

## Pollen morphology of *Madhuca* Buch.-Ham. ex J.F. Gmelin (Sapotaceae) and its taxonomic significance

Naser Omar<sup>1</sup>

University of Benghazi-Alabear Branch, Libya

Noraini Talip

Abdul Latiff

University Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia

Anisa S. Al-Hakimi

Taiz University, Yemen

**Abstract:** Pollen morphology of 19 species of *Madhuca* Buch.-Ham. ex J.F. Gmelin of Malaysia was examined using both light and scanning electron microscopes. The pollen grains are single, radially symmetrical, isopolar, mostly subprolate, rarely prolate-spheroidal and spheroidal and generally 4-colporate. The largest pollen belongs to *M. curtisii* and *M. motleyana* and *M. khoonmengii* and *M. calcicola* have the smallest. On the basis of pollen surface ornamentation four main types have been recognized namely, granular, anastomosed granular, rugulate and perforate which have taxonomic significance in species grouping. Within the genus pollen diversity is valuable for both identification and delimiting of species.

**Keywords:** Malaysian *Madhuca*, micrographs, ornamentation, significance, taxonomy

### INTRODUCTION

The genus *Madhuca* Buch.-Ham. ex J.F. Gmelin is one of the important genera in Sapotaceae. It is estimated there are ca. 100 species distributed from India through Malesia and south China to New Guinea [Pennington, 1991]. It is composed of small-to large-sized trees that produce high quality *nyatuh* timber, well-known for its fine texture and decorative grains. Locally the timber is highly valued for paneling, flooring, solid doors, veneer and plywood [Yii, Chai, 2002]. In Malaysia the genus is known by various vernacular names such as *nyatuh*, *bitis*, *nyatuh sundik*, *nyatuh balak*, *nyatuh lebar daun*, *putat* among the Malays and *kayu medang Wangi* and *medang* among the indigenous Temuan.

In the early treatment of *Madhuca* by H.J. Lam [1925, 1927] he had recognised two sections within the genus *Dasyaulus* and *Kakosmanthus* and he recorded

a total of 61 species. The last systematic treatment of *Madhuca* of Malesia was carried out by P. van Royen [1960] who divided the genus not into sections but four groups based on the types of secondary and tertiary leaf nervation. F.S.P. Ng [1972] when revising the genus for the *Tree Flora of Malaya* recognized 24 species. Subsequently, T.D. Pennington [1991] had showed that *Madhuca* and *Ganua* Pierre ex Dubard could not be separated in both the vegetative and floral characters and concluded the two genera are congeneric. Subsequently, I.M. Turner (1995), included *Ganua* in *Madhuca* and listed 30 species as occurring in Peninsular Malaysia and Singapore. Recently, five new species, namely *M. latiffiana*, *M. khoonmengii*, *M. pasohensis*, *M. malaysiana* and *M. whitmorei* and one new record, *M. palembanica* was reported in Peninsular Malaysia by N. Omar and A. Latiff [2013, 2014] and Omar et al. [2015].

Generally, palynological characters contribute enormously to plant systematics and were first introduced by G. Erdtman [1952]. They play an important role as the pollen grains have diverse characteristics, exine morphological characters and sculpturing enabling identification of taxa of certain affinities to species level or at least to genus and family level [Moore, Webb, 1978; Aftab, Perveen, 2006]. According to K.P. Shivanna and N.S. Rangaswamy [1992], the most important diagnostic features of pollen grains are size, shape, surface, aperture, exine sculpture and variations in pollen morphology largely related to details of the exine.

The pollen of Sapotaceae was first described by G. Erdtman [1952] on ten species. M.M. Harley [1986, 1990, 1991a, 1991b] had carried out intensive studies on Sapotaceae pollens and she divided the family into two major pollen groups, based on the presence and absence of continuous endexinous thickening in the equatorial region, number of apertures, surface pattern and colpus length. The author recognized ten pollen types within the first major group, while the other groups were not further subdivided. The genus *Madhuca* occurs in the first three groups, the first group with 25 species, the second with 10 species and the third group with only one species.

<sup>1</sup>E-mail: pakteh48@yahoo.com

Received 20.01.2023; Received in revised form 13.10.2023; Accepted 28.11.2023

M.M. Harley [1991b] observed the pollen in 398 species belonging to 53 genera of Sapotaceae, six species of *Madhuca* from Peninsular Malaysia were included. Their pollen was described as having heterogeneous ornamentation (granular, slightly regulate, perforate), with variations in shape class which are subprolate in *M. aristulata*, *Madhuca* sp. (now *M. khoonmengii*) and *Madhuca* sp. (now *M. malaysiana*), spheroidal in *M. curtisii* and prolate-spheroidal in *M. tomentosa* and *M. tubulosa*. The objectives of the present study are to give an account of pollen morphology of 19 species of *Madhuca* in Peninsular Malaysia and to ascertain its taxonomic significance.

#### MATERIAL AND METHODS

The pollen samples examined in this study were obtained mostly from the herbarium specimens in Forest Research Institute Malaysia (KEP) and Universiti Kebangsaan Malaysia (UKMB), as fresh flowers are difficult to obtain in the field. Each specimen was chosen as a representative of the species studied (Table 1). The pollen slides were prepared for light (LM) and scanning electron microscopy (SEM) studies by the standard methods as described by G. Erdtman [1952] and acetolysis technique was slightly modified as given below:

*Acetolysis Method.* Unopened flower buds from the herbarium specimens were softened and fixed in fixative Acetic acid-Alcohol Acetic anhydride for 24 hours. The acetolysis mixture consists of nine parts acetic anhydride to one part concentrated sulphuric acid. The mixture was made daily and the procedure was carried out in a fume hood. After discarding the fixative and the pollen grains by 1% Teepol and then glacial acetic acid, a few drops of acetolysis mixture were added to the pollen in a labeled small glass vial on water bath until the pollen darkened and acetolysis mixture went brown. The process took a few minutes. The sample was put in Eppendorf tube with acetolysis mixture and washed with glacial acetic acid for 5 min., followed by 5 min. in 2.5% potassium hydroxide (KOH) and then thoroughly washed with water. The samples were dehydrated in an ascending series of alcohol of 30%, 50%, 70%, 80 % and 95% for 10 min. and 100% three times at one-hour interval, followed by 100% acetone at 10 min. before CO<sub>2</sub> critical point drying. The prepared samples were then divided to provide materials for light microscopy (LM) and scanning electron microscopy (SEM).

*Light Microscopy.* The pollen grains were mounted in unstained glycerine jelly and observations were made

with Olympus BX43F microscope under x 400 magnification. For each species 10-20 readings were taken and the following parameters recorded: polar length, equatorial diameter, exine thickness, colpus length and mesocolpium.

*Scanning Electron Microscopy.* Pollens were suspended in a drop of water, then directly transferred with a fine pipette to a metallic stub using double-sided cello-tape and coated with gold in a sputtering chamber (BIO RAD sputter coater SC500). The SEM examination was carried out on a ZEISS Scanning Electron microscope SUPRA 55VP. The terminology used is in accordance with G. Erdtman [1952], G.O.W. Kremp [1965], K. Faegri et al. [1964] and J.M. Walker and J.W. Doyle [1975].

#### RESULTS AND DISCUSSION

The palynological observations for 19 species of *Madhuca* are summarized in Tables 2 and 3. Figures 1 and 2 showed pollen micrographs taken under the light microscope and Figures 3 and 4 showed pollen micrographs taken under the SEM. The pollen grains in *Madhuca* are single, radially symmetrical, isopolar, angulaperturate (Fig. 1a), or less frequently planaperturate (Fig. 1b). The apertures are 4-colporate as in most species studied, three species namely, *M. curtisii*, *M. erythrophylla* and *M. kingiana* showed 5-colporate apertures, two species *M. malaysiana* and *M. motleyana* showed 4-5-colporate, *M. khoonmengii* with 3-4-colporate and 3-colporate is only observed in *M. korthalsii*. These findings are also reported in Sapotaceae taxa by M.M. Harley [1991b]. The polar view (amb) of pollen grains is more or less circular or varied according to the number of apertures present. For example, tricolporate grains tend to appear circular as in *M. korthalsii* (Fig. 1c), 4-colporate grains tend to appear squarish as in most species (Fig. 1a), and 5-colporate grains tend to appear pentagonal as in *M. curtisii* (Fig. 1d).

The ratio between the mean polar axis (P) and the mean equatorial diameter (E) can be used to assign the pollen grains to shape classes following G. Erdtman [1952]. There were three groups of pollen of *Madhuca* that have been recognized in this study on the basis of pollen shape, namely, Group I: pollen subprolate, Group II: pollen prolate-spheroidal and Group III: pollen spheroidal.

The biggest group is Group I which consists of 15 species (e.g. *M. calcicola*, *M. erythrophylla*, *M. hirtiflora*, *M. khoonmengii*, *M. kingiana*, *M. laurifolia*,

**Table 1.** The list of species and specimens used in this study.

Species	Voucher specimens
<i>M. calcicola</i>	Kedah, Pulau Langkawi, Tasik Dayang Bunting, 29 November 2012, Naser Omar, NA 140 (UKMB).
<i>M. curtisii</i>	Pahang, Ulu Sungai Anak Endau, 5 April 1968, Cockburn, FRI 8154, (KEP).
<i>M. erythrophylla</i>	Pahang, Gunung Lesong., 1 October 1981, Pennington, Wong & Kamarudin Saleh, FRI 10249, (KEP).
<i>M. hirtiflora</i>	Johor, Labis Forest Reserve., Ulu Endau, 25 March 1968, Cockburn, FRI 7913 (KEP).
<i>M. khoonmengii</i>	Pahang, Bukit Ibam road, ca. 5 miles south of Segamat-Kuantan highway junction, 28 September 1981, Pennington & Wong, FRI 32267 (KEP).
<i>M. kingiana</i>	Johor, Ulu Endau, Labis Forest Reserve, 25 March 1968, Cockburn, FRI 7916 (KEP).
<i>M. korthalsii</i>	Pahang, Lanchang, 24 February 1985, Latiff, ALM 826, (UKMB).
<i>M. laurifolia</i>	Keda, Bukit Bintang Forest Reserve, 18 March 1940, Sherin, KEP 35158, (KEP).
<i>M. malaccensis</i>	Negeri Sembilan, Pasoh Forest Reserve, 11 March 2009, Wilkie & Imin, pw 838, (KEP).
<i>M. malaysiana</i>	Pahang, Lesong Forest Reserve, 1 October 1981, Kamarudin Saleh, FRI 28872 (KEP).
<i>M. motleyana</i>	Selangor, Sungai Tinggi, Tanjung Karang, 16 October 1937, Nur, KEP 34107, (KEP).
<i>M. penangiana</i>	Pulau Pinang, Penara Bukit, March 1888, Curtis 1450 (KEP).
<i>M. penicillata</i>	Selangor, Sungai Buloh Forest Reserve 11 April 1918, Hamid, KEP 1580, (KEP).
<i>M. selangorica</i>	Selangor, Ampang Forest Reserve, 21 March 1970, Kochummen, FRI 16002 (KEP).
<i>M. sericea</i>	Perak, Sg. Plus, Chior Forest Reserve, Sg. Siput, 5 October 1967, Ng, FRI 5730 (KEP).
<i>M. tomentosa</i>	Johor, Ulu Endau, Labis Forest Reserve, 22 March 1968, Cockburn, FRI 7866 (KEP).
<i>M. tubulosa</i>	Johor, Ulu Endau Johor-Pahang Border, 31 March 1968, Cockburn, FRI 8030 (KEP).
<i>M. utilis</i>	Selangor, Kajang, Ayer Hitam Forest Reserve, 12 February 1931, Somerville, KEP 26380, (KEP).
<i>M. whitmorei</i>	Pahang, Gunung Benom, Whitmore, FRI 3330, (KEP).

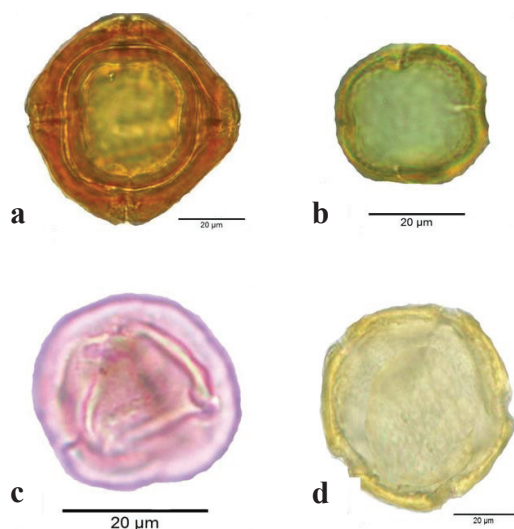
*M. malaccensis*, *M. malaysiana*, *M. penangiana*, *M. penicillata*, *M. selangorica*, *M. sericea*, *M. tomentosa*, *M. tubulosa* and *M. whitmorei*. Group II includes two species namely, *M. korthalsii* and *M. motleyana* and Group III includes only one species namely, *M. curtisii* (Fig. 2). The pollen shape as observed under the light microscope is diagnostic for three group of species.

The size of pollen grains varies considerably (Table 2). The largest grains are observed in *M. curtisii* and *M. motleyana* which have a polar axis of 58, 62  $\mu\text{m}$  and an equatorial diameter of 57, 58  $\mu\text{m}$ , respectively. The smallest size are in *M. khoonmengii* and *M. calcicola* which have a polar axis of 37.9 and 39.5  $\mu\text{m}$  and an equatorial diameter of 30.8 and 29.5  $\mu\text{m}$ ,

respectively, while in the rest of the species the pollen grains range ca. 40-50  $\mu\text{m}$  of polar axis and 34-42  $\mu\text{m}$  of equatorial diameter as in *M. kingiana*, *M. laurifolia*, *M. malaccensis*, *M. selangorica*, *M. sericea* and *M. tomentosa*. Similarly, the size of pollen grains especially the length of polar axis and equatorial diameter is also diagnostic for some species.

Exine surface ornamentation shows good taxonomic significance for the genus. Four main types of surface ornamentation could be discerned in *Madhuca* i.e. granular, anastomosed granular, rugulate and perforate and these are good diagnostic characters.

The dominant ornamentation pattern is granular, which can be divided into two subtypes namely, finely



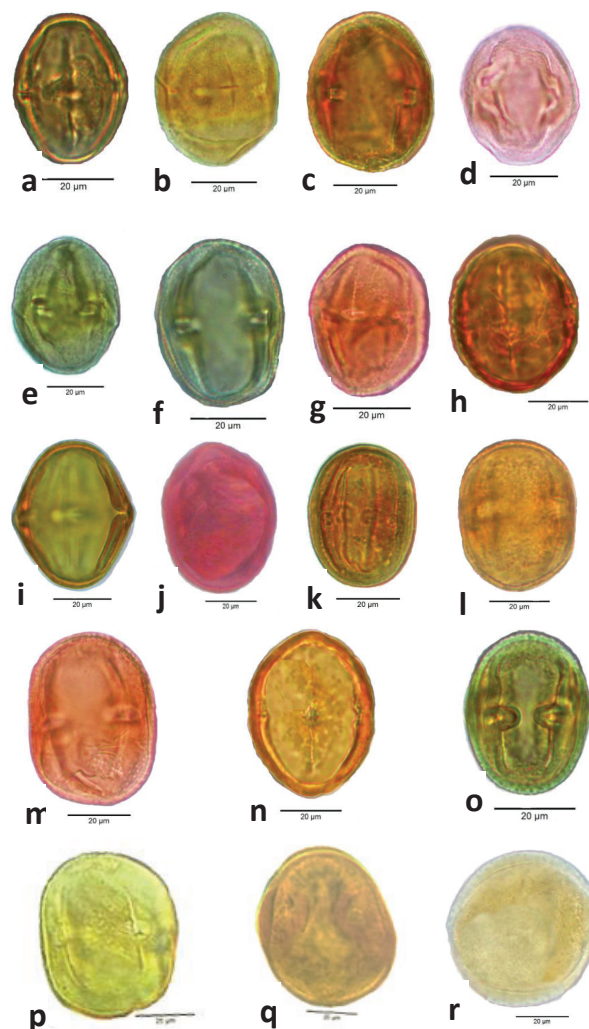
**Figure 1.** Light micrographs of whole pollen grains, polar view: (a) angulaperturate and squarish polar view in *M. motleyana*, (b) planaperturate and squarish polar view in *M. penicillata*, (c) circular polar view in *M. khoonmengii* and (d) pentagonal polar view in *M. curtisii*.

granular as in *M. khoonmengii* and *M. penicillata* (Figs. 4a-b) and perforate-granular as in *M. calcicola*, *M. korthalsii*, *M. malaccensis*, *M. selangorica*, *M. tomentosa* and *M. tubulosa* (Figs. 4c-e); anastomosed granular as in *M. malaysiana*, *M. penangiana* and *M. sericea*, but in *M. malaysiana* the ornamentation appears smoother than in others (Figs. 4f-g), (Table 3). M.M. Harley [1991b] stated the granular exine is a typical of many species of *Mimusops*, *Madhuca*, *Manilkara*, *Payena* and *Palaquium*. The third type of ornamentation pattern is regulate in which the elongated sexine elements are more than 1µm long, arranged in an irregular pattern [Punt et al., 2007], but among species there is a variation in length, width, shape and organization of the rugulae.

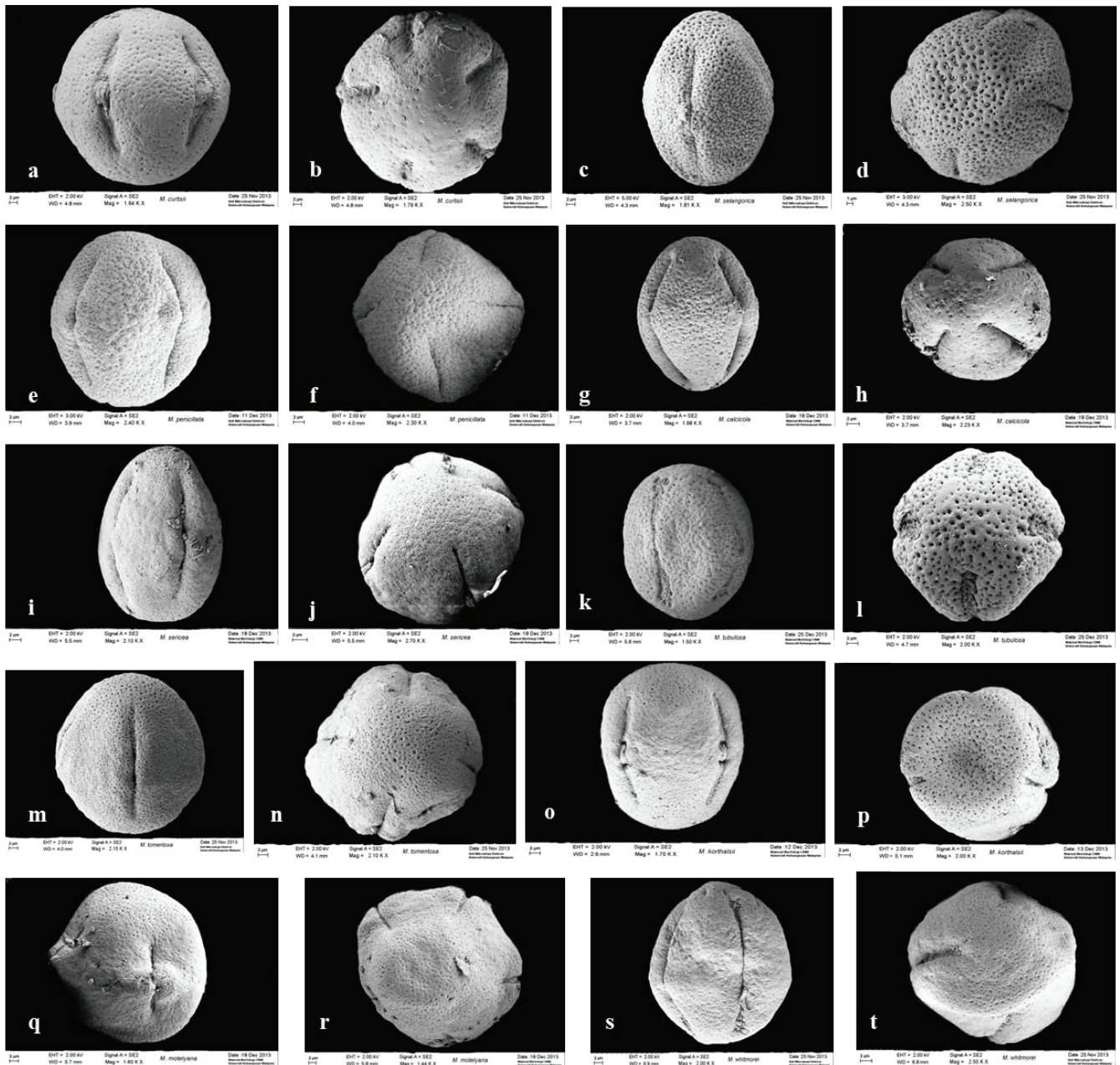
Several subtypes are defined for descriptive purposes. The first subtype is perforate-microrugulate which shows very short, irregularly shaped and randomly arranged rugulae, mostly of average length between ca. 0.1 µm and 0.5 µm. This subtype occurs only in *M. laurifolia* and *M. whitmorei* (Fig. 4 h-i). The second subtype is finely perforate-rugulate which is characterized by straight to slightly sinuate, mostly superficial rugulae. The average length of the elements usually varies between ca. 0.6 µm and ca. 1.2 µm as in

*M. erythrophylla*, *M. hirtiflora* and *M. kingiana* (Figs. 4j-k). The fourth type is perforate which occurs only in *M. motleyana* and *M. curtisii* (Figs. 4l-m).

Mesocolpial width of pollen show useful taxonomic significance for a few species. It varies among the examined species, the greatest width is observed in



**Figure 2.** Light microscopy micrographs of pollen grains according to shape: (a-o): Group I: pollen subprolate; (a) *M. calcicola*; (b) *M. erythrophylla*; (c) *M. hirtiflora*; (d) *M. khoonmengii*; (e) *M. kingiana*; (f) *M. malaccensis*; (g) *M. malaysiana*; (h) *M. penangiana*; (i) *M. penicillata*; (j) *M. selangorica*; (k) *M. sericea*; (l) *M. tomentosa*; (m) *M. tubulosa* and (o) *M. laurifolia*; (p-q): Group II: pollen prolate-spheroidal; (p) *M. korthalsii* and (q) *M. motleyana*; (r): Group III: pollen spheroidal; (r) *M. curtisii*.



**Figure 3.** Pollen grains of *Madhuca* from polar and equatorial views under SEM (a-b): *M. curtisii*; (c-d): *M. selangorica*; (e-f): *M. penicillata*; (g-h): *M. calcicola*; (i-j): *M. sericea*; (k-l): *M. tubulosa*; (m-n): *M. tomentosa*; (o-p): *M. korthalsii*; (q-r): *M. motleyana*; s-t: *M. whitmorei*.

*M. motleyana* and *M. curtisii* with 27.36  $\mu\text{m}$ , 25.55  $\mu\text{m}$ , respectively, *M. tomentosa* up to 21.63  $\mu\text{m}$ , *M. hirtiflora* with 21.57  $\mu\text{m}$ , whilst the smallest width in *M. khoonmengii* with 12.94  $\mu\text{m}$ , *M. sericea* with 13.66  $\mu\text{m}$ , *M. erythrophylla* with 13.79  $\mu\text{m}$ , *M. kingiana* 14.96  $\mu\text{m}$ , whereas for the rest of the species the mesocolpial width of pollen grains are in the range between ca. 15

$\mu\text{m}$  to ca. 20  $\mu\text{m}$ .

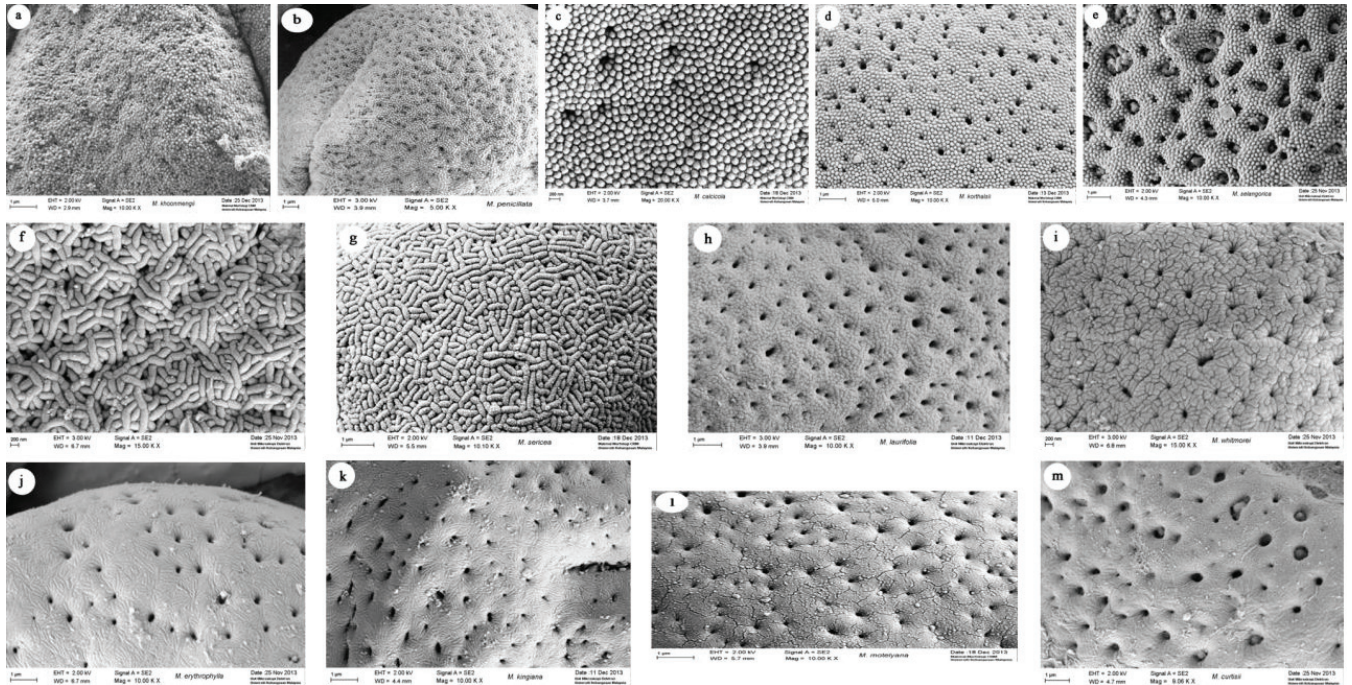
Exine was clearly visible in all species of the genus, quite thick in *M. curtisii* ca. 4.34  $\mu\text{m}$  followed by *M. motleyana* ca. 2.89  $\mu\text{m}$ , *M. penangiana* ca. 2.80  $\mu\text{m}$  and *M. kingiana* ca. 2.69, very thin exine was recorded in *M. korthalsii* ca. 1.18  $\mu\text{m}$ , *M. selangorica* ca. 1.29  $\mu\text{m}$  and *M. laurifolia* ca. 1.53  $\mu\text{m}$ , whereas in the rest of the

**Table 2.** Summary of pollen measurement, size and shape of *Madhuca*.

Species	Polar axis	Equatorial diameter	P/E	Shape class
	(P) ( $\mu\text{m}$ )	(E) ( $\mu\text{m}$ )		
	Range	Range		
<i>M. calcicola</i>	(37-)39.5(-42)	(27-)29.7(-32)	1.32	Subprolate
<i>M. curtisii</i>	(56-)58.5(-60)	(54-)57.98(-59)	1.00	Spheroid
<i>M. erythrophylla</i>	(35-)41(-45)	(29-)35.5(-39)	1.15	Subprolate
<i>M. hirtiflora</i>	(47-)49.8(-53)	(38-)41.6(-43)	1.19	Subprolate
<i>M. khoonmengii</i>	(36-)37.8(-40)	(26-)32.6(-34)	1.16	Subprolate
<i>M. kingiana</i>	(44-)47.5(-50)	(37-)39(-44)	1.21	Subprolate
<i>M. korthalsii</i>	(43-)49.2(-53)	(38-)43.6(47)	1.12	Prolate- spheroidal
<i>M. laurifolia</i>	(40-)43.2(-44)	(31-)33(-34)	1.30	Subprolate
<i>M. malaccensis</i>	(38-)41.7(-44)	(31-)35(-39)	1.19	Subprolate
<i>M. malaysiana</i>	(38-)45 (-54)	(28-)35.3(-44)	1.27	Subprolate
<i>M. motleyana</i>	(59-)61.9(-65)	(54-)59.5(-61)	1.04	Prolate- spheroidal
<i>M. penangiana</i>	(45-)48.8(-52)	(37-)41.4(-44)	1.17	Subprolate
<i>M. penicillata</i>	(45-)47(-49)	(39-)41.15(-43)	1.14	Subprolate
<i>M. selangorica</i>	(45-)49.9(-53)	(39-)42.4(-44)	1.17	Subprolate
<i>M. sericea</i>	(39-)42(-45)	(29-)32.2(-36)	1.30	Subprolate
<i>M. tomentosa</i>	(42-)45.8(-52)	(34-)39.1(-45)	1.17	Subprolate
<i>M. tubulosa</i>	(45-)50.8(-55)	(35-)39.5(-42)	1.28	Subprolate
<i>M. utilis</i>	(50-)53.2(-57)	(41-)43.5(-45)	1.23	Subprolate
<i>M. whitmorei</i>	(44-)47.3(-49)	(35-)37.9(-34)	1.24	Subprolate

**Table 3.** Summary of pollen measurement, morphology and surface ornamentation of *Madhuca*.

Species	Colpus length ( $\mu\text{m}$ )	Mesocolpium ( $\mu\text{m}$ )	No. of apertures	Polar view	Exine thickness ( $\mu\text{m}$ )	Ornamentation
<i>M. calcicola</i>	23.65	16.8	4	Square	1.94	perforate-granular
<i>M. curtisii</i>	29.80	25.55	5	pentagonal	4.34	perforate
<i>M. erythrophylla</i>	18.11	13.79	5	pentagonal	2.42	Perforate-Rugulate
<i>M. hirtiflora</i>	26.57	21.57	4	Square	2.20	Perforate-Rugulate
<i>M. khoonmengii</i>	16.44	12.94	3-4	Circular-square	1.62	Finely granular
<i>M. kingiana</i>	17.52	14.96	5	pentagonal	2.69	Perforate-Rugulate
<i>M. korthalsii</i>	25.2	19.7	3	Circular	1.18	perforate-granular
<i>M. laurifolia</i>	22.50	17.57	4	Square	1.53	perforate-microrugulate
<i>M. malaccensis</i>	23.34	16.78	4	Square	1.65	perforate-granular
<i>M. malaysiana</i>	25.68	17.65	4-5	Square - pentagonal	1.74	Fine, anastomosed granular
<i>M. motleyana</i>	20.72	27.36	4-5	Square - pentagonal	2.89	perforate
<i>M. penangiana</i>	30.74	18.56	4	Square	2.80	Fine, anastomosed granular
<i>M. penicillata</i>	24.88	19.27	4	Square	2.31	Finely granular
<i>M. selangorica</i>	26.82	20.15	4	Square	1.29	perforate-granular
<i>M. sericea</i>	23.46	13.66	4	Square	2.18	Fine, anastomosed granular
<i>M. tomentosa</i>	21.38	21.63	4	Square	2.35	perforate-granular
<i>M. tubulosa</i>	30.79	21.04	4	Square	2.02	perforate-granular
<i>M. utilis</i>	21.18	15.98	4	Square	2.43	perforate-granular
<i>M. whitmorei</i>	27.33	17.94	4	Square	2.35	perforate-microrugulate



**Figure 4.** Pollen surface ornamentation of *Madhuca* under Scanning Electron microscope. (a-b): Finely granular; (a) *M. khoonmengii*; (b) *M. penicillata*; (c-e): Perforate-granular; (c) *M. calcicola*; (d) *M. korthalsii*; (e) *M. selangorica*; (f-g): Fine, anastomosed granular; (f) *M. malaysiana*; (g) *M. sericea*; (h-i): Perforate-microrugulate; (h) *M. laurifolia*; (i) *M. whitmorei*; (j-k): Finely Perforate-rugulate; (j) *M. erythrophylla*; (k) *M. kingiana*; (l-m): Perforate; (l) *M. motleyana*; (m) *M. curtisii*.

species the exine thickness ranges from ca. 1.62  $\mu\text{m}$  to ca. 2.42  $\mu\text{m}$ .

#### CONCLUSION

A total of 19 species of *Madhuca* were studied to assess the taxonomic significance of their pollen morphology. The pollens are subprolate and 4-colporate, their exine ornamentation could be grouped into four maintypes, namely granular, anastomosed granular, rugulate and perforate with a few subtypes. The pollen size and mesocolpial width are also diagnostic for a few species.

#### ACKNOWLEDGEMENTS

The authors thank to the Curators of Herbarium, Forest Research Institute Malaysia (KEP) and Herbarium, Universiti Kebangsaan Malaysia (UKMB) for providing specimens and lastly Mr. Idris Shariff and Mrs. Normala Samsuddin for their assistance in obtaining SEM works at the Unit Microscopy.

#### REFERENCE

Aftab R., Perveen A. (2006). A palynological study of some cultivated trees from Karachi. *Pakistan*

*Journal of Botany*, 38(1): 15-28.

Erdtman G. (1952). Pollen Morphology and Plant Taxonomy. Angiosperms. Almqvist & Wiksells, Uppsala-Stockholm.

Fægri K, Iversen J. (1964). Textbook of Pollen Analysis. 2<sup>nd</sup> ed., Hafner Publishing New York.

Harley M.M. (1986). Distinguishing Pollen Characters for the Sapotaceae. *Canadian Journal of Botany*, 64(12): 3091-3100.

Harley M.M. (1990). Pollen morphology of Neotropical Sapotaceae. In: Pennington, T.D. Ed., Flora of Neotropica, Sapotaceae. New York Botanical Garden, p. 52.

Harley M.M. (1991a). Pollen morphology of the Sapotaceae. In: Pennington, T.D. Ed., The Genera of Sapotaceae. United Kingdom: The Royal Botanic Gardens, p. 23-50.

Harley M.M. (1991b). The Pollen Morphology of the Sapotaceae. *Kew Bulletin*, 46(3): 379-491.

Kremp G.O.W. (1965). Morphologic encyclopedia of palynology: An international collection of definitions and illustrations of spores and pollen. University of Arizona Press, Tuscon.

- Lam H.J. (1925). The Sapotaceae, Sarcospermaceae and Boerlagellaceae of the Dutch East Indies and Surrounding countries (Malay Peninsula and Phillipine Island). *Bulletin du Jardin botanique de Buitenzorg*, 7(3): 152-183.
- Lam H.J. (1927). Further studies on Malayan Sapotaceae I. *Bulletin du Jardin Botanique de Buitenzorz*, 8(3): 443-463.
- Moore P.D., Webb J.A. (1978). An Illustrated Guide to Pollen Analysis. Hong Kong, Hodder and Staughton.
- Ng F.S.P. (1972). Sapotaceae. In: Whitmore, T.C. Ed., Tree Flora of Malaya. Longman group Limited. London, p. 388-439.
- Omar N., Latiff A. (2013). A new *Madhuca* species (Sapotaceae) from Peninsular Malaysia. *Malaysian Foresters*, 76(1): 47-50.
- Omar N., Latiff A. (2014). Two new species and a new record of *Madhuca* Gmelin (Sapotaceae) From Peninsular Malaysia. *Malaysian Forester*, 77(1): 31-38.
- Omar N., Chantaranonthai, P., Latiff, A. (2015). Two new *Madhuca* species (Sapotaceae) from Peninsular Malaysia. *Malayan Nature Journal*, 67(2): 136-142.
- Pennington T.D. (1991). The genera of Sapotaceae. Royal Botanical Gardens, Kew. Richmond and New York Botanical Garden, New York.
- Punt W., Hoen P.P., Blackmore, S., Nilsson, S.Le., Thomas, A. (2007). Glossary of pollen and spore terminology. *Review of Palaeobotany and Palynology*, 143(1-2): 1-81.
- Shivanna K.P., Rangaswamy, N.S. (1992). Pollen Biology: A Laboratory Manual. Berlin, London: Springer.
- Turner I.M. (1995). A Catalogue of Vascular Plants of Malaya. *Gardens' Bulletin Singapore*, 47(1): 463-465.
- van Royen P. (1960). Revision of the Sapotaceae of the Malaysian area in a wider sense. XX. *Madhuca* Gmelin. *Blumea*, 10(1): 1-321.
- Walker J.W., Doyle J.A. (1975). The basis of Angiosperm phylogeny: Palynology. *Annals of the Missouri Botanical Garden*, 62: 666-723.
- Yii P.C., Chai P.K. (2002). *Madhuca* Buch.-Ham. ex J.F.Gmelin. In: Soepadmo, E., Saw, L.G., Chung, R.C.K. Eds., Tree Flora of Sabah and Sarawak. Forest Research Institute Malaysia (FRIM), Sabah and Sarawak Department and Sarawak Forestry Department, p. 221-268.

***Madhuca* Buch.-Ham. ex J.F. Gmelin (Sapotaceae) cinsinin tozcuq morfologiyası və onun taksonomik əhəmiyyəti**

**Naser Omar<sup>1</sup>**

*Benqazi Universiteti-Alabear kafedrası, Liviya*

**Noraini Talip**

**Abdul Latiff**

*Malayziya Milli Universiteti, 43600 Bangi, Selangor, Malayziya*

**Anisa S. Al-Hakimi**

*Taiz Universiteti, Yaman*

Malayziyanın *Madhuca* Buch.-Ham. ex J.F. Gmelin cinsinin 19 növünün tozcuq morfologiyası həm işıq, həm də skan elektron mikroskoplar vasitəsilə araşdırılıb. Tozcuq dənələri tək, radial simmetrik, izopolyar, əsasən uzunsov, nadir hallarda dartınmış-kürəvari və kürəvari, ümumiyyətlə 4-şırımlıdır. Ən böyük tozcuq *M. curtisii* və *M. motleyana*, ən kiçik tozcuq isə *M. khoonmengii* və *M. calcicola* növlərinə aiddir. Tozcuqların səthinin ornamentasiyası əsasında dörd əsas növ fərqləndirilir: növ qruplaşmasında taksonomik əhəmiyyətə malik olan dənəvər, budaqlanan dənəvər, uzunsov və dəlikli. Cins daxilindəki tozcuq müxtəlifliyi növlərin müəyyənləşdirilməsi baxımından böyük əhəmiyyətə malikdir.

**Açar sözlər:** *Malayziya Madhuca, mikroqrafiklər, ornamentasiya, əhəmiyyət, taksonomiya*

**Морфология пыльцы *Madhuca* Buch.-Ham. ex J.F. Gmelin (Sapotaceae) и ее таксономическое значение.**

**Насер Омар<sup>1</sup>**

*Филиал Алабир Университета Бенгази, Ливия*

**Норайни Талип**

**Абдул Латифф**

*Университет Кебангсаан Малайзия, 43600 Банги, Селангор, Малайзия*

**Аниса С. Аль-Хакими**

*Университет Тауз, Йемен*

С помощью светового и сканирующего электронного микроскопа изучена морфология пыльца 19 видов *Madhuca* Buch.-Ham. ex J.F. Gmelin из Малайзии. Пыльцевые зерна одиночные, радиально-симметричные, изополярные, преимущественно субвытянутые, реже вытянуто-сферо-



идальные и шаровидные, обычно 4-бороздные. Самая крупная пыльца принадлежит *M. curtisii* и *M. motleyana*, а наименьшая — *M. khoonmengii* и *M. calcicola*. По орнаментации поверхности пыльцы выделены четыре основных типа: зернистый, анастомозно-зернистый, складчатый и перфори-

рованный, имеющие таксономическое значение в группировке видов. Большое значение для идентификации видов имеет внутривидовое разнообразие пыльцы.

**Ключевые слова:** *Малазийский Мадука, микрофотографии, орнамент, значение, систематика*