Studies on Singapore Pollen[1]

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The pollen flora of Singapore and Malaya has been studied very little despite the wealth of the lush tropical vegetation. In well-known works on pollen morphology (Wodehouse, 1935; Erdtman, 1952) few of the indigenous plants of Southeast Asia have been described and most of the descriptions are based on herbarium material. About five years ago, when several requests were made for identification of certain pollens in connection with a few allergic cases reported in the local hospitals, an interest developed in the study of Singapore pollen. Since then a reference pollen collection of about 400 local species has been built up in the Botany Department of the University of Singapore, and a study on the morphological characters of the pollen of these plants has been undertaken. This paper is the first report of these studies. The valuable works of Cranwell (1953), Erdtman (1943, 1952), Faegri and Iversen (1964), Hyde and Adams (1958), Nair (1965), and Wodehouse (1935), and the journals *Grana Palynologica, Botanical Review* (Faegri, 1956), and *Pollen et Spores* were consulted as chief sources of reference. The pollen characters of about 85 species which have not been described in these earlier works are dealt with here, and another eight species are redescribed to indicate the variations displayed by local forms.

Materials and Methods

Pollen grains used in the present study were collected from the fresh open flowers of plants growing in Singapore and South Malaya as well as from dried flowers of herbarium specimens. Fresh pollen material was gathered by the natural shedding method (Wodehouse, 1935). The anthers in such flowers were examined periodically for signs of dehiscence and the dehisced anthers were then tapped gently, so that the grains fell into a vial containing glacial acetic acid. These were stored until it was covenient to use them for acetolysis. The dried anthers from herbarium specimens were teased and macerated in a vial with glacial acetic acid. The acetolysis method outlined by Erdtman (1952) was followed to obtain the necessary preparations, and glycerine jelly was used for mounting. Blue and yellow filters were helpful in determining the sporoderm characters accurately and for photomicrography.

At least 20 grains were measured in each case to obtain the average measurements recorded here. Differences in size and shape of the pollen grains are attributed to the presence of hygroscopic substances in the pollen grains and the degree of absorption of stains, jelly, etc. (Wodehouse, 1933). Size measurements of fresh as well as processed pollen grains were compared to establish the possible variations in size and shape of the grains caused by acetolysis and staining procedures. Very few minor variations were noticed and these do not merit recording. To determine the size, shape, exine sculpture, and LO-pattern, the methods employed by Erdtman (1952) and Nair (1965) were followed, and the descriptive terms used are in conformity with their published works.

The data for each species are arranged as follows: species name, authority, figure number if any, details of herbarium or voucher specimens, nature of apertures, shape and/or size of the individual grain or tetrad, exine thickness and its surface pattern. When the material used was obtained from an herbarium specimen, the specimen number is marked with an asterisk (e.g., *Santiria laevigata* SBGH, 30474*). In other cases (e.g., *Gloriosa superba* SUH, R101) pollen was collected from fresh flowers, and voucher specimens are deposited in the herbarium. The symbols SUH and SBGH denote Singapore University Herbarium and Singapore Botanic Garden Herbarium, respectively. The majority of the voucher specimens are deposited in the herbarium of the University of Singapore,

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and others in the herbarium of Singapore Botanic Gardens.

OBSERVATIONS AND DISCUSSION

In this presentation the families are cited in accordance with the system of Engler and Diels, *Syllabus der Pflanzenfamilien,* 1936 (see Lawrence, 1951, for details). The size measurements do not exclude the processes of the exine. In the measurements given, the polar diameter is mentioned first, followed by the equatorial diameter unless the grains are bilateral. In such cases the terms length (l), breadth (b), and height (h) are so denoted. All measurements are in microns. Exine thickness is mentioned only for certain species where it is 1μ or more; where it is not mentioned it may be assumed that the thickness is less than 1μ.

Monocotyledons

PALMAE

Cyrtostachys lakka Becc. (Fig. 1) (SUH, R123). Grains bilateral, monosulcate, l = 30μ, b = 17μ, h = 15μ, exine smooth.

Elaeis guineensis Jacq. (Fig. 2) (SUH, 3534). Grains triangular in polar view, trichotomosulcate, 22 × 33μ; exine smooth, finely reticulate.

Pollen structure of these two genera appears to be unrecorded so far. About 75 species belonging to 55 genera have been described (Erdtman, 1952). In discussing the origin of the oil palm plant, the trichotomosulcate condition is used as a basis for comparison with fossil pollen grains (Zeven, 1964).

LILIACEAE

Gloriosa superba L. (Fig. 28) (SUH, R101). Grains bilateral, furrow visible, l = 35μ, b = 33μ, h = 19μ; exine 1μ thick, and slightly thicker at proximal face, reticulate.

The genus *Gloriosa* is considered along with seven other genera belonging to three suborders—Veratraeae, Uvularieae, and Tricyrteae (Erdtman, 1952; Nair, 1965). Further details about pollen of this well-known species are recorded here.

IRIDACEAE

Trimezia martinicensis Herb. (SUH, 3062a). Grains bilateral, monosulcate, l = 41μ, b = 30μ, h = 22μ; exine reticulate, baculate.

Pollen of this species collected from plants in Jamaica was described by Erdtman (1952); the grains were bigger than in the present material collected from Fraser's Hill, Malaya.

Dicotyledons

MYRICACEAE

Myrica farquhariana Wall. (Figs. 3, 29) (SUH, 1738a). Grains 3-porate, sub-prolate, 24 × 21μ; exine smooth.

Pollen of three other species has been described previously (Erdtman, 1952). The pores in pollen grains of *M. farquhariana* are 3 to 4 in number, as in *M. gale* which has 2 to 4 pores. The exine is thicker in *M. gale* than in *M. farquhariana* (Erdtman et al., 1961; Proglowski, 1962).

ULMACEAE

Trema orientalis Blume. (SUH, 93a). Grains 2-porate, pore diameter 2μ, prolate spheroidal, 13.5 × 13.5μ; exine smooth.

Pollen of the Australian species *T. aspera* has been previously described; the grains are bigger, but other characters are similar to *T. orientalis.* In general, the pollen grains of *Celtis, Hemiptelea, Planera,* and *Ulmus* species are bigger. The species of *Ulmus* are the best known (Erdtman, 1952; Hyde and Adams, 1958; Nair, 1965; Wodehouse, 1935).

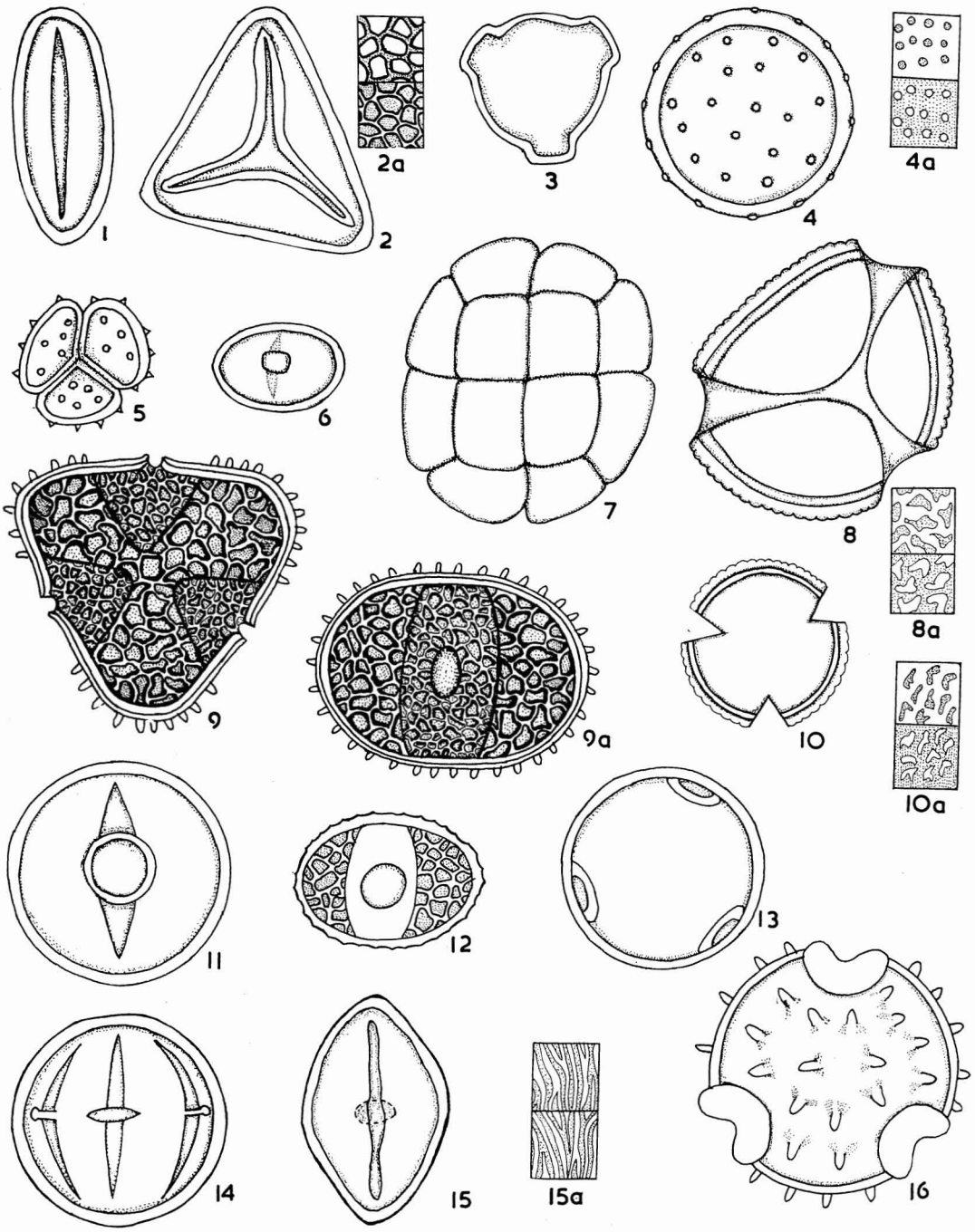
TROCHODENDRACEAE

Trochodendron aralioides Siab and Zucc. (SUH, R102). Grains 3-colporoidate, 21 × 18μ; exine reticulate.

Pollen grains of this species found locally compare well with Formosan material, but are smaller (Erdtman, 1952).

MAGNOLIACEAE

Talauma candollei Blume. (Fig. 30) (SUH, 2990*). Grains 1-sulcate, fairly rugose, l =



FIGS. 1–16. Drawings of pollen grains. (Abbreviations used: Ev, equatorial view; Lv, lateral view; Pv, polar view; Sv, surface view. Figure numbers followed by the letter "a" refer to drawings which show the LO analysis of the same pollen. All magnifications ×764.)

FIG. 1, *Cyrtostachys lakka* (Sv). FIGS. 2, 2a, *Elaeis guineensis* (Pv). FIG. 3, *Myrica farquhariana* (Pv). FIGS. 4, 4a, *Cinnamomum zeylanicum*. FIG. 5, *Nepenthes gracilis* (Pv). FIG. 6, *Pygeum polystachyum* (Ev). FIG. 7, *Acacia auriculaeformis* (Pv). FIGS. 8, 8a, *Brownea coccinea* (Pv). FIGS. 9, 9a, *Caesalpinia sappan* (Pv and Ev). FIGS. 10, 10a, *Agrostistachys sessilifolia* (Pv). FIG. 11, *Hymenaea aminifera* (Ev). FIG. 12, *Flemingia congesta* (Ev). FIG. 13, *Chisocheton divergens*(Ev). FIG. 14, *Dracantomelon mangiferum* (Ev). FIG. 15, *Harpullia zanguebarica* (Ev). FIG. 16, *Schoutenia kunstleri* (Pv).

51μ, b = 28μ, h = 25μ; exine almost smooth.

Pollen of only one species of this family has been described before—*T. minor* collected from Cuba (Erdtman, 1952).

MYRISTICACEAE

Myristica fragrans Hoult. (SUH, S102). Grains bilaterally symmetrical, 1-sulcate, l = 46μ, b = 35μ, h = 31μ; exine 1μ thick, exine baculate, coarsely reticulate.

Only *M. sebifera* has been studied before, and it has smaller pollen grains than *M. fragrans* (Erdtman, 1952).

LAURACEAE

Cinnamomum zeylanicum Nees. (Fig. 4) (SUH, 5002a). Grains nonaperturate, prolate spheroidal, 39 × 39μ, striations absent; exine with wartlike projections, foveolate.

Pollen of *C. camphora* has been described (Erdtman, 1952). It is similar to *C. zeylanicum,* but the grains are smaller.

CAPPARIDACEAE

Crataeva religiosa Forst. (SUH, R103). Grains 3-colporate, subprolate, 20 × 17μ; exine smooth, slightly thicker at the poles, foveolate.

Pollen of species of this genus seems not to have been described before, but the grains are 3-colporate like those of species of *Cadaba* and *Forchhammeria* (Erdtman, 1952).

CRUCIFERAE

Brassica rapa L. (SUH, R16a). Grains 3-colpate, oblate spheroidal, 15 × 19μ; exine baculate, OL-pattern, reticulate.

Pollen grains of *B. arvensis, B. campestris,* and *B. juncea* are spheroidal in shape and bigger than those of *B. rapa* (Hyde and Adams, 1958; Nair, 1965).

NEPENTHACEAE

Nepenthes dominii Hert. (Fig. 31) (SUH, 3781*) Vietch and *N. gracilis* (Korth) (Fig. 5) (SUH, 167-1). Grains of both species in tetrahedral tetrads, tetrad diameter 22μ (*N. gracilis*) and 24μ (*N. dominii*), each grain more or less inaperturate; exine 2μ thick, spinulose, length of spinule 0.5μ.

The pollen grains of *N. dominii,* described here for the first time, resemble those of 15 other species recently reported by Basak and Subramanyam (1966) in both size and wall characteristics. Pollen grains of *N. gracilis* from both high altitude and coastal regions were studied; there were no differences in size or structure of the grains from the two types of locality. The illustration presented in this paper (Fig. 5) is of pollen collected at an elevation of 5,150 feet, Cameron highlands, Malaya. Pollen characters of *N. alata, N. phyllamphora,* and *N. viellardi* are summarized (Erdtman, 1952).

ROSACEAE

Pygeum polystachyum Hook. (Fig. 6) (SUH, 4433). Grains triangular in polar view, pore oval in shape (5 × 4μ), suboblate to oblate spheroidal, 18.5 × 21μ; exine psilate, OL-pattern indistinct.

No previous description is available of pollen of this genus (Erdtman, 1952; Nair, 1965).

LEGUMINOSAE

Mimosoideae

Acacia auriculaeformis A. Cunn. (Figs. 7, 32) (SUH, R104). Grains in polyads of 16 cells, 8 cells centrally placed (4 upon 4) surrounded at the periphery by 8 cells. Each grain inaperturate, exine smooth. Average diameter of polyad 32μ.

Seven other species of *Acacia* have been described previously and all of them have polyads (16- or 32-celled), with or without distinct apertures (Erdtman, 1952; Hyde and Adams, 1958; Nair, 1965; Wodehouse, 1935). General description of polyads and positional relationship of individual grains in them are discussed in detail by Wodehouse (1935).

Entada spiralis Ridl. (Fig. 34) (SUH, 366*). Grains 3-colporate, subprolate, 30 × 35μ, tegillate, OL-pattern faintly reticulate.

The shape of *E. scandens* pollen grains and pollen characters of *E. phaseoloides* are previously recorded (Erdtman, 1952).

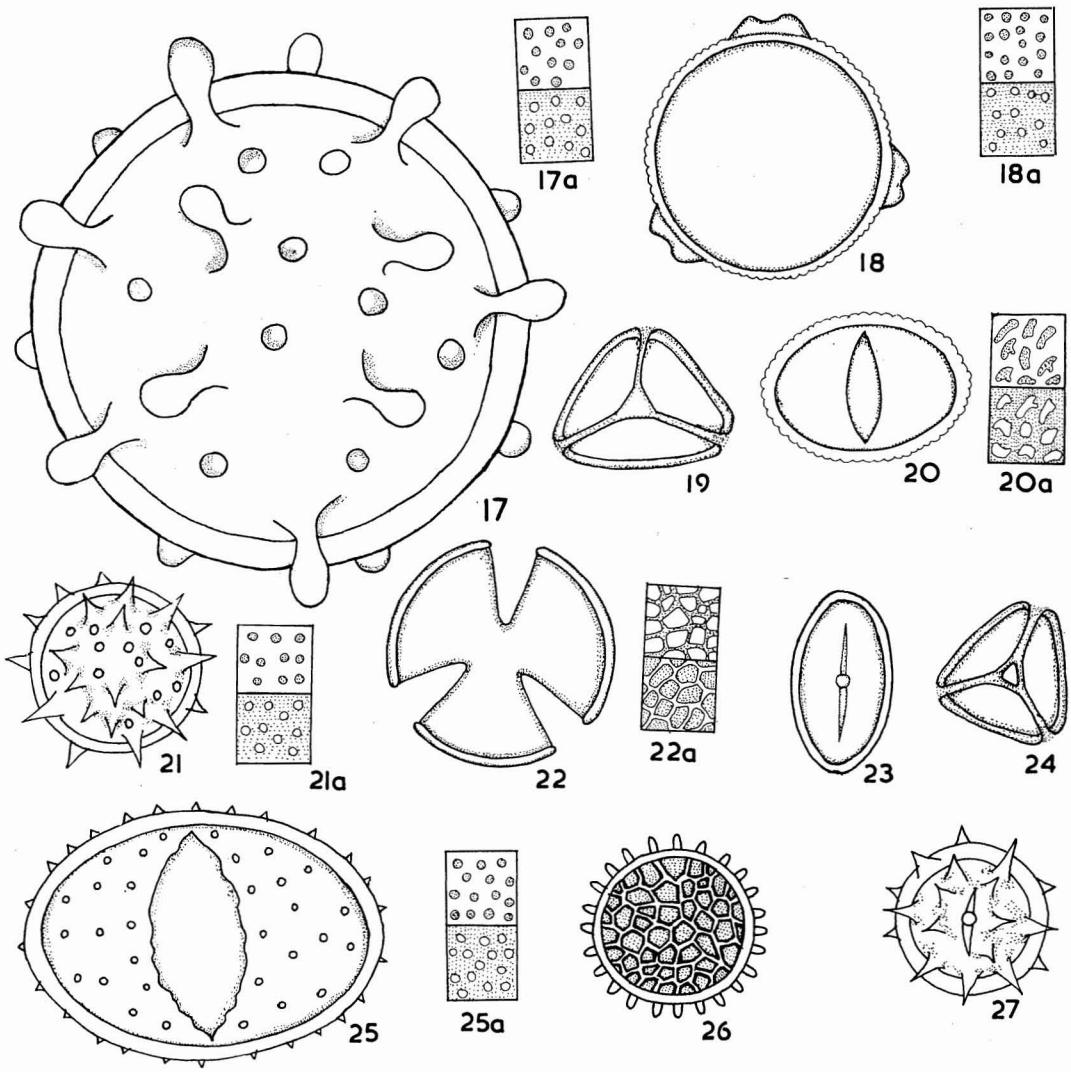
Mimosa pudica Mill. (SUH, J70-2). Grains in tetrahedral and decussate tetrads, each grain inaperturate, average diameter of tetrads 9μ.

Though the tetrad condition in this genus is well known, no description is available of pollen of any species (Erdtman, 1952; Wodehouse, 1935).

Caesalpinioideae

Bauhinia kockiana Korth. (SUH, R105). Grains 3-colporate, prolate, 40 × 26μ; exine smooth, 2μ thick.

The pollen of two other species, *B. coronata* and *B. faberi,* have been described. In *B. faberi*



FIGS. 17–27. Drawings of pollen grains. (Abbreviations used: Ev, equatorial view; Lv, lateral view; Pv, polar view; Sv, surface view. Figure numbers followed by the letter "a" refer to drawings which show the LO analysis of the same pollen. All magnifications ×764).

FIGS. 17, 17a, *Bombycidendron vidalyanum.* FIGS. 18, 18a, *Neesia altissima* (Pv). FIG. 19, *Coelostegia borneensis* (Pv). FIGS. 20, 20a, *Dryobalanops oblongifolia* (Ev). FIGS. 21, 21a, *Urena lobata.* FIG. 22, *Carica papaya* (Pv). FIG. 23, *Begonia semperflorens* (Ev). FIG. 24, *Eugenia jambos* (Pv). FIG. 25, *Clerodendron villosum* (Ev). FIG. 26, *Timonius peduncularis.* FIG. 27, *Helianthus angustifolius.*

the wall is beautifully striato-reticulate (Erdtman, 1952) unlike that in *B. kockiana.*

Brownea coccinea Jacq. (Fig. 8) (SUH, R106). Grains 3-syncolpate, subprolate to prolate, 48 × 36μ; exine smooth, 1μ thick, rugulate.

This genus is not considered in previous work (Wodehouse, 1935; Erdtman, 1952; Nair, 1965).

Caesalpinia sappan L. (Figs. 9, 9*a*, 33) (SUH, R107a). Grains triangular in polar view, each with three colpoid streaks and a pore at the equator, oblate, 32 × 46μ; exine baculate in the intercolpoid region but not so in the region of the colpoid streaks, this region being devoid of ornamentation, 2μ thick, coarsely reticulate in the intercolpoid region but the region of the colpoid streaks finely reticulate.

Description of pollen of *C. nuga* collected from Celebes is available (Erdtman, 1952).

Cassia siamea Lam. (SUH, L126*). Grains 3-colpate, subprolate, 41 × 33μ, streaks indistinct; exine subpsilate, rugulate.

Pollen of only one species of this genus, *C. abbreviata,* has been described previously (Erdtman, 1952).

Hymenaea aminifera (= *C. courbaril*) Stokes (SUH, R108). Grains 3-colpate, prolate spheroidal, 35 × 35μ; exine smooth, OL-pattern indistinct.

Koompassia malaccensis Maing. (SUH, A321). Grains 3-colpate, prolate, 19.5 × 12.5μ; exine psilate.

No previous description is available of pollen of members of these genera (Erdtman, 1952; Nair, 1965; Wodehouse, 1935).

Papilionoideae

Derris sinuata Benth. (SUH, 748). Grains 3-colpate, prolate spheroidal to subprolate, 26 × 35μ; exine slightly granular.

Desmodium umbellatum D.C. (SUH, K494). Grains 3-colporate, subprolate, 24 × 19μ; exine granular, reticulate.

The wall and pore characters of *D. umbellatum* are similar to those of the other three species described previously (Nair, 1965).

Erythrina glauca Willd. (Fig. 35) (SUH, R109). Grains triangular in polar view, 3–4 porate, oblate spheroidal, 24 × 27μ; exine granular, 1μ thick, rugulate.

Three species other than *E. glauca* have been described previously (Erdtman, 1952; Nair, 1965). Though the wall and pore characters are similar in all of them, differences in size are significant.

Flemingia congesta Roxb. (Fig. 12) (SUH, G110). Grains triangular in polar view, 3-colpoidorate, pore 4μ in diameter, oblate spheroidal, 23 × 26μ; exine undulating, reticulate.

Pterocarpus indicus Willd. (SUH, R110). Grains 3-colporate, prolate spheroidal to subprolate, 20 × 18μ; exine smooth, finely reticulate.

No previous description of pollen is available for species of *Derris, Flemingia,* and *Pterocarpus* (Erdtman, 1952; Nair, 1965; Wodehouse, 1935).

The variations in shape of the grain and size of the pore are well documented in different members of Leguminosae. In the present studies also, subprolate (*Entada spiralis, Cassia siamea,* etc.), prolate (*Bauhinia kockiana, Koompassia malaccensis*), and spheroidal forms (*Erythrina glauca, Flemingia congesta*) are observed. Variations in apertural characteristics are also found: colporate (*Bauhinia kockiana, Hymenaea aminifera,* etc.), colpate (*Cassia siamea*), and syncolpate forms (*Brownea coccinea*).

BURSERACEAE

Dacryodes incurvata (Engl.) H. J. Lam. (SUH, 6602*). Grains 3-colporate, subprolate, 25 × 19μ; exine smooth.

No previous description of pollen is available for this genus (Erdtman, 1952).

Santiria laevigata Blume. (SBGH, 30474*). Grains 3-colporate, ora lalongate, subprolate, 23 × 20μ; exine smooth.

A brief description of pollen in an unnamed species of *Santiria* was given by Erdtman (1952); the characters are similar to *S. laevigata.*

MELIACEAE

Chisocheton divergens Blume. (Figs. 13, 36) (SUH, 1487). Grains 3-porate, pores oval in shape (6 × 5μ), oblate spheroidal, 31 × 33μ; exine psilate, 1μ thick, OL-pattern indistinct.

Dysoxylum cauliflorum Hienn. (SUH, 1485*). Grains 4-colporate, ora lalongate, prolate spheroidal, 35 × 34μ; exine psilate, rugulate.

Melia indica Brand. (SUH, W138*). Grains 4-colporate, ora lalongate, prolate spheroidal, 35.5 × 33.5μ; exine psilate, rugulate.

Sandoricum indicum Cav. (SUH, K958*). Grains 3-colporate, ora lalongate, prolate spheroidal, 34 × 31μ; exine psilate, foveolate.

No previous description of pollen is available for *Chisocheton, Dysoxylum,* and *Sandoricum* (Erdtman, 1952; Nair, 1965). The characters of *Melia indica* clearly agree with those of *M. azedarach,* previously described by Erdtman (1952). Pollen of *Chisocheton* shows the 3-porate condition, which is rather unusual for a member of Meliaceae (Erdtman, 1952, p. 268). Further investigation thus seems to be necessary not only for other species of *Chisocheton* but also for other genera of Meliaceae to evaluate the stenopalynous condition of the family.

EUPHORBIACEAE

Agrostistachys sessilifolia Pax, and K. Hoffm. (Fig. 10) (SUH, R4427). Grains 3-colporate, ora lalongate, prolate spheroidal, 19 × 18μ; exine granular, 1μ thick, rugulate.

Aporosa frutescens Benth. (SUH, 236*). Grains 3-colporate, ora lalongate, prolate, 17 × 15μ; exine finely granular, reticulate.

Blumeodendron tokbrai Kurz. (SBGH, CWL. 347*). Grains 3-porate, pore 1μ in diameter, prolate, 20 × 17μ; exine granular, foveolate.

Excoecaria affinis Endl. (SUH, R111). Grains 3-colpoidorate, pores 2μ in diameter, spheroidal, 29 × 29μ; exine finely granular, reticulate.

Longetia malayana Pax. and K. Hoffm. (Fig. 37) (SUH, Ridley, 112*). Grains oligoforate, pores 4μ in diameter, spheroidal, 33.5 × 33.5μ; exine spiny, spines 5μ long.

The eurypalynous condition of Euphorbiaceae is further confirmed by these observations on five species. Pollen of *Agrostistachys sessilifolia* resembles that of *A. malabaricus* in shape and pore characters, but are smaller in size (Erdtman, 1952). In *Longetia malayana* the pollen grains are spiny, oligoporate, and spheroidal, while those of *L. buxoides* are without spines, 5–6 colp(oroid)ate and suboblate (Erdtman, 1952). The former are bigger than the latter. The present report appears to be the first record for species of *Aporosa, Blumeodendron,* and *Excoecaria.*

ANACARDIACEAE

Mangifera indica L. (SUH, R113). Grains triangular in polar view, 3-colporate, subprolate, 29 × 24μ; exine baculate, rugulate.

Dracantomelon mangiferum Blume. (Figs. 14, 38) (SUH, 98a). Grains 4-colporate, ora lalongate, oblate spheroidal, 26 × 29μ; exine smooth.

Grains of *Mangifera indica* are larger and have a very small ora compared with those of *M. foetida,* previously described (Erdtman, 1952). No previous description is available for pollen characters of *Dracantomelon* species (Erdtman, 1952; Nair, 1965).

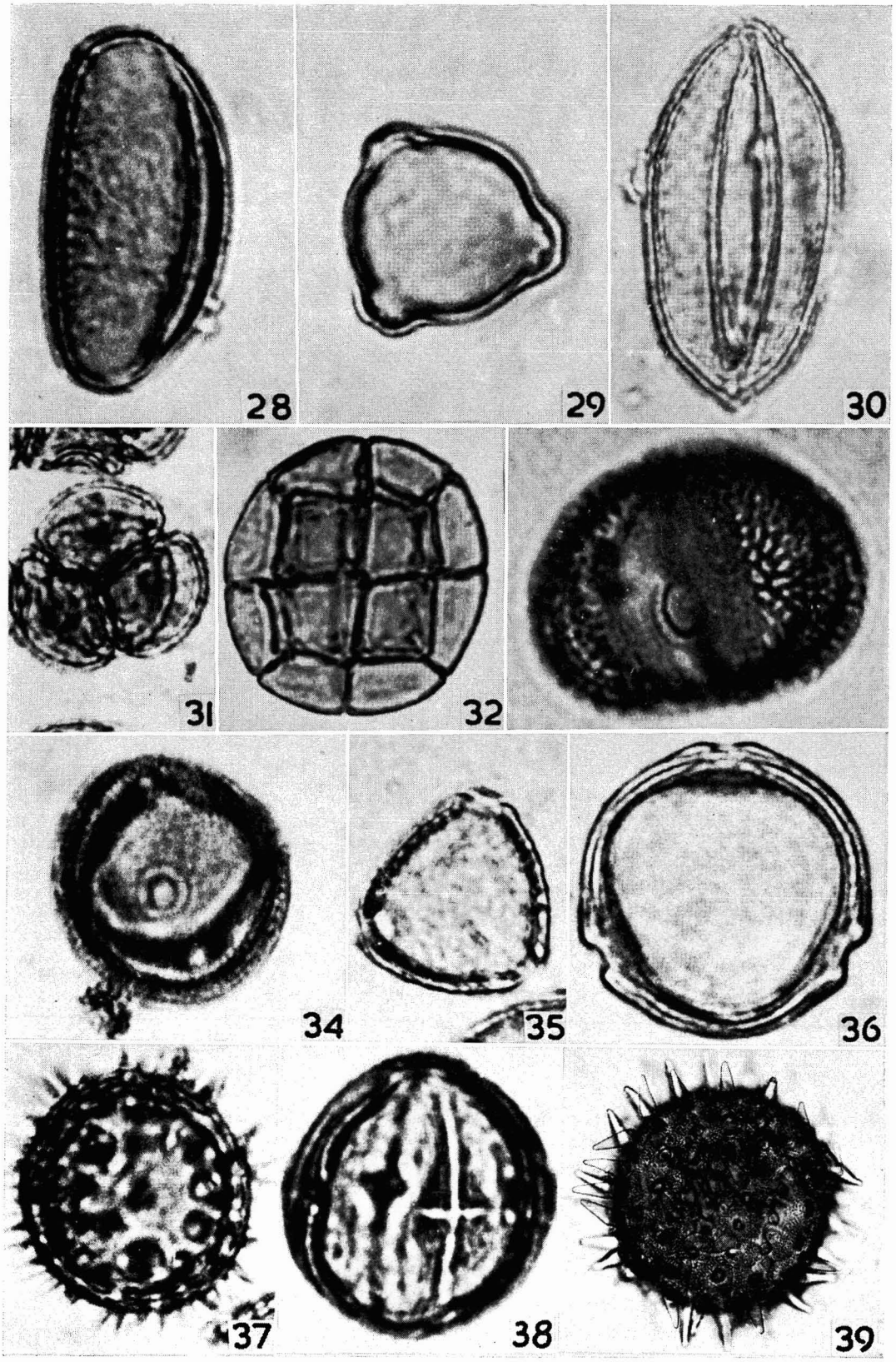
SAPINDACEAE

Arfeuillea arborescens Pierre. (SUH, K4438). Grains 3-colporate, subprolate, 26 × 21μ; exine smooth, striate.

Harpullia zanguebarica Radlk. (Fig. 15) (SUH, K683). Grains 3-colporate, ora lalongate, subprolate, 27 × 22μ; exine psilate, striate.

Otophora imbricata Blume. (SUH, K689). Grains 3-colporate, prolate, 31 × 24μ; exine baculate, 2μ thick, thicker in the region of the equator, finely reticulate.

Pometia alnifolia Radl. (SUH, R122). Grains triangular in polar view, 3-porate, pore 2μ wide, aspidote, suboblate, 22 × 28μ; exine granular, reticulate.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No previous description is available for members of these genera, and pollen characters of the above species agree with the general characters of the family (Erdtman, 1952; Nair, 1965; Wodehouse, 1935).

TILIACEAE

Schoutenia kunstleri King. (Fig. 16) (SUH, R115). Grains 3-porate, pores 4μ wide, each pore surrounded by a 4μ-thick rim, oblate spheroidal, 48 × 48μ; exine 1μ thick, with blunt spinules about 2.5μ high.

This description supplements that of Erdtman (1952).

MALVACEAE

Bombycidendron vidalianum Merrill and Rolfet (Fig. 17) (SUH, R118). Grains polyforate, pore 5μ in diameter, oblate spheroidal, 122 × 122μ; exine clavate, 2μ thick, foveolate, height of clava 17μ, width 9μ.

Hibiscus tiliaceus L. (SUH, R117). Grains polyforate, pores 5μ in diameter, oblate spheroidal, 105 × 105μ; exine spiny, interporal area reticulate, spines 19μ in length, foveolate.

Neesia altissima Blume. (Fig. 18) (SBGH, Brink, 5884*). Grains 3-porate, pores 6μ in diameter, rim around pores 5μ thick, aspidote, prolate spheroidal, 42 × 42μ; exine granular, foveolate.

Urena lobata L. (Figs. 21, 39, 40) (SUH, R116). Grains polyforate, pores 5μ in diameter, prolate spheroidal, 105 × 105μ; exine spiny, spines 14μ long, reticulate.

Prominent spines are present in all the three species of *Hibiscus* previously described, and variations noticed in the size of the grain and spines serve as useful diagnostic characters. Pollen characters of *Bombycidendron, Neesia,* and *Urena* are not mentioned in previous work (Erdtman, 1952; Nair, 1965; Wodehouse, 1935).

BOMBACACEAE

Coelostegia borneensis Becc. (Figs. 19, 41) (SUH, 3465). Grains triangular in polar view, 3-syncolpate, oblate spheroidal, 11 × 13μ; exine psilate.

Coelostegia griffithii. Benth. (Fig. 42) (SUH, FMS4222*). Grains 3-porate, pores 3μ in diameter, exine subpsilate, oblate spheroidal, 31 × 34μ, foveolate.

No description of pollen in this genus is available in previous work (Erdtman, 1952; Nair, 1965).

THEACEAE

Ploiarium alternifolium Melchior. (SUH, 1770a). Grains 3-colporate, prolate spheroidal, 31 × 28μ; exine tegillate, reticulate.

Pollen of this genus has not been described in earlier work (Erdtman, 1952; Nair, 1965).

DIPTEROCARPACEAE

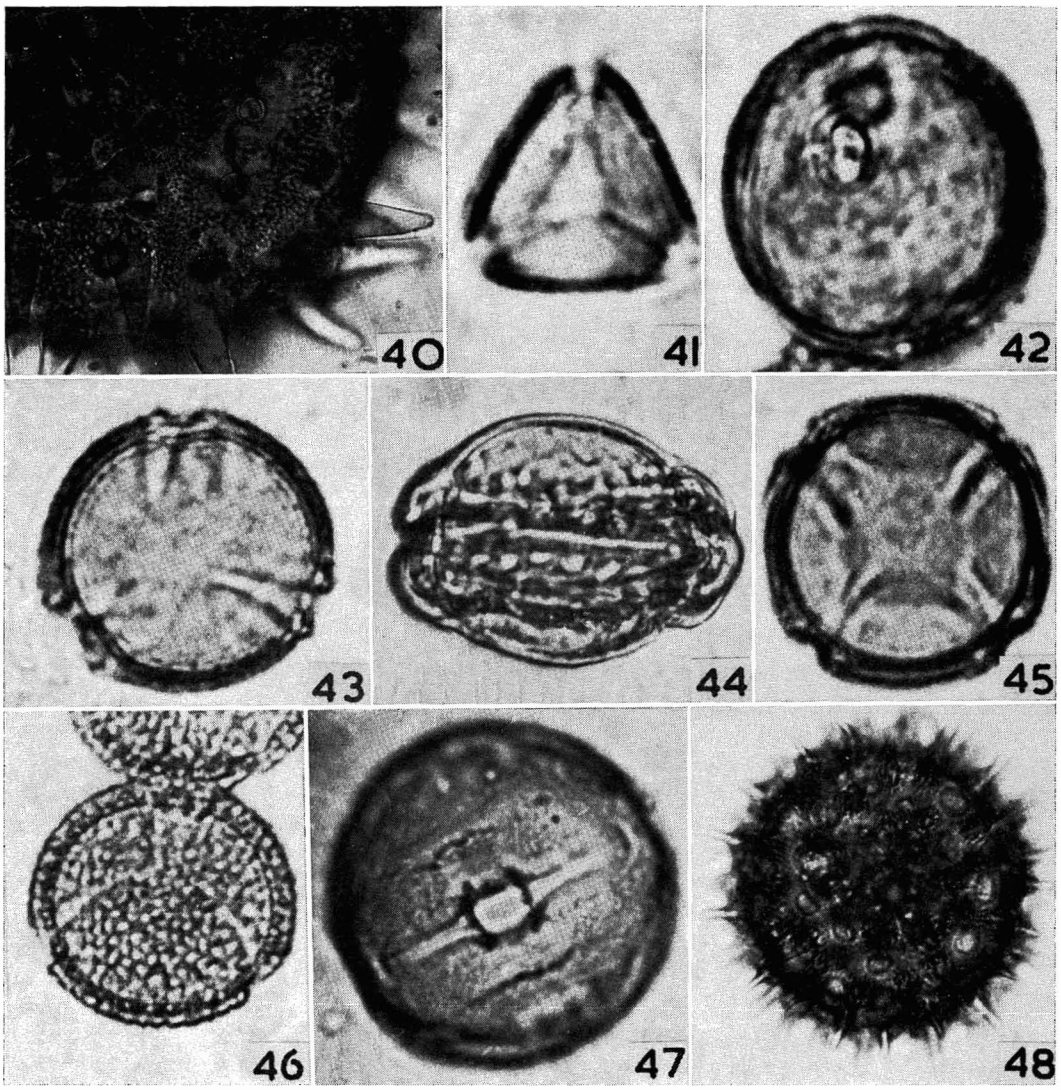
Dryobalanops oblongifolia Dyer. (Fig. 20) (SUH, FMS2734*). Grains 3-colpate, suboblate, 25 × 29μ; exine granular, rugulate.

Vatica wallichii Dyer. (SUH, K557*). Grains 3-colpate, subprolate, 25 × 20μ; exine granular, 1μ thick, foveolate.

The species of only two genera of this family, *Dipterocarpus* and *Monotes,* are dealt with in previous work, and two other genera are considered here. In general, very little information is available on pollen of Dipterocarpaceae, an important family in Southeast Asia (Erdtman, 1952; Nair, 1965; Wodehouse, 1935).

FIGS. 28–39. Photomicrographs of pollen grains. (Abbreviations as for Figs. 1–27.)

FIG. 28, *Gloriosa superba,* × 3294. FIG. 29, *Myrica farquhariana,* × 4612. FIG. 30, *Talauma candollei,* × 2882. FIG. 31, *Nepenthes dominii,* × 3294. FIG. 32, *Acacia auriculaeformis,* × 3294. FIG. 33, *Caesalpinia sappan* (Ev), × 3294. FIG. 34, *Entada spiralis* (Ev), × 3294. FIG. 35, *Erythrina glauca,* × 4953. FIG. 36, *Chisocheton divergens,* × 3294. FIG. 37, *Longetia malayana,* × 3294. FIG. 38, *Dracantomelon mangiferum* (Ev), × 3294. FIG. 39, *Urena lobata,* × 1153.



FIGS. 40–48. Photomicrographs of pollen grains. (Abbreviations as for Figs. 1–27.)
FIG. 40, *Urena lobata,* part of Figure 39 enlarged to show the pores and spines, ×988. FIG. 41, *Coelostegia borneensis,* ×4953. FIG. 42, *Coelostegia griffithii,* ×3646. FIG. 43, *Carica papaya,* ×3294. FIG. 44, *Barringtonia racemosa* (Ev), ×2635. FIG. 45, *Mimusops elengii,* ×3294. FIG. 46, *Fagraea fragrans,* ×3294. FIG. 47, *Vinca rosea,* ×2553. FIG. 48, *Ipomea pulchella,* ×1647.

CARICACEAE

Carica papaya L. (Figs. 22, 43) (SUH, 1742a). Grains 3-colporate, oblate spheroidal, 30 × 32μ; exine granular, 1μ thick, reticulate.

This information supplements the earlier description of papaya pollen (Erdtman, 1952).

BEGONIACEAE

Begonia semperflorens Hook. (Fig. 23) (SUH, 3541). Grains 3-colporate, prolate, 20 × 14μ; exine psilate, striate.

Four other species of *Begonia* are described by Erdtman (1952), and all show similar characters.

LECYTHIDACEAE

Barringtonia racemose Roxb. (Fig. 44) (SUH, 2695a). Grains 3-syncolpate, margins of the colpa thickened (corresponding to the "Planchonia type" in Erdtman, 1952), prolate, 48 × 34μ; exine psilate, 3μ thick.

Gustavia gracillima Miers. (SUH, R3494). Grains 3-colpate, prolate spheroidal, 18 × 16μ; exine psilate, 1μ thick.

Another species of each of these genera is described by Erdtman (1952). In *Gustavia mexicana,* grains are colporoidate, and in *G. gracillima* they are colpate.

THYMELAEACEAE

Gonystylus maingayi Hook. (SUH, 508*). Grains oligoforate, pores 2–3μ in diameter, prolate spheroidal, 46 × 46μ; exine subpsilate, wavy reticulate.

Only the size of the grains is given by Erdtman (1952) for *G. maingayi,* and therefore other details are mentioned here. Small spinuloid excresences reported for *G. bancanus* (the only other species described) are absent in *G. maingayi.*

LYTHRACEAE

Lagerstroemia floribunda Jack. (SUH, 564*). Grains 3-colporate, prolate spheroidal, 24 × 24μ; exine subpsilate, 2μ thick, rugulate.

Another species, *L. calyculata,* was described by Erdtman (1952).

MYRTACEAE

Decaspermum fruticosum Forst. (SUH, K5088). Grains triangular in polar view, 3-syncolpate, oblate, 14 × 20μ; exine psilate, 1μ thick, OL-pattern indeterminate.

Eugenia jambos Linn. (Fig. 24) (SUH, 2686a). Grains triangular in polar view, 3 or 4 parasyncolpate, oblate, 12 × 19μ; exine psilate, 2μ thick, thinning at the poles.

Melaleuca leucodendron L. (SUH, 119a). Grains triangular in polar view, 3-parasyncolpate, oblate, 12 × 17μ; exine psilate.

Rhodamnia trinervia Blume. (SUH, 5022a). Grains triangular in polar view, 3-colpate, subprolate, 17 × 13μ; exine psilate, 1μ thick, thicker at the region of the equator.

Rhodomyrtus tomentosa Weight. (SUH, Gilliland 363a). Grains triangular in polar view, aspidote, 3-porate, pore 1–2μ wide, suboblate, 17 × 20μ; exine psilate, 1μ thick, thicker in the region of the asps.

Unlike those of *Eugenia jambos,* the pollen grains of *E. chrootricha* (the only other species previously described) are longicolpate. Members of the genera *Decaspermum, Melaleuca, Rhodamnia,* and *Rhodomyrtus* have not been considered previously (Erdtman, 1952; Nair, 1965; Wodehouse, 1935). The family Myrtaceae is considered a stenopalynous one, the pollen being characterized by the presence of 2–3–4 colpi, sometimes syncolpate or colporate. An exceptional condition was observed in *Rhodomyrtus tomentosa,* which has 3-porate pollen grains.

MELASTOMACEAE

Anplectrum divaricatum Triana. (SUH, 2634*). Grains 3-colpate, the colpi alternating with 3 pseudocolpi, prolate, 20 × 11μ; exine psilate, indistinct.

Clidemia hirta D. Don. (SUH, 2878a). Grains 3-colpate, the colpi alternating with 3 pseudocolpi, peroblate, 15 × 13μ, exine psilate.

Marumia nemorosa Blume. (SUH, 272*). Grains 3-colpate, the colpi alternating with 3 pseudocolpi, subprolate to prolate, 14 × 11μ; exine smooth.

Melastoma molle Wall. (SUH, 355*). Grains 3-colporoidate, the colpi alternating with 3 pseudocolpi, peroblate, 19 × 16μ, exine psilate.

Miconia hookeriana Triana. (SUH, 504*). Grains 3-colpate, the colpi alternating with 3 pseudocolpi, prolate, 18 × 13μ, exine smooth.

Melastoma malabathricum was previously described (Nair, 1965); the characters are similar to those of *M. molle,* mentioned above. Members of *Anplectrum, Clidemia, Marumia* and

Miconia have not been described previously (Erdtman, 1952; Nair, 1965; Wodehouse, 1935).

ARALIACEAE

Arthrophyllum diversifolium Blume. (SUH, 124*). Grains 3-colporate, ora lalongate, subprolate to prolate, 23 × 20μ; exine granular, 1μ thick.

Schefflera biternata Harms. (SUH, S103). Grains 3-colporate, ora lalongate, prolate, 34 × 24μ; exine psilate, rugulate.

No detailed account seems to have been made previously on the species of these two genera. The length of the axis is briefly mentioned by Erdtman (1952) for the genus *Schefflera.*

ERICACEAE

Gaultheria fragrantissima Wall. (SUH, 677*). Grains in tetrads, each grain 3-colporate, tetrad diameter 30μ; exine psilate.

Only *G. trichophylla* has been considered before, and, as in some other genera of the family (e.g., *Rhododendron, Pieris*), its pollen grains are arranged in tetrahedral tetrads (Erdtman, 1952; Nair, 1965).

MYRSINACEAE

Aegiceras majus Gaertn. (SUH, 256a). Grains 3-colporate, subprolate, 20 × 16μ; exine psilate, vaguely foveolate.

Ardisia littoralis Andr. (SUH, 602a). Grains 3-colporate, oblate spheroidal, 13 × 13μ; exine psilate, 1μ thick, reticulate.

Two other species of *Ardisia* have been described earlier; the pollen of the different species is similar (Erdtman, 1952; Nair, 1965). *Aegiceras* pollen has not been described before.

PLUMBAGINACEAE

Plumbago alba Hort. ex. Pasq. (SUH, R121). Grains 3-colpate, subprolate, 49 × 42μ; exine baculate, 2μ thick, coarsely reticulate.

The pollen of *P. alba* resembles that of *P. capensis,* the only species previously described (Erdtman, 1952).

SAPOTACEAE

Palaquim obovatum King and Gamble. (SUH, K4409). Grains 6-colporate, ora lalongate, subprolate, 25 × 21μ; exine smooth, 2μ thick.

Payena lucida A. DC. (SUH, K609a). Grains 4-colporate, ora lalongate, subprolate, 32.5 × 27μ; exine smooth, foveolate.

Mimusops elengi L. (Fig. 45) (SUH, 6018). Grains 4-colporoidate, subprolate, 38 × 31μ; exine smooth, faintly reticulate.

Only wall character is described for pollen of *Mimusops blantyreana* (Erdtman, 1952). The genera *Palaquim* and *Payena* are not mentioned in earlier work (Erdtman, 1952; Nair, 1965; Wodehouse, 1935).

LOGANIACEAE

Fagraea fragrans Roxb. (Fig. 46) (SUH, 307a). Grains 3-colpate, prolate to subprolate, 30 × 26μ; exine baculate, coarsely reticulate.

Two other species, *Fagraea imperialis* and *F. morindaefolia,* have been previously described; their pollen grains are porate and colporate, respectively, unlike those of *F. fragrans* which are colpate. Other species also should be studied to determine variations.

APOCYNACEAE

Vinca rosea L. (Fig. 47) (SUH, 293a). Grains triangular in polar view, 3-colpate, ora lalongate, subprolate, 47 × 37μ; exine psilate, 1μ thick, OL-pattern faintly foveolate.

Only the shape of *V. rosea* pollen grains is briefly mentioned by Erdtman (1952); other characters are given here.

CONVOLVULACEAE

Erycibe princei Wall. (SUH, 613*). Grains 3-colpate, subprolate, 28 × 22μ; exine tegillate, fossulate.

Ipomoea pulchella Roth. (Fig. 48) (SUH, R120). Grains polyforate, pores 5μ in diameter,

spiny (spines average 10μ in length and a circlet of collumellae surrounds the base), oblate spheroidal, 66 × 66μ.

Two other species of *Ipomoea* have been described earlier. The presence of prominent spines is an important character of all (Erdtman, 1952; Nair, 1965). This appears to be the first description for *Erycibe*.

VERBENACEAE

Clerodendron villosum Blume. (Fig. 25) (SUH, 5091a). Grains 3-colpate, suboblate, 16 × 19μ; exine spinulate, 2μ thick, foveolate.

Vitex trifolia Linn. (SUH, 3251a). Grains 3-colpate, oblate, 17 × 26μ; exine granular, reticulate.

Two other species of *Clerodendron* have been described; wall and spine characters are similar in all of them (Erdtman, 1952; Nair, 1965). *Vitex* species have not been considered earlier.

ACANTHACEAE

Acanthus ebracteatus Vahl. (SUH, R109). Grains 3-colpate, prolate, 40 × 26μ; exine baculate, 1μ thick, finely reticulate.

Pollen of eight species of *Acanthus* has been described earlier (Bhoj Raj, 1961). The characters of *A. ebracteatus* pollen agree with the other species.

RUBIACEAE

Ixora congesta Roxb. (SUH, 5015a). Grains 3-colporate, colpoid streaks perpendicular to the colpi are present, oblate spheroidal, 26 × 26μ; exine slightly granular, 2μ thick, reticulate.

Morinda umbellata (SUH, 302a). Grains 3-colpoidorate, oblate spheroidal, 30 × 32μ; exine baculate, 2μ thick, reticulate.

Mussaenda erythrophylla Schum. and Thonn. Beskr. (SUH, 5029). Grains 4-porate, pore diameter 2μ, prolate spheroidal to subprolate, 19 × 17μ; exine granular, reticulate.

Timonius peduncularis Ridl. (Fig. 26) (SBGH, Burkill, SFN.15515*). Grains oblate spheroidal, 24 × 24μ; exine baculate, coarsely reticulate.

Another species of *Morinda* has been described (Erdtman, 1952; Nair, 1965). The others are not considered in previous work. The phenomenon of pollen dimorphism reported by Baker (1956) in *Faramea occidentalis* and *Rudgea jasminioides* was not observed in any of the four Rubiaceous forms described here.

COMPOSITAE

Ageratum conyzoides L. (SUH, S104). Grains 3-colporate, prolate spheroidal, 20 × 20μ; exine spiny, spines 5μ in length.

Helianthus angustifolius L. (Fig. 27) (SUH, S105). Grains 3-colporate, prolate spheroidal, 22 × 22μ; exine spiny, spines 6μ in length.

Additional details to those mentioned by Erdtman (1952) are given here for *Ageratum conyzoides*. Pollen of *Helianthus angustifolius* and *H. annuus* (previously described) are similar, but the former is smaller in size (Erdtman, 1952). Cranwell (1953) has described the pollen of *H. trionum* and *H. diversifolius*, the former with spines and the latter without.

SUMMARY

The pollen grain morphology of about ninety species representing forty families of angiosperms (3 of monocots, 37 of dicots) collected in Singapore and Malaysian regions are studied and the observations are recorded in this paper. These include new descriptions for forty-nine genera and eighty-four species. Eight species are redescribed to record the structural variations of local pollen grains. The pollen characters of most of the species described presently, conform to generic or specific characters reported in case of their respective families. The variations observed in size, wall, or pore characteristics of other members belonging to Leguminosae, Meliaceae, Euphorbiaceae, Anacardiaceae, Dipterocarpaceae, Caricaceae, Myrtaceae and Rubiaceae are comparatively discussed with reference to previous literature.

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