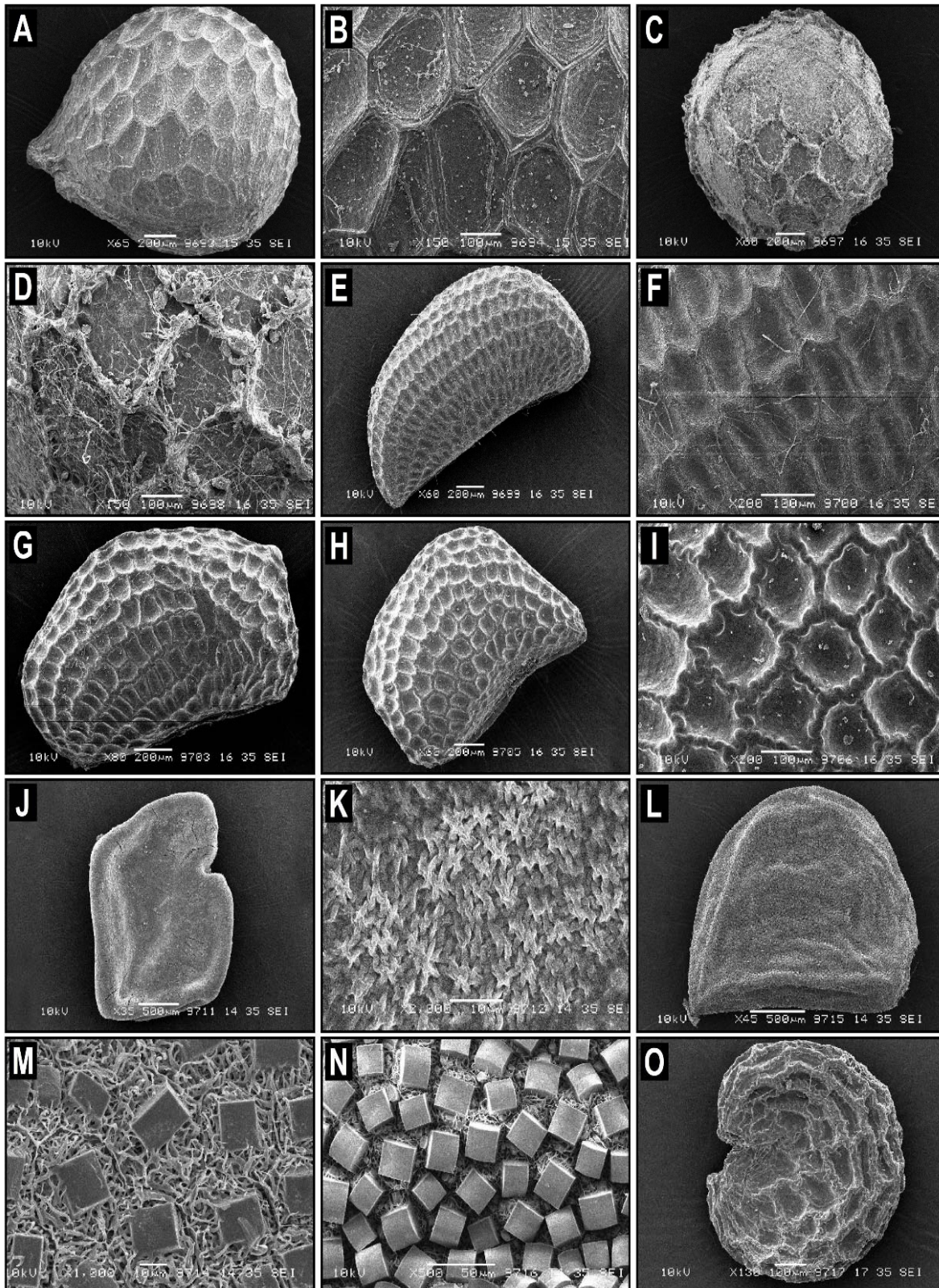


Plate 1. Scanning electron micrographs. *Argemone mexicana*: A, seed; B, surface. *Eschscholtzia californica*: C, seed; D, surface. *Glaucium elegans*: E, seed; F, surface. *Glaucium fimbriigerum*: G, H, seeds; I, surface. *Hypocoum pendulum* var. *parviflorum*: J, seed; K, surface. *H. pendulum* var. *pendulum*: L, seed; M, N, surface. *Papaver decaisnei*: O, seed. (Scale bars: H=500 μ m; F, J, L, N=200 μ m; B, D, K, M, O=100 μ m; A, G, I=50 μ m; C, E=10 μ m).

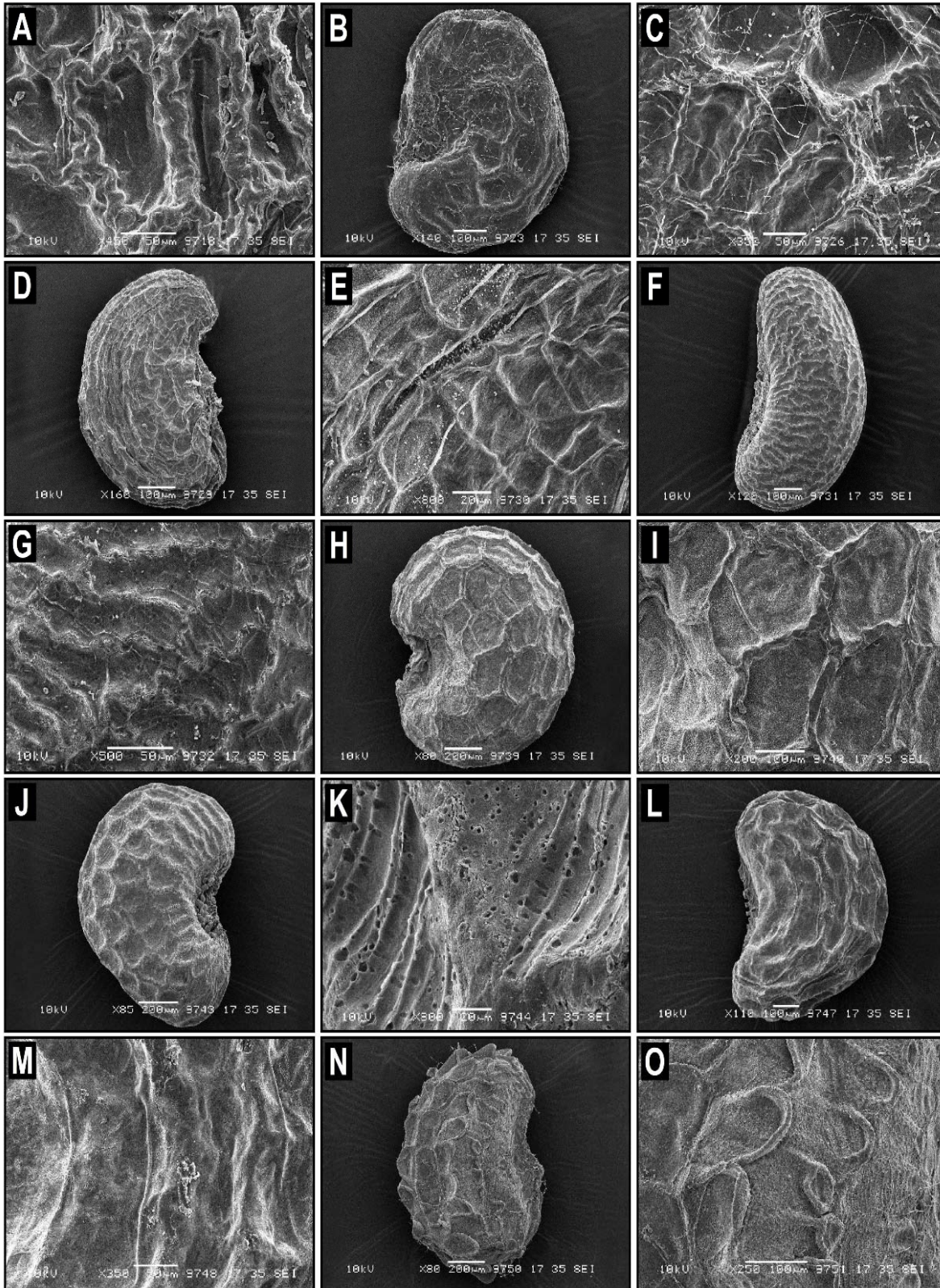


Plate 2. Scanning electron micrographs. *Papaver decaisnei*: A, surface. *P. hybridum*: B, seed; C, surface. *P. nudicaule*: D, seed; E, surface. *P. pavoninum*: F, seed; G, surface. *P. somniferum*: H, seed; I, surface. *Roemeria hybrida* ssp. *dodecandra*: J, seed; K, surface. *R. hybrida* ssp. *hybrida*: L, seed; M, surface. *R. refracta*: N, seed; O, surface. (Scale bars: D, F=500 µm; A, B=200 µm; C, I, K, M, O=100 µm; H, J, L=50 µm; N=20 µm; E, G=10 µm).

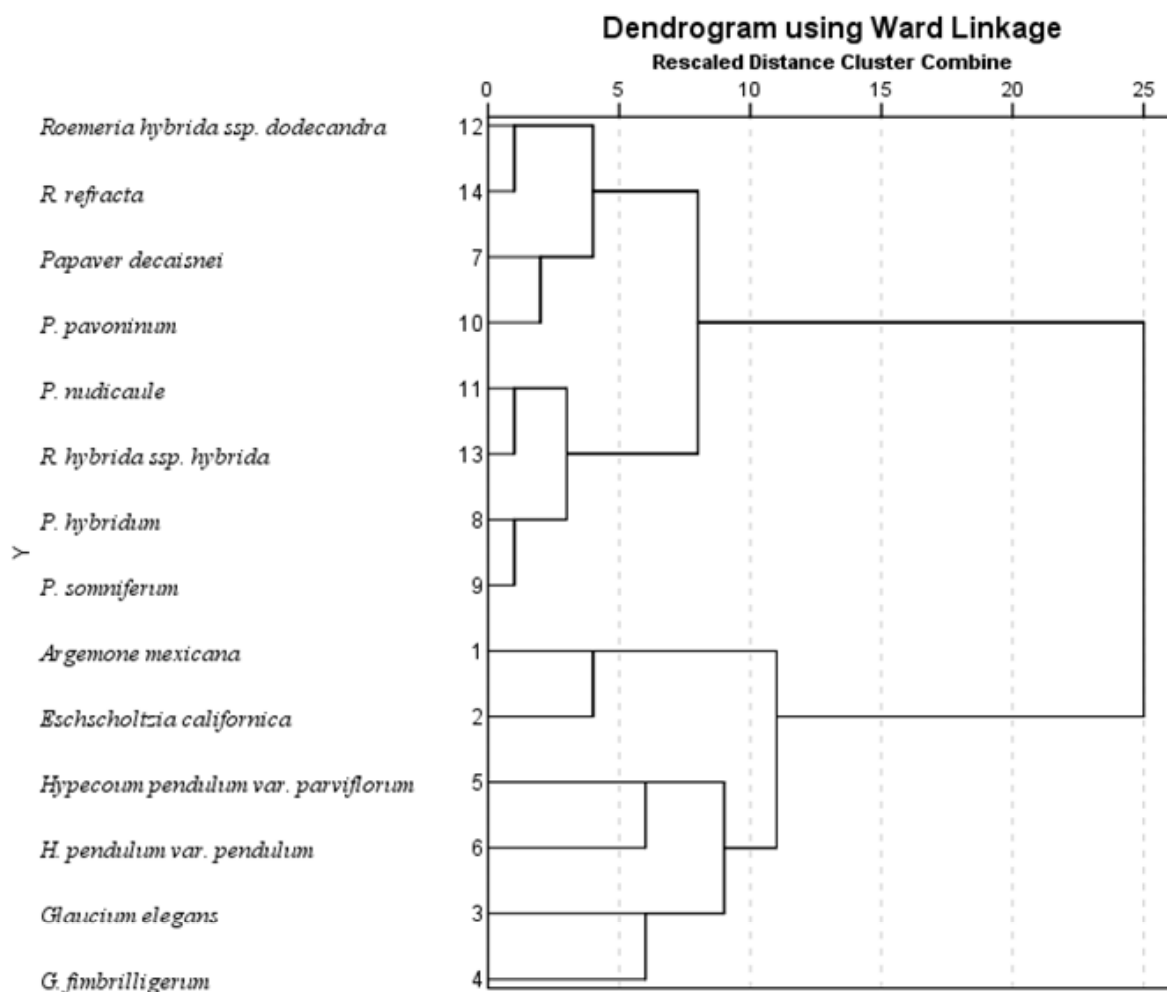


Fig. 1. Dendrogram showing the relationships within the species of the family Papaveraceae.

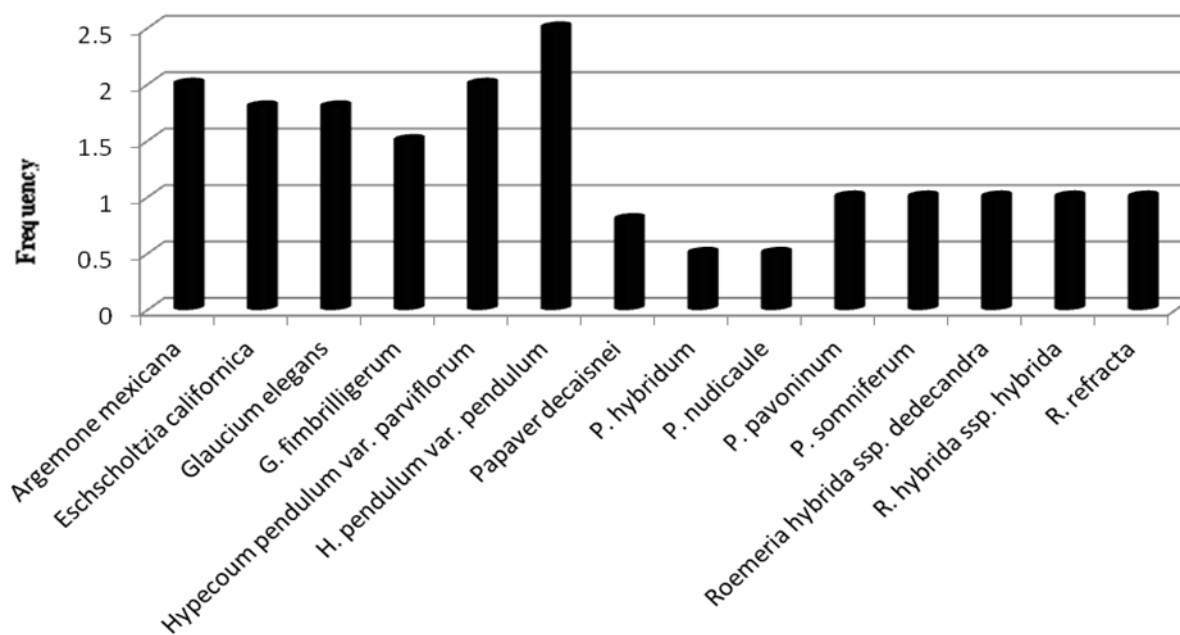


Fig. 2. Bar diagram showing the variation in seed length within the species of the family Papaveraceae.

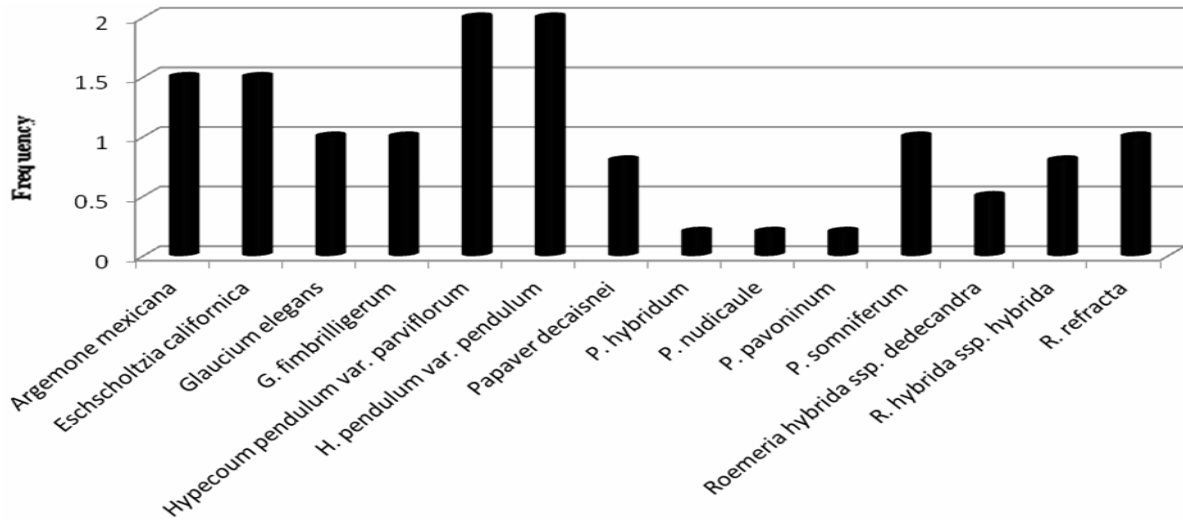


Fig. 3. Bar diagram showing the variation in seed breadth within the species of the family Papaveraceae.

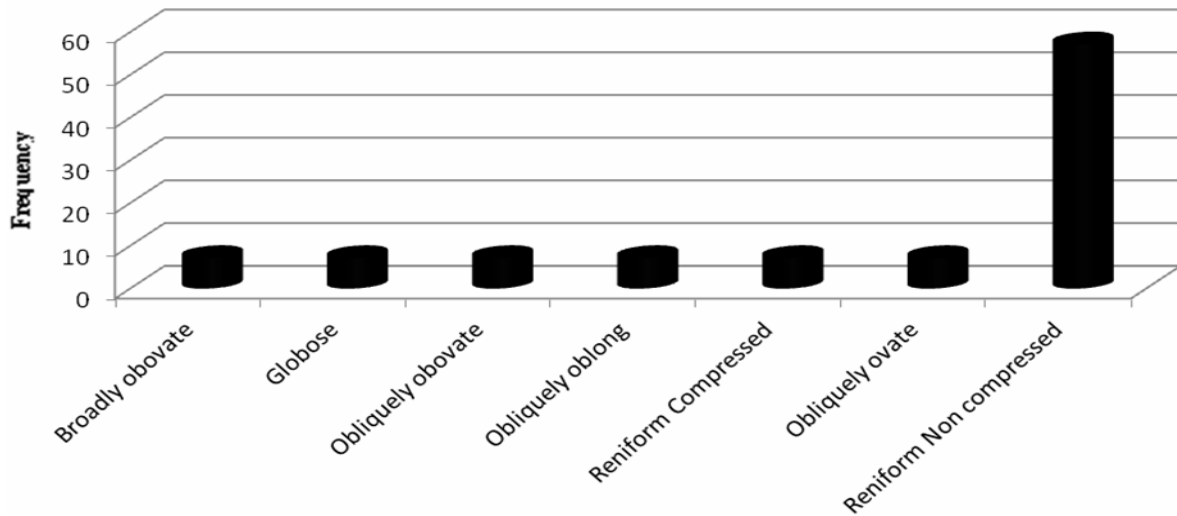


Fig. 4. Bar diagram showing the variation in seed shape within the species of the family Papaveraceae.

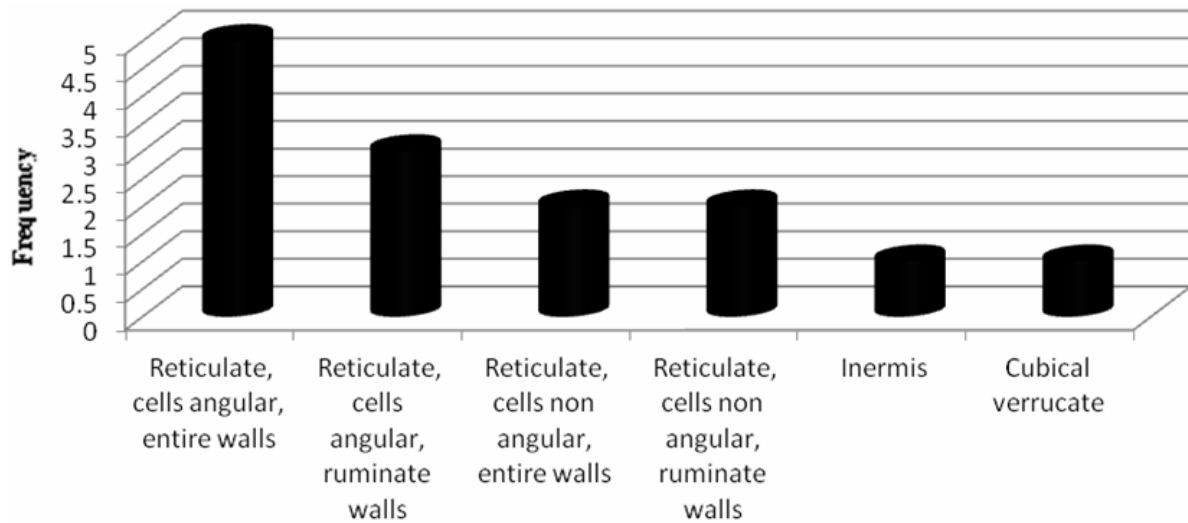


Fig. 5. Bar diagram showing the variation within seed surface within the species of the family Papaveraceae.

Key to the species

- 1 + Seeds obliquely obovate, yellow *G. elegans*
 - Seeds obliquely oblong, blackish brown *G. fimbriigerum*

***Hypecoum* L.**

Seeds 2-2.5x2mm, angular, compressed, reniform or obliquely ovate, apex oblique or truncate base truncate, orange brown or creamy-light brown, surface inermis or

cubical verrucate, hilum laterally central or basal (Table 1; Plate 1J-N).

Represented by a single species with 2 varieties viz., *Hypecoum pendulum* L. var. *parviflorum* (Kar. & Kir.) Cullen, *H. pendulum* L. var. *pendulum*.

Key to the varieties

- 1 + Seeds reniform, orange brown, surface inermis
 *H. pendulum* var. *parviflorum*
 - Seeds obliquely ovate, creamy-light brown, surface cubical verrucate
 *H. pendulum* var. *pendulum*

***Papaver* L.**

Seeds 0.5-1x0.2-1mm, non-angular, non-compressed, reniform, apex and base rounded, light brown, orange brown, dusty brown, greenish brown, grayish green, whitish yellow or yellowish brown, surface reticulate or

irregularly reticulate with angular or non-angular cells and with ruminant or entire walls, hilum laterally central (Table 1; Plates 1O, 2A-K).

Represented by 5 species viz., *Papaver decaisnei* Hochst. & Steud. ex Boiss., *P. hybridum* L., *P. nudicaule* L., *P. pavoninum* Schrenk, *P. somniferum* L.

Key to the species

- 1 + Seeds 0.5mm long, orange brown and light brown 2
 - Seeds 0.8-1mm long, dusty brown, greenish brown, grayish green, whitish yellow or yellowish brown 3
 3
 2 + Seeds light brown, surface reticulate with ruminant walls *P. hybridum*
 - Seeds orange brown, surface irregularly reticulate with entire walls
 *P. nudicaule*
 3 + Seeds white-yellow to yellowish brown, surface reticulate with angular cells and entire walls
 *P. somniferum*
 - Seeds brown-dusty brown or greenish brown-greyish green, surface reticulate with non-angular cells and ruminant walls 4
 4 + Seeds 0.5-0.8mm broad, brown-dusty brown *P. decaisnei*
 - Seeds 0.2mm broad, greenish brown-greyish green *P. pavoninum*

***Roemeria* Medic**

Seeds 1x0.5-1mm, non-angular, non-compressed, reniform, apex and base rounded, creamy, greyish brown or light green, surface reticulate with angular or non-

angular cells, entire walls, hilum laterally central (Table 1; Plate 2L-O).

Represented by 2 species viz., *Roemeria hybrida* (L.) DC., *R. refracta* DC.

Key to the species

- 1 + Seeds greyish brown or light green *R. hybrida*
 - Seeds creamy *R. refracta*

Discussion

The family Papaveraceae has diversified seed characters and usually characterized by reniform and reticulated seeds (Clark & Jernstedt, 1978; Debnath & Nayar, 1986; Sulaiman *et al.*, 1995). The dendrogram (Fig. 1) of the family Papaveraceae clearly revealed that the seed shapes are found to be significant for generic delimitation while, seed coat morphology may be significantly used for specific delimitation. Present findings are in agreement to those of the earlier findings of Sulaiman *et al.* (1995) and Zhao

(2011) such as, the first group of genera having non-compressed reniform seeds viz., *Roemeria* and *Papaver* also characterized by capitata or disc shape stigma (Cullen, 1966, Jafri & Qaiser, 1974). While, the genera of the second group viz., *Argemone*, *Eschscholtzia*, *Glaucium* and *Hypecoum* fall separately by having different seed shapes and gross morphology such as, non reniform or compressed reniform seeds with conical, filiform, lobed or recurved stigma (Cullen, 1966; Jafri & Qaiser, 1974; Kiger, 1997). Within the first group the species and subspecies of the genera *Roemeria* and *Papaver* further show affinities on the basis of

cells of reticulation such as *P. hybridum*, *P. nudicaule*, *P. somniferum* and *R. hybrida* subsp. *hybrida* forming common cluster by having reticulation with angular cells. While, *Papaver decaisnei*, *P. pavoninum*, *Roemeria hybrida* subsp. *dodecandra* and *R. refracta* are grouped by having reticulation with non-angular cells. Moreover, within the second group *Argemone mexicana* and *Eschscholtzia californica* having close affinity by sharing the seed characters like globose and broadly obovate seeds with rounded apex and 4-7 stigmas (Jafri & Qaiser, 1974, Kiger, 1997). While, *Argemone mexicana* is further characterized by having seeds with beaked base (Cresson & Schneider, 1988) and *Eschscholtzia californica* having seed with rounded base. Similarly, the placement of the taxa of *Glaucium* and *Hypecoum* with in a common cluster supported by having seeds with truncate or oblique apex and 2 stigmas (Jafri & Qaiser, 1974, Kiger, 1997). However, the species of *Hypecoum* and *Glaucium* may remain distinct from each other by having 4 stamens, ± tripartite inner petals and compressed seeds with inermis or cubical verrucate surface pattern and numerous stamens without tripartite inner petals and non-compressed seeds with reticulate surface pattern respectively. It is also noteworthy that the genus *Hypecoum* have exclusive gross morphology and seed surface pattern due to which some workers gave suggestions that the genus *Hypecoum* should be treated under the separate subfamily Hypecoideae or family Hypecoaceae (Rendle, 1925; Erdtman, 1952; Zhao, 2011).

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References

- Abid, R., A. Ather and M. Qaiser. 2013. The Seed Atlas of Pakistan-VIII Fumariaceae. *Pak. J. Bot.*, 45(1): 87-92.
- Akbari, R.S. and D. Azizian. 2006. Seed morphology and seed coat sculpturing of *Epilobium* L. species (Onagraceae Juss.) from Iran. *Turk. J. Bot.*, 30: 435-440.
- Anonymous. 2012. IBM. SPSS. 19 for windows XP 2002.
- Ather, A., R. Abid and M. Qaiser. 2009. The Seed Atlas of Pakistan- II. Grewioideae. *Pak. J. Bot.*, 41(6): 2647-2656.
- Bergreen, G. 1981. *Atlas of seeds, and small Fruit of Northwest European plant species, Salicaceae-Cruciferae. Part 3.* Swedish Museum of Natural History, Stockholm.
- Bojnans, W.V. and A. Fargasova. 2007. Atlas of seed and Fruit of central of east Europe. Springer-Verlag, Berlin.
- Clark, C. and J.A. Jernstedt. 1978. Systematic studies of *Eschscholtzia* (Papaveraceae) II Seed coat microsculpturing. *Sys. Bot.*, 3: 386-402.
- Cresson, R.A. and E.L. Schneider. 1988. Ovule and seed structure in *Argemone aurantiaca* (Papaveraceae). *Bull. Torr. Bot. Club.*, 115(2): 108-112.
- Cullen, J. 1966. *Flora Iranica*, Vol. 34. Papaveraceae. Akad Druck- und Verlag-Anst.
- Debnath, H.S. and M.P. Nayar. 1986. The poppies of Indian region (Papaveraceae). Calcutta: *Botanical survey of India*.
- Elisens, W.J. and A.S. Tomb. 1983. Seed morphology in new world *Antirrhineae* (Scrophulariaceae): Systematic and Phylogenetic Implications. *Pl. Syst. Evol.*, 142: 23-47.
- Erdtman, G. 1952. *Pollen morphology and Plant taxonomy.* Angiosperms. Chronica Botanica Co., Waltham, Massachusetts.
- Hoot, S.B. and P.R. Crane. 1995. Interfamilial relationships in the Ranunculidae Based on molecular systematics. In: *Systematics and evolution of the Ranunculiflorae*, ds. U. Jensen and J.W. Kadereit. *Plant Sys. & Evol.*, (Supplement) 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* sequence, *trnK* Restriction sites, and morphological characters. *Sys. Bot.*, 22(3): 575-590.
- Hufford, L. 1995. Seed morphology of Hydrangeaceae and its phylogenetic implications. *Int. J. Pl. Sci.*, 156(4): 555-580.
- Jafri, S.M.H. and M. Qaiser. 1974. Papaveraceae, No. 61 In: *Flora of Pakistan*. (Eds.): E. Nasir and S.I. Ali. Deptt. Bot. Univ. Karachi and National Herbarium Pak. Agri. Research Council, Islamabad.
- Kadereit, J.W., F.R. Blattner, K. Jork and A. Schwarzbach. 1994. Phylogenetic analysis of the Papaveraceae I (including Fumariaceae, Hypecoaceae, and Pteridophyllum) based on morphological characters. *Botanische Jahrb cher f r Systematik und Pflanzengeographie*, 116: 361-390.
- Kanwal, D., R. Abid and M. Qaiser. 2012. The Seed Atlas of Pakistan-VI. Caryophyllaceae. *Pak. J. Bot.*, 44 (1): 407-424.
- Kiger, R.W. 1997. *Flora of North America*. Papaveraceae, vol. 3. Beijing press.
- Lawrence, G.H.M. 1970. *Taxonomy of Vascular plants*, The Macmillan Company, Collier-Macmillan Canada, Ltd, Toronto, Ontario, New York.
- Loconte, H., L.M. Campbell and D.W. Stevenson. 1995. Ordinal and familial relationships of Ranunculid genera. In: *Systematics and evolution of the Ranunculiflorae*. (Eds.): U. Jensen and W. Kadereit. *Plant Sys. & Evol.*, (Supplement) 9: 99-118.
- Mabberley, D.J. 2008. *The Plant-book*, Cambridge University press, Cambridge.
- Qaiser, M. 1987. Studies in the seed morphology of the family Tamaricaceae from Pakistan. *Bot. J. Lim. Soc.*, 94: 469-484.
- Radford, A.E., W.C. Dickison, J.R. Massey and B.C. Ritchie. 1974. *Vascular Plants Systematics*. Harper & Row, New York, Evanston, San Francisco, London.
- Rajbhandary, S. and K.K. Shrestha. 2010. Taxonomic and Ecological significance of seed micromorphology in Himalayan Begonias: SEM analysis. *Pak. J. Bot.*, (SI) 42: 135-154.
- Rendle, A.B. 1925. *The classification of Flowering Plants*. Vol 2. Cambridge University Press. Cambridge.
- Stearn, T.W. 1983. *Botanical Latin*, 3rd edition David & Charles Britain.
- Sulaiman, I.M. 1995. Scanning Electron Microscopic studies on Seed Coat patterns of five endangered Himalayans species of *Meconopsis* (Papaveraceae). *Ann. of Bot.*, 76: 323-326.
- Sulaiman, I.M., N.Z. Ehtesham and S.E. Hasnain. 1995. A multicopy DNA sequence from *Meconopsis simplicifolia* discriminates between the different species of this endangered Himalayan poppy. *Gene*, 156: 223-227.
- Zhao, X.L. 2011. Studies on seed Micro-morphology characteristics and its systematic significance in Papaveraceae (s.l.) from China. Unpublished M.Sc. Assignment. Deptt. Botany. Nanjing Normal University.