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Full Length Research Paper

Pollen morphology of 14 species of *Abutilon* and *Hibiscus* of the family Malvaceae (*sensu stricto*)

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Pollen morphology and the degree of pollen variability within the fourteen species belonging to the two genera, *Abutilon* Mill. and *Hibiscus* L. of the family Malvaceae was studied and documented in detail using light microscopy (LM) and scanning electron microscopy (SEM). Two distinct pollen types were recognized based on polarity, shape, diameter and spine index of the pollen grains. The genus, *Hibiscus* is characterized by apolar, pantoporate and globose to spheroidal pollen grains whereas *Abutilon* is delimited by isopolar, 3-zonoporate and suboblate-spheroidal pollen grains. The wall of a mature pollen was composed of unremitting intine and exine overspread with spines of variable width and height. The character of spine index was used for the first time to describe Malvaceous pollen and was found to be of significant taxonomic importance.

Key words: Pollen morphology, *Hibiscus*, *Abutilon*, Malvaceae.

INTRODUCTION

Both *Abutilon* Mill. and *Hibiscus* L. are heterogeneous and difficult genera of the family Malvaceae (Fryxell, 1997). *Abutilon* is represented by over 150 species distributed in the tropics and subtropics of both hemispheres (Abedin, 1979) whereas the genus *Hibiscus* is represented by over 200 species of trees, shrubs and herbs, widely distributed in tropical and subtropical regions (Bailey, 1950; Bates, 1965; Beers and Howie, 1992). The potent healing qualities of the many species have been used in different therapeutic philosophies throughout history. Flowers, roots, and buds of *Hibiscus rosa-sinensis* are traditionally attributed to antifertility activity in Ayurvedic literature, whereas the leaves are usually used in traditional system of medicine as emollient, aperients, and in the treatment of burning sensation, skin disease, and constipation (Ivan, 1999; Kirtikar and Basu, 1999; Pullaiah, 2006). Jani and Shah (2008) reported the exploitation of novel hydrophilic mucilage from *H. rosa-sinensis*, for the development of sustained release tablets. A decoction of roots and infusion of flowers of *Abutilon theophrasti* Medicus, is used internally and externally against inflammatory conditions (Naqshi et al., 1988). The ethyl acetate extract of *Abutilon grandiflorum* G. Don also showed prominent antiplasmodial activity both *in vivo* and *in vitro* (Beha et al., 2004). The various parts of *Abutilon indicum* (L.) Sweet, are reported to have hypoglycemic, analgesic, hepatoprotective, and hyperlipidemic activities (Roshan et al., 2008). Root and bark of the plant are used as aphrodisiac, anti-diabetic and nerve tonic whereas seeds are used in the treatment of urinary disorders (kirtikar and Basu, 1983).

The significance of pollen morphology in plant systematics has been stressed by a number of workers, especially by Lindley (1830 - 40), Mohl (1835), Fritzsche (1832), Fischer (1890), Selling (1946-1947), Cranwell (1952) and Erdtman (1952, 1957). Pollen morphology of the selected genera, *Abutilon* and *Hibiscus* from Pakistan has been investigated by a number of workers. The most recent and significant study in this respect is that of Perveen et al. (1994) and Bibi et al. (2008). They reported the pollen diameter, pore diameter and spine length for each species. Most of the species included in their study are not included in the present study. Besides the above mentioned characters, spine width, spine index and measurements of different layers of pollen wall are

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also recorded to give a more comprehensive and clear picture of the pollen grain morphology of the genera concerned. Character of spine index is used for the first time to characterize Malvaceous pollen and is found to be of significant taxonomic importance.

Some mistakes worth mentioning in some of the previous studies have also been identified which may have misled subsequent researchers. Therefore, the main objectives of this paper are; to provide additional knowledge about the pollen morphology of the taxa already investigated as well as to include additional taxa which were not considered in the previous studies and to determine the extent to which the data can be used as a taxonomic character in the delimitation of the genera and species under study and; to point out and discuss some mistakes in the description of the pollen morphology of the genus *Hibiscus* in previous studies.

MATERIALS AND METHODS

Preparation of Glycerin Jelly

Glycerin jelly was prepared according to the modified method of Ahmad et al. (2008), who followed Erdtman (1952). 500 ml of distilled water was taken in a beaker and heated on a hot plate (model UELP Scientifica, Germany). When temperature reached 70 - 80°C, 35 g of gelatin was added to it. With increase in temperature, it became a viscous liquid of glycerin jelly. Heating was continued for 1 h and thereafter, 35 g of glycerol was mixed in it with few crystals of phenol. Subsequently, 0.1% safranine was added with $^1/_8{}^{th}$ volume of the glycerin jelly and it was stirred till a uniform pink color appeared. The jelly was stabilized at room temperature.

Processing of pollen

Specimens collected from different localities in Pakistan and representative specimens in the Herbarium of Quaid-i-Azam University, Islamabad Pakistan (ISL), listed in Table 1 were used as a source for polliniferous material. Vouchers of fresh collection were deposited in the Herbarium of Quaid-i-Azam University (ISL). The pollen grains were prepared for light and scanning microscopy by the modified procedure of Erdtman (1952, 1960, 1966, and 1969). For light microscopy, the pollen grains were mounted in glycerine jelly and stained with 1% safranine, on a glass slide. A glass cover slip was placed on the prepared pollen glycerine jelly mixture. When cooled, the glass slide was labeled and edges of the cover slip were sealed with transparent nail vanish. The prepared slides were studied under a light microscope. Pollen shape and diameter, polar axis and equatorial diameter for isopolar grain, exine thickness and sculpturing, height of the spine, width of the spine at its base, spine index, inter-spinal distance and pore diameter were examined. Details of pollen morphology were based on the measurements of 10 - 15 grains. For SEM studies, pollen grains suspended in a drop of 40% acetic acid were transferred to clean metallic stubs and coated with gold using a JEOL JFC 1100 E ion sputtering device. SEM observations were carried out on a JEOL microscope JSM5910. The work was carried out in the Centralized Resource Laboratory, University of Peshawar (Pakistan).

The terminology used is that of Erdtman (1952), Faegri and Iverson (1964), Huang (1972), Walker and Doyle (1975), Moor et al. (1991) and Punt et al. (2007).

RESULTS

Light and scanning electron microscopic investigations of the pollen grains of the 14 species belonging to the two genera, *Abutilon* and *Hibiscus* of the family Malvaceae revealed the presence of two distinct pollen types, *Abutilon* type and *Hibiscus* type. Table 2 summarizes the detailed pollen morphological features of the investigated taxa. Representative pollen grains are illustrated in Figures 1 - 13 whereas palynological variants of taxonomic significance are represented graphically in Figures 14 and 15.

Abutilon type

Pollen grains are 35 - 78 µm in diameter, isopolar, 3-zonoporate, and sub-oblate to spheroidal in shape. Exine thick; nexine is poorly developed and indistinct in most of the taxa studied (Table 2). Intine is nearly as thick as sexine in the entire taxa understudy (Table 2). The thickest sexine is observed in *Abutilon fruticosum* (2.5 µm) with short spines with acute or acuminate apices, usually bulbous or with distinct basal cushions, and spine index ranging from 0.5 (*Abutilon pakistanicum*) to 1.2 (*Abutilon indicum*); tectum micro-verrucate or micro-granulate to punctuate.

Hibiscus type

Pollen grains are 80 - 180 µm in diameter, apolar, pantoporate, globose to spheroidal. The wall of a mature pollen grain is composed of unremitting intine and exine overspread with echini of variable height and width. Sexine is thinner than nexine or rarely thicker (*H. mutabilis*); Intine in most of the taxa understudy is approximately as thick as sexine (Table 2). Spines are dimorphic; longer spines with sharp and pointed apex and shorter ones with slightly obtuse apex, or the height of all these spines is inconsistent. *Hibiscus sabdariffa* has the highest mean spine height with a spine index of 3.18 whereas *Hibiscus mutabilis* has the smallest value of 1.5 for spine index.

DISCUSSION

Pollen morphological studies revealed that both genera are quite distinct. There is practically no similarity between the pollen grains of the *Abutilon* type and *Hibiscus* type. Pollen are usually classified on the basis of their shape, size, symmetry, polarity, apertural types and exine sculpturing (Perveen, 1993).

Pollen size varies greatly among the different genera and species as well as among different pollen of the same species; it ranges from 35 - 78 µm in the studied taxa of *Abutilon* and 80 - 180 µm in the genus *Hibiscus*.

Table 1. List of specimen used in palynological investigations.

S/No.	Taxa	Locality	District	Collector Name	Acc. No.
1.	*Abutilon bidentatum* A. R. Rich	Kallar Kahar	Chakwal	Manzoor Hussain and Javed Akhtar	07647 (ISL!)
		Said Pur	Rawalpindi	Shahzad Maqsood	39911 (ISL!)
2.	*A. fruticosum* Guill. and Perr.	Kurram Agency	Parachinar	Hafizullah and Dilawar	58537 (ISL!)
		Kohat	Kohat	Hafizullah and Dilawar	55207(ISL!)
3.	*A. indicum* (L.) Sweet	Islamabad	Rawalpindi	Wali and Javaid	119367(ISL!)
		Margallah Hills	Rawalpindi	Zqwar, Wali and Saeed	119047(ISL!)
4.	*A. molle* (Wild.) Sweet	Rawalpindi	Rawalpindi	Iqbal Dar, Anjum Amin and M. A. Siddiqi	07612(ISL!)
5.	*A. muticum* (Del. Ex. DC,) Sweet	Jiwani	Makran	M. Ashraf anf Lal Hussain	44811(ISL!)
		Quetta	Quetta	M. Ashraf anf Lal Hussain	117998(ISL!)
6.	*A. pakistanicum* Jafri and Ali	Nazimabad	Karachi	Muqarrab Shah and Wali	119360(ISL!)
		Manghopir	Karachi	Muqarrab Shah and Nisar	118006(ISL!)
7.	*A. theophrasti* Medic	Jhelum	Jhelum	Wali-ur-Rehman	119206(ISL!)
		Gordon College	Rawalpindi	Muqarrab Shah and Ajaz	119046(ISL!)
8.	*Hibiscus caesius* Gracke	Munnawar Hill	Chitral	Muqarrab Shah and Dilawar Ayaz.	33716 (ISL!)
		Muzaffarabad	Muzaffarabad	Jan Mohammad	21850 (ISL!)
9.	*H. mutabilis* L.	Hanna	Quetta	Manzoor and Maqsood	103350(ISL!)
		Bandazai	Zhob	Manzoor Hussain and Muhammad Arif	82192(ISL!)
10.	*H. rosa-sinensis* L.	Muzaffarabad	Muzaffarabad	Shahzad Iqbal and Nisar	82196 (ISL!)
		Parachinar	Parachinar	Bashir Ahmad and Javaid	11406 (ISL!)
11.	*H. sabdariffa* L.	Faizabad	Rawalpindi	Khalid and Dilawar	118141(ISL!)
		Rawalpindi	Rawalpindi	Muqarrab Shah, Zubair, Bashir, Manzoor, Khalid	116601(ISL!)
12.	*H. schizopetalus* (Mast. Hook. f.)	Sharan valley	Abbottabad	M. Zubair and Zawar Shah	116583(ISL!)
		Peshawar	Peshawar	Zubair and Zawar shah	116589(ISL!)

Table 1. Contd

13.	*H. syriacus* L.	Attock	Attock	Bashir Ahmad and Dilawar	119048(ISL!)
		Magallah Hills	Rawalpindi	Maqsood and Dilawar	102418(ISL!)
14.	*H. trionum* L.	Near Zero Point	Rawalpindi	Sarfaraz and Ayaz	118003 (ISL!)
		Attock	Attock	Shahzad mehmund, M.Ashraf, Sarfaraz Khan	101388 (ISL!)

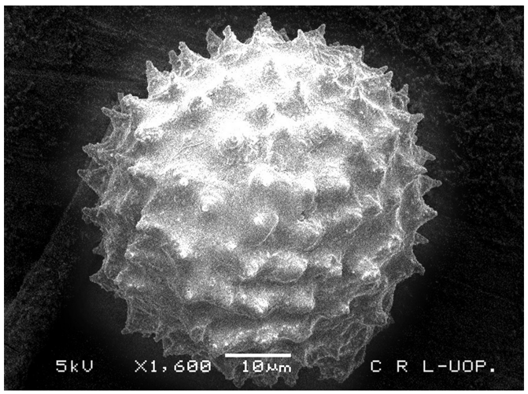

Figure 1. SEM micrographs of pollen grains of *Abutilon* Mill; Pollen grain of *A. indicum*.

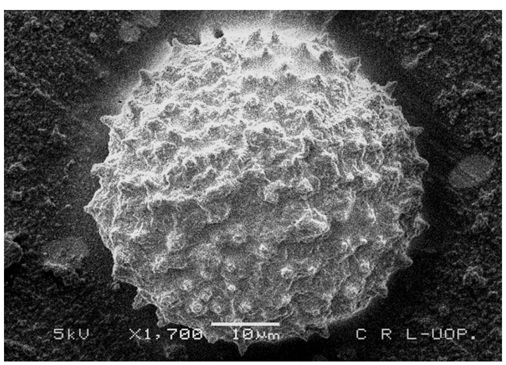

Figure 2. SEM micrographs of pollen grains of *Abutilon* Mill; pollen grain. *A. bidentatum*

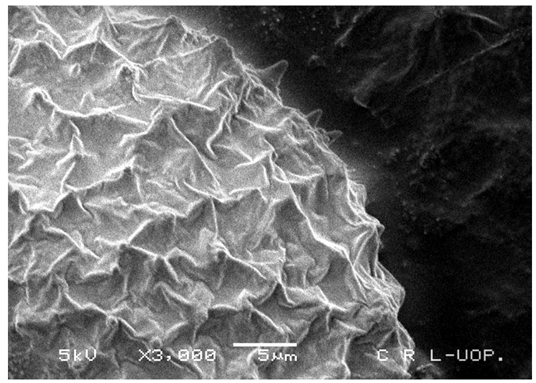

Figure 3. SEM micrographs of pollen grains of *Abutilon* Mill; exine pattern of *A. bidentatum*

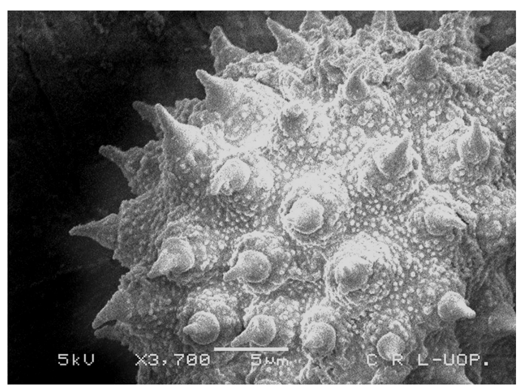

Figure 4. SEM micrographs of pollen grains of *Abutilon* Mill; exine pattern of *A. theophrasti.*

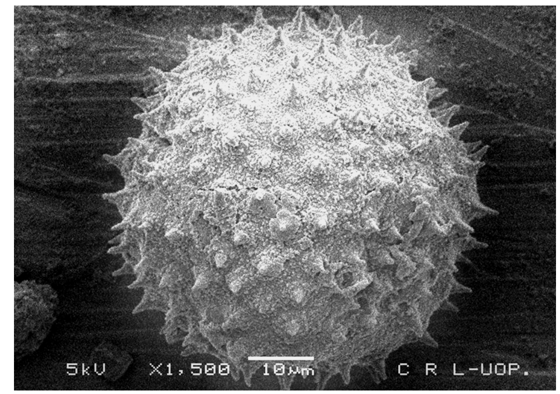

Figure 5. SEM micrographs of pollen grains of *Abutilon* Mill; pollen grain. *A. muticum.*

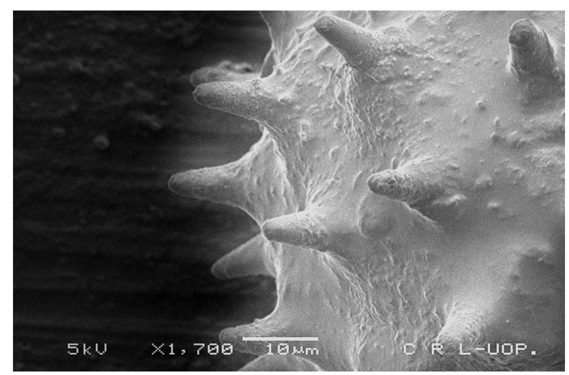

Figure 6. SEM micrographs of pollen grains of *Hibiscus* L.; exine pattern of *H. schizopetalus.*

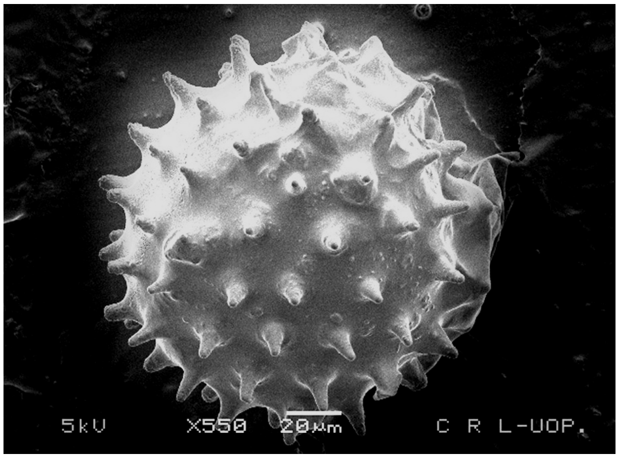

Figure 7. SEM micrographs of pollen grains of *Hibiscus* L.; pollen grain of *H. mutabilis.*

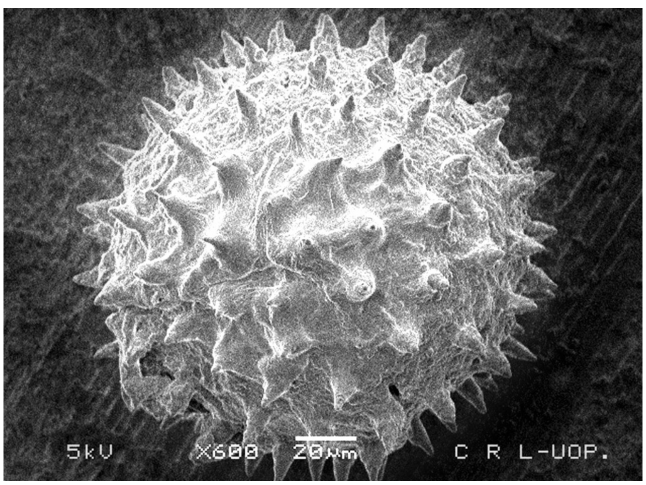

Figure 8. SEM micrographs of pollen grains of *Hibiscus* L.; pollen grain of *H. rosa-sinensis*.

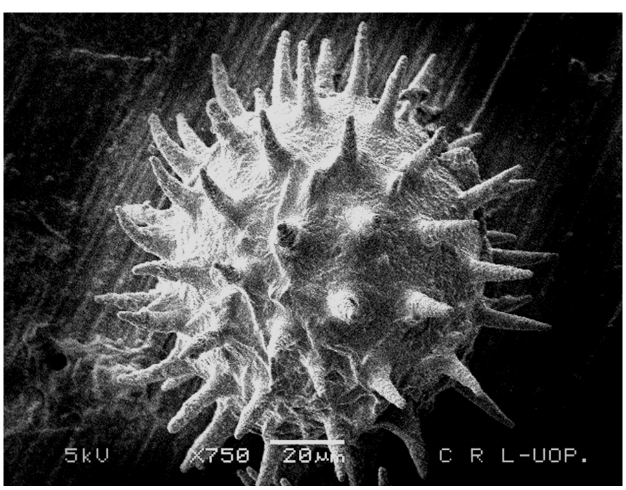

Figure 9. SEM micrographs of pollen grains of *Hibiscus* L.; pollen grain of *H. sabdariffa*.

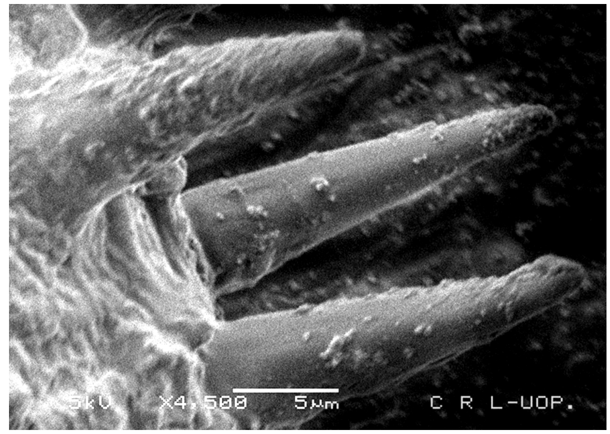

Figure 10. SEM micrographs of pollen grains of *Hibiscus* L.; exine pattern of *H. sabdariffa*.

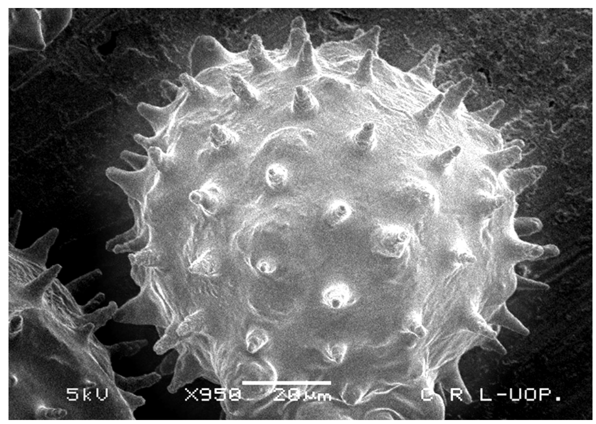

Figure 11. SEM micrographs of pollen grains of *Hibiscus* L.; pollen grain of *H. caesius*.

The smallest mean pollen size is recorded for polar axis of *Abutilon molle* (37.5 µm); nearly the same value of pollen size (37 µm) was obtained by El Naggar (2003) for *Abutilon theophrasti* and he described it as the smallest pollen size in his study of the family Malvaceae. The maximum value for pollen size is obtained for *Hibiscus schizopetalus* that is, 110 (158 ± 4.2) - 180 µm. Present findings are in contrast with the conclusions made by Bibi et al. (2008) that pollen size is a reliable taxonomic tool to separate species. Pollen size is described as a useful taxonomic tool at tribal level by El Naggar (2003).

The shape of the pollen grain is by and large spheroidal in all the studied taxa of the genus *Hibiscus* whereas in the studied taxa of *Abutilon,* it is sub-oblate to oblate-spheroidal (Table 2). Pollen grains of *Abutilon* are also distinct in being 3 - 4 zonoporate in contrast to the *Hibiscus* species that have apolar and pantoporate pollens. According to Pope (1925), the shape of the grain may be correlated with the presence of echinations, as all grains possessing spines are either spherical or ellipsoid-

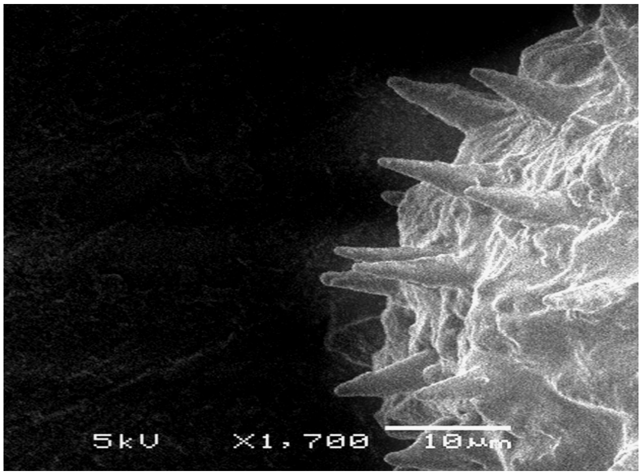

Figure 12. SEM micrographs of pollen grains of *Hibiscus* L.; exine pattern. *H. caesius*.

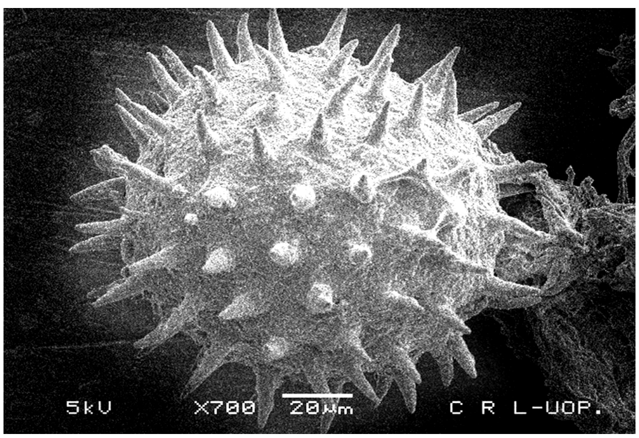

Figure 13. SEM micrographs of pollen grains of *Hibiscus* L.; pollen grain of *H. trionum*.

dal. One of the most significant features on the basis of which Fryxell and Hashmi (1971) were able to segregate *Raydera* from *Hibiscus* was the difference between the shape of pollen grains of both taxa. The pollen grains of *Raydera* are oblate to sub-oblate whereas those of *Hibiscus* are spherical to spheroidal in shape (Fryxell and Hashmi, 1971). Nair (1970) does not consider the shape of the pollen as a reliable parameter in pollen morphological analyses of angiosperms in relation to taxonomy and phylogeny. Lakshmi (2003) describes it as a character that is usually unfixed and is affected by the embedding media.

External marking of the pollen grains is described as the best, most constant and distinct character by which grains may be delimited at different taxonomic levels in case of stenopalynous families (Pope, 1925; Nair and Sharma, 1965). One of the most prominent and interesting features of Malvaceous pollen is the echinations or prolongations of the exine into definite spines (El Naggar 2003). Malvaceae is fairly advanced because of the echinate sculpturing and pantoporate character of its pollen grains (Perveen, 1993). The number, height, and position of these spines vary in the different plant families in which they occur, and constitute some of the most significant characters for identification purposes (Pope, 1925). The variations in size, shape and surface distribution of spines in the pollen grains of Malvaceae are of significant value at different taxonomic levels as these are not only recorded at intergeneric level but also between species of the same genus (El Naggar, 2003). The present study shows that the highest value of spine index is recorded for *Hibiscus sabdariffa* (Table 2; Figure 15) and smallest in *Abutilon pakistanicum* (0.5); although the longest spines are observed in *Hibiscus syriacus* (17.5 - 25 µm) and *Hibiscus sabdariffa* (15 - 25 µm) and smallest in *Abutilon fruticosum* (2 - 2.5 µm) (Figure 14). Spine index, the proportion between the height and width of the spine at its base defines the spine configuration and is used as a taxonomic characteristic to delimit Malvaceous taxa for the first time in the present work. Two main groups are identified. All the species of the genus *Abutilon* included in the present study are recognized with a spine index of less than 1.5 whereas the studied taxa of *Hibiscus* are placed in a group having spine index in the range of 1.5 - 3.18 (Table 2).

Hibiscus is a large, well known and heterogeneous genus of the family Malvaceae (Fryxell and Hashmi, 1971). Pollen morphology of the genus from Pakistan has been investigated by a number of workers. The most recent and significant study in this respect is that of Perveen et al. (1994) and Bibi et al. (2008). There are some mistakes worth mentioning in some of the previous studies which may mislead subsequent researchers. One of the major mistakes is that made by Bibi et al. (2008); they amazingly used the caption of "polar view" and equatorial "view" in Figures 11 - 21 for the pollen of *Hibiscus*. This is obviously a mistake. The terms "polar" and "equatorial" are used to describe the morphology of isopolar pollen whereas the pollen grains of *Hibiscus* are apolar as it is confirmed in the present study as well as in previous findings by Perveen et al. (1994) and El Naggar (2003). Fryxell and Hashmi (1971) also did not use the terms polar and equatorial views to describe the pollen of the genus *Hibiscus*. Lakshmi (2003) in her comprehensive study investigated the pollen morphology of 15 species of the genus *Hibiscus* and all of the taxa examined were with apolar and pantoporate pollen. This is not only in contrast with previous findings but also contradicts the authors own statement in the abstract of the said paper where they used the term "apolar" for the pollen of the genus *Hibiscus*. There is also some controversy in the description of the range of pollen grain size for one particular species. Pollen size described by Bibi et al. (2008) for *H. rosa-sinensis* is 124 - 165 µm which is larger than that described by El Naggar (2003)

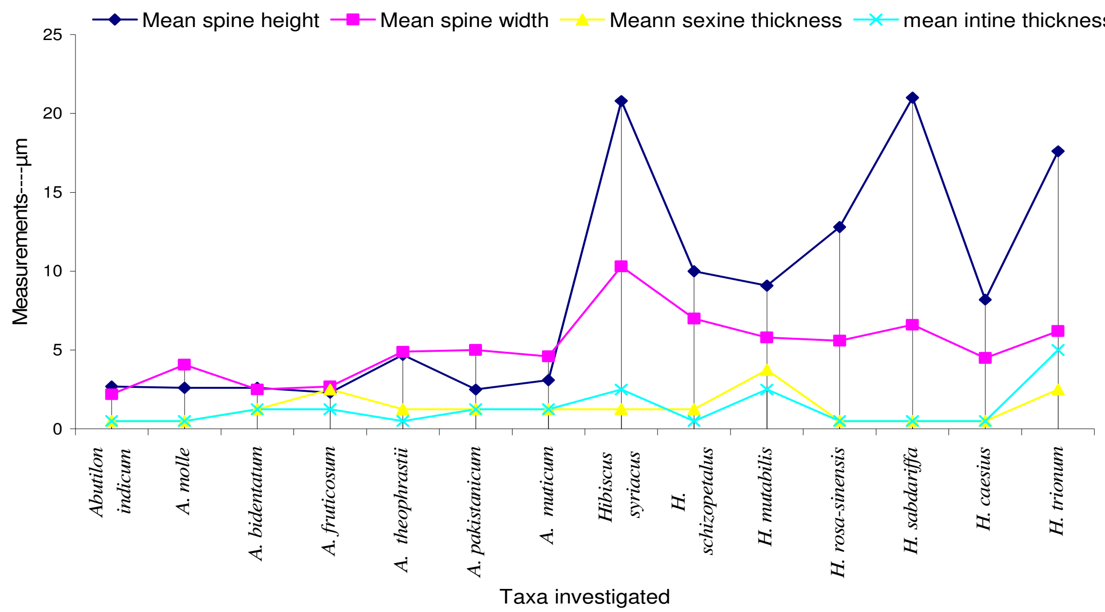

Figure 14. Quantitative variation in different palynological features among Malvaceous taxa investigated.

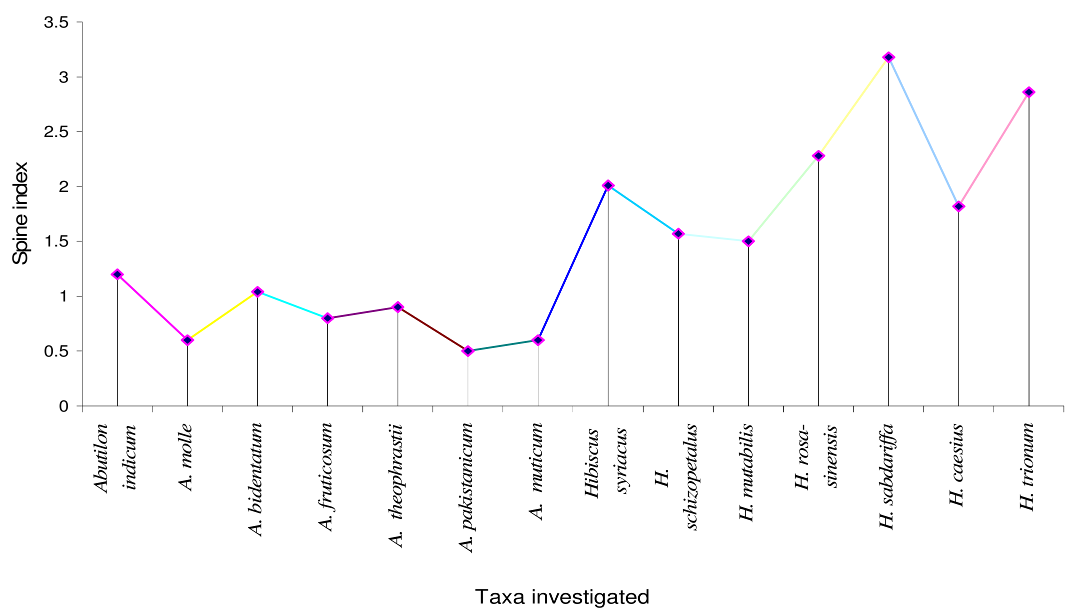

Figure15. Variation in spine index in Malvaceous taxa investigated.

and Lakshmi (2003) that is 73 - 75 and 72.8 - 98.8 µm respectively. Perveen et al. (1994) did not study the pollen morphology of *H. rosa-sinensis* but the pollen size recorded by them for selected *Hibiscus* species is not less than 70 µm. Similarly, Fryxell and Hashmi (1971) also described the range of 79 - 182 µm for the pollen size of *Hibiscus* species. Present studies are also in accordance with the findings of previous authors (Fryxell and Hashmi, 1971; Perveen et al., 1994) and recorded the size of pollen grains in the range of 80 - 170 µm. The data given by Noor et al. (2004) for the pollen size of *H. rosa-sinensis* is in clear contrast with previous and present findings. Noor et al. (2004) recorded the value of 35 µm for the pollen size of *H. rosa-sinensis* which is too small and does not fall within the prescribed range reported for the genus by any of the above mentioned authors and is most probably a calculation error. Pollen grains of *H. rosa-sinensis* from specimens belonging to

Table 2. Qualitative and quantitative palynological features in investigated Malvaceous taxa.

Taxa investigated	Shape	(Apolar pollen) Min. (Mean ± S.E) Ma.	(Isopolar pollen) Min. (Mean ± S.E) Ma.		Pollen class	Min. (Mean ± S.E) ZMa. Spine height µm	Min. (Mean ± S.E) Ma. Spine width µm	Spine index
		Pollen diameter µm	**P. axis. µm**	**E. diam. µm**				
Abutilon indicum	Sub-oblate	_	69 (74.3 ± 0.9)78	50 (51.3 ± 0.6) 60	3.zonoporate	2.5 (2.7 ± 0.07) 3	2 (2.2 ± 0.08) 2.5	1.2
A. molle	Oblate-spheroidal	_	37.5 (37.5 ± 0)	37 (40.6 ± 0.8) 40	3.zonoporate	2.5 (2.6 ± 0.07) 3	3.75 (4.07 ± 0.1) 4.5	0.6
A. bidentatum	Spheroidal	_	50 (52.5±1.1) 55	50 (52.5 ± 1) 55	3.zonoporate	2.5 (2.6 ± 0.07) 3	2.5 (2.5 ± 0.1) 3	1.04
A. fruticosum	Oblate-spheroidal	_	35 (50±1.9)55	50 (55 ± 0.5)58	3.zonoporate	2 (2.27 ± 0.07) 2.5	2.5 (2.7 ± 0.08) 3	0.84
A. theophrastii	Oblate-spheroidal	_	47.5 (49.6±1.1)55	50 (49.6 ± 0.6) 55	3.zonoporate	4.5 (4.7 ± 0.08) 5	4.5 (4.9 ± 0.08) 5	0.9
A. pakistanicum	Oblate-spheroidal	_	50 (52.8 ± 0.8) 55	52 (63.2 ± 2.6) 70	3.zonoporate	2.5 (2.5 ± 0)	5 (5 ± 0)	0.5
A. muticum	Sub-oblate	_	40 (44.5 ± 2.7) 60	62 (65.4 ± 0.6) 67	3.zonoporate	2.5 (3.1 ± 0.2) 3.75	3.75 (4.6 ± 0.02) 5	0.6
H. syriacus	Spheroidal	100 (114.16 ± 4.5) 130	_	_	Pantoporate	17.5 (20.8 ± 1.02) 25	10 (10.3 ± 0.3) 12.5	2.01
H. schizopetalus	Spheroidal	110 (158 ± 4.2)180	_	_	Pantoporate	12.5 (11 ± 2.04) 15	5 (6.99 ± 0.36) 7.5	1.57
H. mutabilis	Spheroidal	120 (132 ± 2.26)140	_	_	Pantoporate	7.5 (9.09 ± 0.38) 10	5 (5.75 ± 0.38) 7.5	1.5
H. rosa-sinensis	Globose	135 (150 ± 5.2)170	_	_	pantoporate	9 (12.8 ± 0.7) 15	5 (5.6 ± 0.1) 6	2.28
H. sabdariffa	Globose	85 (100.5 ± 5.3)120	_	_	pantoporate	15 (21 ± 1.06) 25	5 (6.6 ± 0.2) 8.07	3.18
H. caesius	Spheroidal	80 (89 ± 3.0)95	_	_	pantoporate	7 (8.2 ± 0.3) 9	4 (4.5 ± 0.1) 5	1.82
H. trionum	Globose	100 (110 ± 1.54)115	_	_	pantoporate	16.5 (17.63 ± 0.4) 20	5 (6.15 ± 0.32) 7.5	2.86

Taxa	I. d. from apex (µm) Min. (Mean ± S.E) Ma.	Pore diameter (µm) Min. (Mean ± S.E) Ma.	Sexine thickness (µm)	Nexine thickness (µm)	Intine thickness (µm)
Abutilon indicum	6 (7.6 ± 0.4)10	Not distinct	0.5	0.5 - 1.25	0.5
A. molle	5 (6 ± 0.2)7	Not distinct	0.5	0.5 - 1.25	0.5
A. bidentatum	5 (5.6 ± 0.2) 7	2 (2.3 ± 0.1)3	1.25	Poorly developed indistinct	1.25
A. fruticosum	5 (7.7 ± 0.6) 10	2.5 (2.5 ± 0)	2.5	Poorly developed	1.25
A. theophrastii	4 (6 ± 0.3) 8	2.5 (2.5 ± 0)	1.25	Poorly developed almost absent	0.5
A. pakistanicum	6 (7.2 ± 0.4) 9	2.5 (2.5 ± 0)	1.25	0.5	1.25
A. muticum	7 (8.5 ± 0.4)10	3 (4.06 ± 0.3)5	1.25	1.25	1.25
H. syriacus	24.9 (33.1 ± 1.8) 40	Not distinct	1.25	2.5	2.5
H. schizopetalus	15.3 (21.09 +/- 1.4)29.22	5 (5.4 ± 0.1) 6.2	1.25	2.5	0.5
H. mutabilis	22.22 (27.11 ± 1.3)33.33	5 (6.75 ± 0.38) 7.5	3.75	1.25	2.5
H. rosa-sinensis	20 (21.5 ± 0.61) 24	5 (5.6 ± 0.1)6	0.5	2 - 2.5	0.5
H. sabdariffa	18.46 (25.8 ± 1.07)27.68	7.5 (8.85 ± 0.33)10	0.5	1.25 - 2.5	0.5
H. caesius	9.35 (11.24 ± 0.9) 13.75	6.5 (7.85 ± 0.4) 10	0.25 - 0.75	3.75 - 5	0.25 - 0.75
H. trionum	12 (15.52 ± 0.86) 20	6.25 (6.8 ± 0.2) 7.5	2.5	5 - 7.5	5

Min., minimum; Ma., maximum; S.E., standard error; P. axis, Polar axis; E.diam., equatorial diameter; I.d., interspinal distance.

different localities were measured to verify the results but the authors could not find any pollen too small to fall within the size range prescribed by Noor et al. (2004). The largest pollen size in the genus *Hibiscus* represented by seven selected species in the present study is recorded for *H. rosa-sinensis* (135 - 170 µm) and *Hibiscus schizopetalus* (110 - 180 µm) which is in accordance with the findings of Bibi et al. (2008) but does not fall in the range prescribed by El Naggar (2003) that is. 73 - 75 µm for *H. rosa-sinensis*. Pollen diameter of *Hibiscus mutabilis* (120 - 140 µm) also match the results obtained by Bibi et al. (2008) that is, 142 µm but differs a great deal from the size range specified by Pervaiz et al. (2005) that is, 60-65 µm.

Pollen exine varies considerably in the studied taxa of Malvaceae and this variation in thickness is related to both nexine and sexine thus disagreeing with Christensen (1986) that sexine is usually of constant thickness in Malvaceae whereas the nexine is variable. The present work supports El Naggar (2003) that variation in exine thickness of Malvaceous pollen is related to both nexine and sexine thickness (Table 2). Nexine is poorly developed in some taxa of *Abutilon* but well developed in *Hibiscus* (Table 2). The thickest sexine is observed in *H. mutabilis* (3.75 µm). Intine also varies considerably in thickness and structure.

It is concluded that palynological markers can be used as a reliable tool to delimit *Hibiscus* and *Abutilon* at generic level. It is further concluded that data from palynological studies is of significant taxonomic importance and must be integrated with traditional morphology based classification to delimit different taxa at the level of species with certainty.

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