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POLLEN MORPHOLOGY OF CERTAIN TROPICAL **PLANTS**

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ABSTRACT

The pollen morphology of 49 species belonging to 48 genera and 31 families ia recorded in this paper. Of these 24 anil 19 taxa are studied at generic and species level respectively. Six species are redescribed to show the variations in the local pollen grains. In most of the species studied presently the characters were similar to those recorded previously for the respective families. The variations seen in some of the taxa with regard to wall characters, nature of the apertures, etc, are pointed out. The present observations ace comparatively discussed with reference to previous literature.

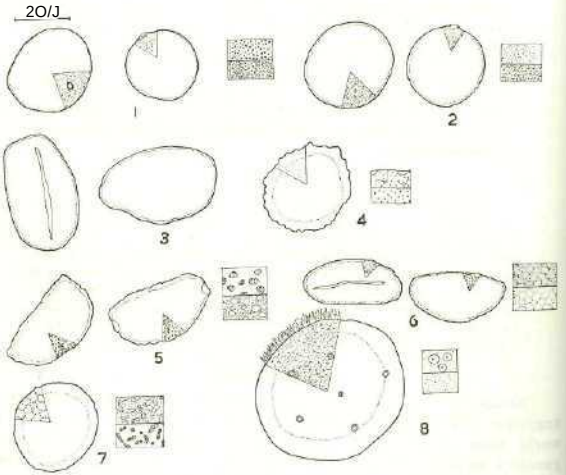
ABSTRAK

Morfologi serbuk sari 49 jenis tumbuh-tumbuhan tropika yang tei-golong dalam 46 marga dan 31 suku telah dilaporkan dalam karangan ini. Enam jenis telah dipertelaken kembali untuk menunjukkan adanya variasi pada serbuk sari tumbuh-tumbuhan setempat. Ciri-ciri kebanyakan jenis yang diteliti ternyata sama dengan ciri-ciri sukunya yang bersangkutan yang sudah dilaporkan orang aebelumnya. Variasi yang terlihat pada sifat-sifat dinding serbuk sari, keadaan lubang-lubang dan Iain-lain di-tunjukkan. Hasil pengamatan yang dilakukan sekarang ini dibandiugkau dan dibahas dengan mengafu pada puhtaka-pustaka yang ada.

IXTRODUCTtON

According to a recent estimate there ftre about 28,000 species of angiosperm in the Malesian region representing about one tenth of the world flora (Van Steenis 1948). The estimated number of Malayan genera is around 1,800 and of Malayan species about 8,300 (Keng 1970). Taxonomieally these are well described and documented in the different regional floras (see Keng 1970, for details). For the last few years detailed investigations are tarried out to study the pollen morphology and other structural details of some of the species. In an earlier publi-cation the pollen morphology of about ninety local species, representing forty families of angiosperms, was described (Rao & Lee 1970). The Pollen characters of about 50 species are recorded in this paper, and few of the tasa are described to indicate the variations seen in the local plants.

The well known works of Cramvell (1953), Erdtman {1943, 1952, 1957, 1961), Faegri & Iveraen (1950, 1964), Hyde & Adams (1958), Nair (1965) and Wodehousc (1935) and the journals Grana Palynologi, Botanical Review (Faegri 1956; Wodehouse 1936), Pollen et Spores, Palaeobotanist and Journal of Palynology served as chief sources of references. Other published papers were consulted wherever necessary.



Pigs. 1-8. 1. *Imperata cylindrica.* 2. *Schizostachyum. braekycladum.* S. *Arckontophoenix alexandrite.* 4. *Aglaonema jrictus.* 6. *Aechmea tinetoria.* 6. *Pitcairn.itiategrifoUa.* 7. *Gnnocaryum Utorate.* 8. *Boerhaavia diffusa.*

MATERIALS A NO METHODS

Pollen grains were collected in the mornings from the fresh open flowers of plants growing in Singapore and West Malaysia. Envelopes were used to separate and prevent contamination of the pollen of different species. In cases where the anthers were large (such as *Datura)* one flower gave all the material required whereas in others (such as *Grossandra* and *Nyctantheg)* 15—20 flowers were found to be necessary. Where contamination of foreign pollen was found, due to the visiting pollinators, the very mature buds were used. Voucher specimens were prepared and deposited in the herbarium and the numbers of such specimens are mentioned against the species name. The symbols USH (University of Singapore Herbarium) and SBGH (Singapore Botanic Gardens Herbarium) indicate the place of deposition and the number mentioned here is the same as recorded on the herbarium sheet.

The pollen grains were fixed in concentrated acetic acid and after 24 hours they were acetolysed following the method outlined earlier (Erdtman 1952, 1960). The procedure was slightly modified as was found necessary. In the case of thick walled pollen grains it was necessary to bleach them before acetolysis, by using saturated sodium chlorate solution.

To obtain the average measurements at least 20 grains were measured in each case. The size of fresh and acetolysed grains was compared and there was insignificant difference between the two. To determine the size, shape, L0 pattern, exine pattern, the methods employed by earlier workers were followed and descriptive terms used presently are in conformity with the published work (Erdtman 1952; Nair 1965). In the palynograms of dicotyledonous plants the first figure on the left represents the polar view, followed by a second of the equatorial view, with the exceptions of the pantoporate or rugulate conditions. For monocotyledonous plants the first diagram represents the surface view followed by a diagram showing lateral view. The OL patterns are given except for those where sexine pattern is psilate.

OBSERVATIONS

MONOCOTYLEDONS

GKAMINEAE

Imperata oylindrica Beauv. USH 4033. Figure 1 Plate I, 1

Monoporate, pore diameter 2.1 ^m, pore margin 1.6 ^m. Exine 1-1 ym thick. Spheroidal, diameter 27.4 jim. Foveolate.

•*Sekixostackyum brachycladum* Kurz. USH 5279. Figure 2

Monoporate, of pore diameter 2.4 iim, pore margin is thick forming an annular ring of 1.8 iim. Exine is 1.3 jim thick. Spheroidal, diameter 28.1 jim. Foveolate.

In all the genera so far studied, pollen grains are monoporate and differences are noted in the diameter of the grain, the porate condition, that is whether they are crassimarginate or tenuimarginate.

PALMAE

Archontophoenix alexandrae H. Wend] & Drude. SBGH 15/15. Figure 3

Monosulcate. Exine 0.9 jun thick. Bilaterally symmetrical 42.3 x 49.5 X 28.8 ij.m. Psilate.

This family ia palynologically heterogenous (Erdtman 1952). The OL pattern ranges from psilate to reticulate, some of them beset with spines and others not so. Generally, members of this family are either 1-sulcate or 2-sulcate.

ARACEAE

Aglaonema pictum Kunth. USH 623. Figure 4

Non-aperturate. Exine thickness of 3.6 [AIH. Spheroidal, diameter 29.8 nm. Exine plicate, that is folded. OL pattern foveolate.

This is a palynologically heterogenoua ranging from the non-aparturate to the sulcate and porate conditions. In this species, the exine is unique because it is plicate and its OL pattern is more or less obscure. Such non-apcrturate pollen grains with thick plicate exine is considered more "advanced" than the monosulcate, finely reticulate ones (Erdtman 1952).

BROMELIACEAE

Aeckmea tinctoria Mez. USH 4458. Figure 5

Biaperturate, one pore at each end of the pollen grain. Exine 1.-1 ijm thick. Bilaterally symmetrical 22.1 x 34.9 x 24.2 y.m. Reticulate.

Pitcairnia, iutegrifolia Hort. SBGH 17/171. Figure 6 Plate I, 2.

Monosulcate. Exine thickness 1.0 nim. Bilaterally symmetrical 19.2 X 32.6 x 21.0 um. Retipilate.

In Bromelioideae, 1-aperturatc grains are found and *Aeckmea involucrata* belonging to this sub-family is not an exception (Erdtman 1952). But *Ae.chmm tinctoria* is exceptional in that the pollen grains are biaperturate. Pollen grains of another species *A. bernoulliana* show the biaperturate condition also (Erdtman 1952). Here, as in pollen grains studied in certain species of *Ochnagavia, Thecophyllwm,* etc.

(Erdtman 1952), the ends of the grain, that is around the regions of the apertures show a finer reticulation than the rest of the grain surface. Members of the group Pitcairnioideae have monosulcate pollen and *pitcairnia. iutegrifolia* is no exception (Erdtman 1952).

PONTEDEKIACEAE

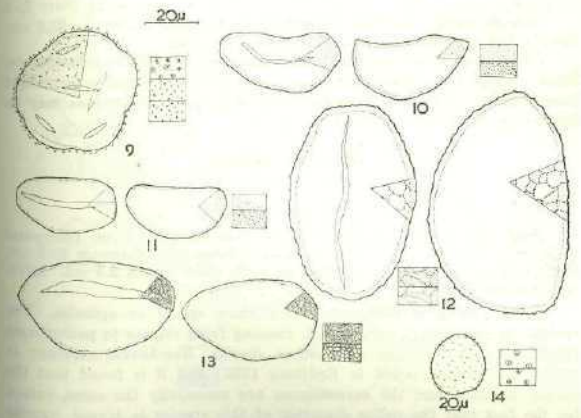
Eickkornw, crassipes Solms. USH 4358. Figure 10

Monosulcate. Exine 1.5 ii.ni thick. Bilaterally symmetrical. Renate, 20.5 x 43.1 x 23.3 *pn.* Finely foveolate.

Monoekorut hastata Solms. SBGH 4/179. Figure 11

Monosulcate. Exine thickness 1.2 -im. Bilaterally symmetrical 17.6 x 37.4 x 18.9 jtm. Foveolate.

The pollen grains of various genera show sulcate condition. Essentially the pollen grains of *Eichhornia crassipes* and that of *Monochoria hastatv* are similar except for the slight difference in size.



Figs. 9-14. 9. *Portulaca grandiflora.* 10. *Eichhornia. craaaipee.* 11. *Monochoria hastata.* 12. *Leptochiton quitoensis.* 13. *Zephyranthes alba.* 14. *GdustacKys rupestris.*

AMAKYI, LIDACEAG

LeptocMlon qia'toensis Sealy. USH 4459. Figure 12 Plate I, 3

Monosulcate. Exine 2.4 ,.ra thick. Bilaterally symmetrical 49.4 *x* 79.2 x 46.9 um. Retipilate.

Zephyranth.es alba Hort. USH 4364. Figure 13

Monosulcate. Exine thickness 1.2 am. Bilaterally symmetrical 27.4 x 51.6 x 27.1 ^m. Very prominently reticulate.

Pollen morphology of members of this family are diversified (Erdtman 1952). Some of them are small and in others very large pollen grains are found here. Longest axis 17 to 160 ;im in some "rains (Erdtman 1952). Likewise, *Oh* pattern ranges from scrobiculate to retipilate. But generally, the aperturate condition is sulcate. Erdtman has divided this family into four main groups on the basis of pollen morphology (Erdtman 1952).

ZINGIBEEACEAE

Geostackys rupestris Ridley. SEGH 12,-170 No. 8. Figure 14 Plate I, 4

Non-aperturate. Exine 0.6 nm thick. Spheroidal. Diameter 87.2 *ym.* Psilate, but excrescences are in the form of gemma.

Pollen grains of members of this family are usually non-aperturate, large in size, but generally, the exine is very thin and hence not resistant to aeetolysis. Exine may be psilate, and sometimes excrescences may be present in the form of spinules or gemma.

DICOTYLEDONS

NYCTAGIXACEAE

Boerhaavia diffiisa L. USH L71 '71. Figure 8

Pantoporate. Pore diameter 2.4 j.m. Pore margin 1.1 ;i.m. Interposal distance is 17.1 ;im. Exine 5.4 ^m thick. Spheroidal, diameter 60.3 |ini. Surface of pollen grain is spiniferous, with spine length 2.4 \j.*iti.* Interspinal areas foveolate.

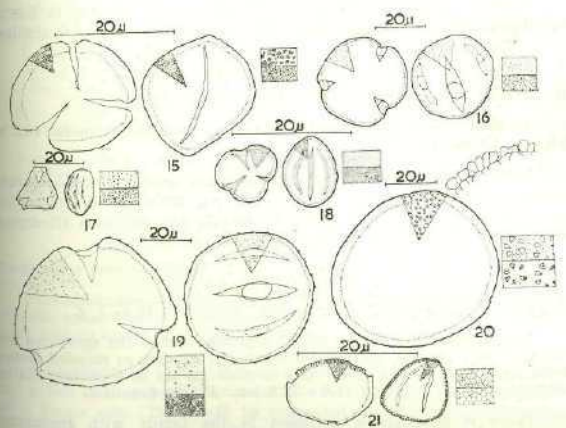
Pollen grains of different genera show spines or spinules. The aperturate condition is very varied, ranging from colpate to pantoporate (Erdtman 1952). Pollen of another species, *Boerhaavia caribaea* is studied by Lundell (cited in Erdtman 1952) and it is found that the porate condition and the excrescences are essentially the same, except for the fact that the pollon diameter of this species is bigger, namely 80 jim. This is true for many other species studied by Nowicke (1970) *e.g. B. anistyphyUa, B. dichoto'nia, B. erecta,* etc.

POBTULACACEAE

Portulaica grandiflora Hook. USH 2711. Figure 9

Polyrugate. Exine thickness 2.3 ;j.m. Spheroidal. Surface of the grain spiniferous, with spine length 1.4 um. Interspinal area areolate. The arrangement of the colpi is irregular and there are about five in each pollen grain. Oil globules are also seen in the grain and they vary from two to four in number.

Pollen of *Portidaca quadrifida* and *Portidaca grandiflora,* a cultivated species in Uppsala, are described (Erdtman 1952). In all cases, the polyrugate condition is seen, but spinules of *Portulxiea, grandiflora* grown in Uppsala are twice the length of that of the same species grown locally. This difference could be attributed to environmental conditions as the climate in Sweden is very different from that of Singapore (Kurtz & Linerman 1958).



Figs. 15-21. 15. *Brassica oleracea.* 16. *Moringa oleifera.* 17. *Andira surinamensis.* 18. *Weinmannia blumei.* 19. *Ixonanthes reticulata.* 20. *Jatropha podagrica.* 21. *Warszewiczia coccinea.*

CRUCIDERAE

Braasiea oleracca L. USH 4457. Figure 15

Tri-zonocolpate. Exine thickness 1.2 ;jm. Prolate spheroidal 14.9 x 33.4 tjm. Reticulate.

Other species studied are *Braasiea campeal.ris* (spheroidal, 35 ;im and *Braasiea Juneea* (spheroidal, 21 ,um; Nair 1965). The pollen aperturate conditions of these 2 species are also tri-zonoeolpate, but their sizes and shapes differ from *B. oleracea.*

MORINGACEAE

Moringa oleifera Lam. USH 4454. Figure 16

Tri-zonocolporate. Lolongate ora 7.5 x 5.2 ^m. Exine 1.2 ym thick. Oblate spheroidal 32.4 x 33.3 ii.m. Foveolate.

Another species was studied, *Moringa aptera,* cultivated in Egypt (Erdtman 1952). The pollen characters of both these species are similar,

CUNONIACEAE

Weinmannia blumei Planch. USH 3588. Figure 18

Tri-zonocolpate. Exine thickness 0.8 ^m. Prolate spheroidal 10.2 × 9.3 jtm. Foveolate.

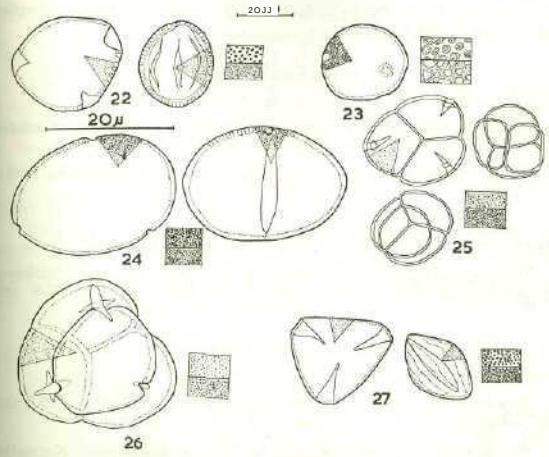
Pollen grains of members of this family are usually 2- or 3-colporate with exine stratifications more or less obscure. *Weinmannia intermedia,* grown in Mexico, has pollen grains of the colporate condition (Erdtmatt 1952). But *Weinmannia blvmei* shows colpate condition.

LEGUMINOSAE

Andira mrinamensis Splitg. USH 739. Figure 17 Plate I, 5

Tri-zonocolporate. Pollen grains aspidote, that is the apertures are borne on small circular areas called aspides, protruding as rounded domes from the surface of the grain. Ora circular 1.3 ^m in diameter. Exiw thickness 0.9 jra. Prolate 17.6 x 12.8 \ita. Finely foveolate.

There is considerable variation in the family with aperturate condition ranging from colporate to porate and exine pattern ranging from psilate to reticulate (Erdtman 1952; Nair 1965). The pollen in i hi - case is monad in contrast to the polyac! condition in many Mimosoidcac.



Figs. 22-27. 22. *Elaeodexdron quadrangulatum.* 23. *Impaliens griffUMi.* 24. *Wormia aiiffrutico&a.* 35. *Pierie ovalifolia.* 26. *Rhododendron leucobotrys.* 27. *Styrax benzoin.*

LINACEAE

Ixonanthes reticulata Jack. USH 402. Figure 19 Plate I, 6

Tri-zonocolporate. Ora lolongate 9.9 x 5.2 (j.m. Exine 1.9 j.m thick. Prolate spheroidal 50.3 x 49.7 jum. Surface of pollen grain spinulous, With spinule length of 0.9 ;jm. Interspinal areas foveolate.

This species was collected from Kedah Peak and when compared with the pollen of Singapore plants studied (Geh 1967), it had pollen grains of a larger size. This could be attributed to different environmental conditions, as the species collected from Kedah Peak was found at an altitude of 3,000 feet above sea level (Kurtz & Liverman 1958). The ora was larger and lalongate compared to that of Singapore plants

which had a smaller and circular ora. Pollen grains of other species, /. *icosandra*, and /. *chinensia* (colporate, spinulose) have similar morphology (Erdtman 1952).

EUFHORBIACEAE

Jatropha podagrica Hook. USH 2282. Figure 20 Plate I, 7

Non-aperturate. Exine thickness 2.9 ;j.m. Spheroidal, diameter 61.5 |im. Excrescences in the form of verruca. Areolate.

Pollen of *Jatropha curcas* has a diameter of 68 ;j.m (Erdtman 1952).

CELASTRACEAE

Elaeodendron quadrangitlatum Reiss. USH 4359. Figure 22

Tri-zonocolporate. Ora lolongate 17.5 x 1.4 ^m. Exine thickness 1.7 *yjn*, thinner towards colpi margins. Subprolate 29.5 x 25.6 ;itn. Punctate.

" . ICACINACEAE

Gonoearyum Morale Sleum. USH 4354. Figure 7

Non-aperturate. Exine 2.6 jim. thick. Spheroidal, diameter 29.3 ;;.m. Retipilate.

This species is an exception in that it is non-aperturate. Normally, pollen grains belonging to members of this family have the colpate, colporoidate, or porate conditions (Erdtman 1952).

BALSAMINACEAE

Impatiens griff ithii Hook. f. SBGH 19/38C/1. Figure 23

Pantoporate with at least three pores. Pore diameter 4.5 ;im. Pore margin 0.6 iim. Irregular distribution of pores and therefore the inlevporal distances are not constant. Exine 1.3 jim thick, spheroidal, diameter 34.1 jim. Spmulous with spinule length of 0.8 |im. Reticulate.

Members of this family have pollen grains of the colpate condition and show variation in size (Erdtman 1952; Nair 1965; Faegri & Iversen 1949). But an exception is found in this species *Impatiens griff ithii*, which shows pantoporate condition. Other species, namely *Impatiens biflora* (24—34 |ira), /. *noli-tangere* (23—31 jim), and *I. parviflora* (29—40 ;Am) have grains of the colp(old)ato condition. (Erdtman 1952; Nair 1965).

DILLENIACBAE

fflormia suffrutieosa Griff. USH 1747. Figure 24

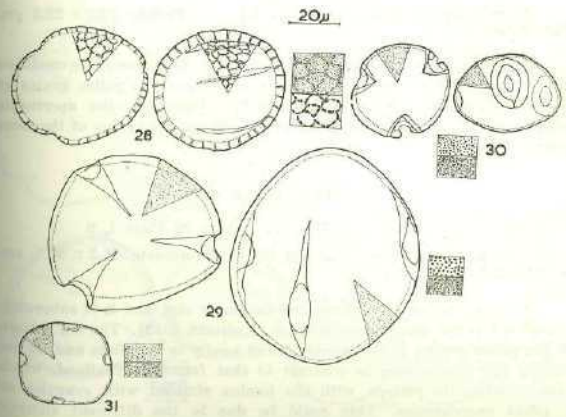
Tri-zonocolpate. Exine thickness 1 ;im. Suboblate 18.6 x 22 inn. Reticulate.

The eolpate condition is found in *Dillenia ovata, Wormia alata, fetracera alnifolia*, etc. (Erdtman 1952). Sometimes, brevicolpate condition is seen in the pollen grains of *Wormia suffrutieosa* cultivated in Bogor (Erdtman 1952).

ERICACEAE

Pierix oval!folia D. Don. SBGH 14/93. Figure 25

Compound pollen grains in tetrads, of two types, namely the tetrahedral and the tetragonal type i.e. 1 pair of pollen grains art perpendicular to the other pair. The tetrahedral type occurs in 83% and tetragonal type occurs in 17%. Tri-zonocolporate. Ora lalongate 2.8 x 4.2 |im. Exine 1.1 ;j.m thick. Oblate 17 X 23.8 M». Longest axis of tetrad 33.9 ;im. Finely foveolate.



Figs. 28 - 31. 28. *Nyctanthes arbor-tristis*. 29. *Cerbera odollam*. 30. *Rauwolfia vomitoria*. 31. *Ronpellia grata*.

Rhododendron leucobotrys Ridley. SBGH 46/93/8. Figure 26 Plate I, 8

Compound pollen grains in tetrahedral arrangement. Tri-zonoeol-porate. Ora lalongate 2.5 x 10.5 ;jm. Exine thickness 2.0 ;im. Longest axis of tetrad 51 Jim. Foveolate.

The pollen grains of this family are either united in tetrads, or occurring singly. Aperturate condition is usually colporate with exine obscure. The ora is lalongate and in this case, it is very prominent forming a streak across the colpus. Size variations are seen in the grains of this family, with a range between 25 jun to more than 50 ;im. Other species studied are *Rhododendron arboreum* (58 jim), *R. barbatum* (54]ini), *R. catawbiense* (62]im), and *R, lepidotivm* (53 ;jm). They show similar pollen morphology except for the size variations (Erdtman 1952; Nair 1965).

STYEACACEAB

Styrax benzoin Dryand. USH 4350. Figure 27

Tri-zouoeolpate. Exine thickness 3.1 y.m. Prolate 32.4 X 23.3 jim. Foveolate.

The pollen grains of *Styrax officiialis* have the colporoidate condition and are much larger in size. *Styrax suberifolhtm* has pollen grains of the colporate condition (Erdtman 1952). Therefore, the aperlurate condition is not a constant feature, even in the pollen grains of the same genus.

0 LEACEAE

Nyetanthes arbor-tristis L. USH 333. Figure 28 Plate I, 9

Tri-zonocolpate. Exine 3.4 ^m thick. Subprolate 46.3 x 39.1 FIHL Retipilate.

Pollen grains of local plants are similar in size, and it is subprolate in contrast to the spheroidal condition (Erdtnian 1952). The OL pattern of the pollen grains of the species found locally is retipilate and do not possess any excrescence in contrast to that found in Thailand, which have a reticiiiate pattern with the lumina studded with granules or ± piloid excrescences. This could be due to the different climatic conditions which existed in different habitats or they are obtained from different horticultural varieties (Kurtz & Liverman 1958).

AFOCYNACBAE

Cerbera odollam Gaertn. USH 384. Figure 29

Tri-zonocolporate. Ora lalongate 15 x 6.6 jmi. Exine thickness 1.8 i^m. Shape ranges from subprolate to prolate spheroidal 72.8—75.3 x 61.6—72.8 ji. Foveolate.

Ramvolfia vomttoria Afzel. USH 4460. Figure 30 Plate II, 1

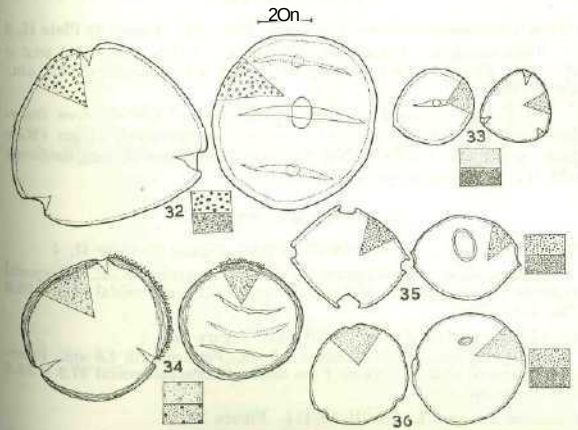
Tricolporate. Ora lolongate 5.6 x 3.4 ;ijn. Margin of colpus, crassi-marginate. Exine 1.2 ;j.m thick. Suboblate 29.9 x 37.8 jtm. Foveolate.

RoupeUia grata Wall & Hook. USH 352. Figure 31

4-zonoporate. Pore diameter 2.S [im. Pore margin 1.5 ^m. Interporal distance 22 *ym*. Exine thickness 1.2 ii.m. Spheroidal, diameter 40.4]xm. Foveolate.

Thevetia peruviatia Merrill. USH 4355. Figure 32

Tri-zonocolporate. Ora lalongate 5.5 X 6.3 ;j.m. Exine thickness 2.8 ;j.m. Suboblate 50.5 x 62.9 iim. Reticulate.



P'gs. 32 - 36. 32. *Thevetia pemviana.* 33. *Ekretia mv-•ophylla.* 34. *Clerodendr-on* sjieciosisffimMm. 35. *Bmnfolsia etlyeiaa.* 36. *Brunfelsia undulata.*

Pollen grains of members of this family are usually colporate or porate in nature. Pollen grains of *Rauwolfia verticillata* are colporate, and ora are lalongate compared to the lolongate condition found in that of *R. vomitoria* (Erdtman 1952). The exine pattern is usually foveolate. The main morphological characters are fairly constant within individual genus (Erdtman 1952).

BOKAGINACEAE

Ehretia mierophylla Hort. USH 4361. Figure 31 Plate II, 8

Tri-zonocolporate. Ora lalongate 3.8 x 1.9 [im. Exine thickness 1.2 jim. Prolate spheroidal 27.1 x 27.8 y.m. Faintly reticulate.

Pollen of other species studied are *Ehretia (aevis* var. *floribunda, E. latifolia, E. rigida* and *E. silvatica* (Erdtman 1952). The morphological characters in all these species are similar.

VERBENACEAE

Clerodendron speciosissimum Van Geert. "USH 4537. Figure 40 Plate II, 3

Tri-zonoeolpate. Exine thickness 2.5 yjn. Prolate spheroidal 50.6 x 46.3 y.m. Exine surface is spiniferous with spine length of 1.3 y.m. Foveolate.

Two other species have been studied, that of *Clerodendron infor~ tunatum:* spheroidal, 60 urn and *C. serratum:* spheroidal, 71 jim (Nair 1965) and it has been found that the general pollen morphology conforms with that of *Clerodendron speciosissimum.*

SOLANACBAE

Brunfelsla calycino, Benth. SBGH 61/114. Figure 35 Plate II, 4

4-zonoporate. Pore diameter 9.6 |im. Pore mai-gin 0.9 |im. Interporal distance 14.6 iim. Exine thickness 1.0 ;im. Oblate spheroidal 35.8 x 35.9 um. Reticulate.

Brunfelsia wndwlata Swartz. USH 585. Figure 36

Tri-aonoporate. Pore diameter 8.4 -im. Pore margin 1.3 |im. Interporal distance 23.5 y.m. Exine 1 |im thick. Oblate spheroidal 37.9 x 39-3 iim. Foveolate.

Capsicum annuum L. SBGH 10/114. Figure 39

Tri-zonocolporate. Ora lolongate 3.4 x 5.8 um, forming a long streak across colpus. Exine thickness 1.2 jim. Prolate spheroidal 23.6 x 21.4 um. Foveolate.

Datura metel L. SUH 445. Figure 37

Tri-zonobrevi col pate. Exine thickness 1.1 ji.m. Oblate spheroidal, 40.4 x 33.1 um. Striate. Striations converging at the polos.

Petunia axitlaris Britton, Stern & Poggenb. USH 4456. Figure 42

Tri-zonocolporate. Ora lolongate 6.4 x 8.1 jjm. Exine 1.1]im thick. Suboblate 23.8 x 29.5 [jm. Faintly reticulate.

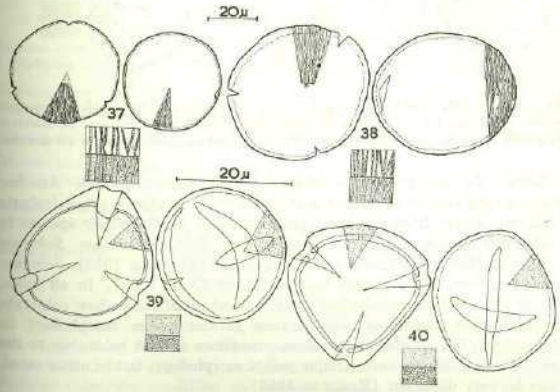
Solatium -melongena L. SBGH 2/114. Figure 40

Tri-zonocolporate. Ora lolongate, forming a streak across the colpus 5.1 x 14.4 [j.m. Exine thickness 1.1 y.m. Prolate spheroidal 26.4 x 24.9 jim. Faintly foveolate.

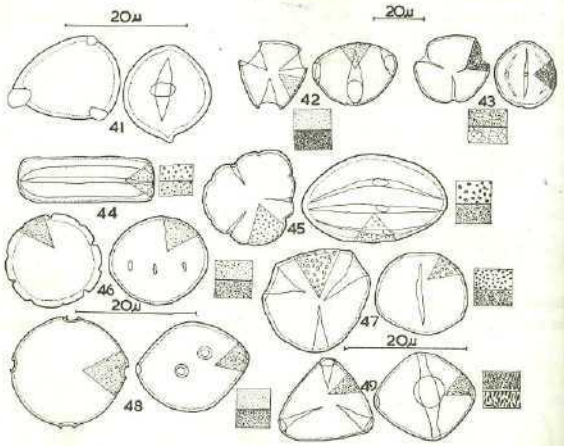
Solanwm wrightii Nees. USH 4356. Figure 41

Tri-zonocolporate. Ora lalongate 6.0 x 4.9 um. Exine thickness 1.3 um. Prolate spheroidal 21.4 x 19.8 um. Psilate.

Datura sziaveolens (Figure 38) is also studied (Erdtman 1952) but based on observations it is found that the aperturate condition is colporate in nature, but the species collected from Malaysia shows the brevicolpate



Figs. 37 - 40. 37, *Datura metel.* 38. *Datura ettoveolens.* 39. *Capsionmannuu* m. 40. *Solanum melongena.*



Figs. 41-49. 41. *Solatium wrigktii.* 42. *Petunia, axittans.* 43. *Tecomaria capensie.* 44. *Crossandra wndulaefolia.* 45. *Psexderanthemum* retioulotum. 46. *Berreria laevictadis,* 47. *Isotoma Umgiflora.* 4B. *Museaenda oblowga.* 49. JiHsseito sarmevifo*sa.*

condition. The ora present ia lalongate in the former species. Another species found locally is *Datura metel* and this too shows a brevicolpate condition. Apart from the two species studied locally, other species in which their pollen grains are studied are *Solanum alatwrn, SoUinwm dulcamara, Solanum luteum, Solanum nigram* (Erdtman 1952), *Solatium pseudocapsieum.,* and *Solanum verbascifoKum* (Nair 1965). In all cases, there ia very little morphological variation and all of them show colporate condition. The taxonomic significance of the pollen morphology in Solanaceae is not so obvious because, sometimes genera belonging to the same tribe or subtribe have similar pollen morphology, but in other cases, it can be very different (Erdtman 1952).

The following table shows the species studied by Erdtman and Nair, compared with the species presently studied.

Species	Aperturate conditions	Sizes
Brunfelsia calycina	Porate	35.8 X 35.9 µm
Brunfelsia undulata	Porate	37.!) x 39.3 jum
Datura arborta (Chaubel & Deodikar 1963)	Colporate	37 X 40 jum
Datura metel	Brevicolpate	40.4 X 33.1 µm
Datura stramonium (Nair 1965)	Colporate	32 µm
Datura suaveolens	Brevicolpate	51.1 × 52.1 µm
Datura suaveoleua (cited in Erdtman 1952)	Colpovate	41 X 45 jj.ni
Capsicum annuum	Colporate	23.6 x 21.4 jj.m
Petunia azillaris	Colporate	23.8 X 29.5 |im
Solanum alatum (Erdtman 1952)	Colporate	30 x 26 :im
Solanum dulcamara (Erdtman 1952)	Colporate	14.5 x 13 jtm
Solanum luteum (Erdtman 1952)	Colporate	28.5 x 24.5 ^m
Solanum nigrum (Erdtman 1952)	Colporatc	20 X 24 y.m
Solanum melongena	Colporate	•26.4 X 24.9 y.m
Solatium peeudocapsicrtiTl (Nair 1965)	Colporate	17.5 X 14 ij.m
Solanum vprbascifolitiin (Nair 1B65)	Colpomte	SI x 18 j.m
Solanum ivrigkUi	Colporate	21.4 *X* 10.S (in

With reference to the table, the pollen grains of *Datura stramonium* are smaller than the other three species. The species studied presently *(D. metel* and *D. sitaveolens)* are brevicolpate, whilst other workers have recorded colporate condition in certain species. Except for the size Variations, the pollen of *Solanum* species generally show the colporate condition.

SCROPHULAKIACEAE

Russelia sarmentosa Facq. USH 3293. Figure 49

Tri-zonocolporate. Ora lalongate 3.2 X 4.4 p.ni, Exine 0.9 y.m thick. Oblate spheroidal 14.8 x 16.1 ij.m. Rugulate.

The pollen grains of members of this family have close affinitieH with that of the genera in Solanaceae. But in this family, striate pattern of exine, the n on-aperturate, or 4-aperturate conditions, and large size of the grains are not so common as are encountered in members of Solanaceae.

BIGNONIACEAE

Tecomatia, capeiisk Spach. USH 3322. Figure 43

Tri-zonocolpoidate. Exine thickness 1.6 ym. Oblate spheroidal 28.9 x 30.7 ;j.m. Retipilate.

ACANTHACLAE

Crossandm undulaefolia Salisb. USH 4360. Figure 44 Plate II, 6

Two colpate. Exine thickness 1.5 ;im. Exine thicker at equatorial region, thinner at the poles. Perprolate 56.0 x 19.7 tim. Reticulate.

The grain is perprolate and 2-colpate. Normally, colpi are three or more in number and perprolate condition is not frequently encountered in pollen grains of other families. Pollen of this species studied earlier also exhibit the perprolate condition, but larger in size (87 x 42 ;im) (Erdtman 1952).

Pseuderwnthemum reticulatum Radlkf. USH 2402. Figure 45 Plate II, 7

Tri-zonocolporate. Ora lalongate, 5.2 x 3.8 ^m. Exine thickness 2.2 iim. Subprolate 39.8 x 32.5 *y.m.* Surface of the grain is scalloped and this is best seen in the polar view. OL pattern punctate. The scalloped shape of the pollen grain is quite unique, and characteristic.

The pollen of 3 other species described are P. *em-datum, P. citatre-casaii* and *P. malaecmise* (Raj 1961). Essentially, they all show the colporate condition.

RUBIACEAE

Borreria laevicavMs Ridley. USH 5037. Figure 46

Zonoporate. Four to six pores are found in one pollen grain-Pores slightly elongated. Pore diameter 1.8 jim. Pore margin 1.4 *v-m-*Interpora! distance 10.6 ^m. Exine 1.4 ?m thick. Prolate spheroidal 33.5 x 32.S ;j.m. Foveolate.

Mitssaenda oblonya King. USH 1790. Figure 48

4-Konoporate. Pore diameter 2.2 [im. Pore margin 0.8 .im. Interporal distance 7.6 7.111. Exine thickness 1 ;J.m. Oblate spheroidal 15.1 X 17 um. Foveolate.

Warseeiviezia eocciuea Klotzseh. USH 507. Figure 21

Tri-zonoporate. Pore diameter 2 {j.m. Pore margin 1.1 ;j.m. Exine thickness 1.2 ;j.m. Prolate spheroidal 16.5 X 15.2 -jun. Excrescences granulose. Retipilate.

Pollen morphological variations are seen with regard to shape, OL pattern, aperturate condition and size.

CAMPANULACEAE

Isotonu), longiflora Presl. USH 3026. Figure 47 Plate 11, 2

Tri-zonocolpate. Exine thickness 2.2 y.m. Oblate spheroidal 35.3 x 37.7 j.m. Reticulate. Lumina in the polar region are very small, and as they reach the equatorial region, they are very prominent.

Variations in pollen morphology are seen in this family. Three other species studied are *Isotoma (Lobelia) anceps* var. *minor:* 29 x 19 ;im; *L.gloria-montis:* 58x35 ;jm (Erdtman 1952) and *L. nicotianaefolia:* 26x23 *vxa* (Chaubal & Deodikar 1963). The aperturate condition in the first two species listed is colporoidate. The latter has pollen grains of the colpate condition. Size variations are indicated.

DISCUBSIOX

The pollen grains of plants studied either at the generic or species level are given in the following table. For others the variations noticed in the local plants are recorded and the data is compared with the earlier accounts.

Studied at the genetic level	Studied at the species level
Imperata cylhidrica	*Aechmea Unctoria* (2)"
Schizostachyum brachycladum	*Boerhaavia diffasa* (14)
Archoittophoenix alexandrae	*Portuluca grandiflora* (1)
Agltwiwma pictttta	*Braesica oleracea (2)*
Pito-aimlo. integrifolia.	*Moringa oleijera* (1)
Eichkornia crassipcs	*Weinmaimia blumei* (1)
Monochiria hastata	*Ixonanlhes reticalata* (2)
Leptochiton quitoensis	*JabrQpha, podagriua* (1)

" The number of species studied previously is shown within the bracket.

Studied at the generic level
Zephyrantkes alba
Geostackys rupestris
Andira surinamensis
Etaeedendron qaadrungulaUin
Gonocaryum Morale
Cerbera odollam
Roupellia grata
Tkevetia peruviana
Brunfelsia species (B. *cafycina* & *B. undulata*)
Capsicum annuum
Petunia axUlaris
Ruseelia sarmentosa
Tecotnariv capeftsia*
Borreria laevicaulie
Muaeaenda oblonga
Wareeewiaiia cocci-nea

Studied at the species level
Impatient griff ithii (S)
Wormia suffruticosa (1)
Rhododendron leucobotrys (4)
Styrax bemoin (2)
Raiiwolfia. vomitaria (1)
Ekretia microphylla (4)
Clerodendron specinsissimttnt (2)
Datura species (D. *metel* & D. *suaveolens)* (2)
Solaiium species *(S. melongena* & *S. wrigktii)* (6)
Fseuderantkemam reticulatum (3)
Isotoma longifloTa (3)

Earlier, under the description of each species a brief comparison is made about the pollen characters of the closely related genus or species.

In the palynological studies, the families studied may be broadly divided into two groups, namely eurypalynous type, that is, their pollen grains are characterised by a great array of pollen types and variations in morphological characters like apertures, exine stratifications, OL patterns, excrescences, etc.; the other group being the stenopalynous type in which the pollen of different genera in a family show more or lesa similar characters. The classification of the different families, presently investigated, under the two groups is summarized below.

Eurypalynous families	Stenopalynous families
Palmae	Gramineae
Araceae	Pontederiaceae
Enimeliaceae	Zingiberaceae
Amaryllidaceae	Cruciferae
Olacaceae	Moringaceae
Nyctaginaceae	Cunoniaceae
Portulacaceae	Celastraceae
Leguminosae	Balsaminaceae
Linaceae	Ericaceae
Euphorbiaceae	Styracaceae
Dilleniaceae	Oleaceae
Apocynaceae	Boraginaceae
Verbenaceae	Scrovhulariaceae
Solanaceae	Rubiaceae
Bignoniaceae	Campanulaceae
Acanthaceae	

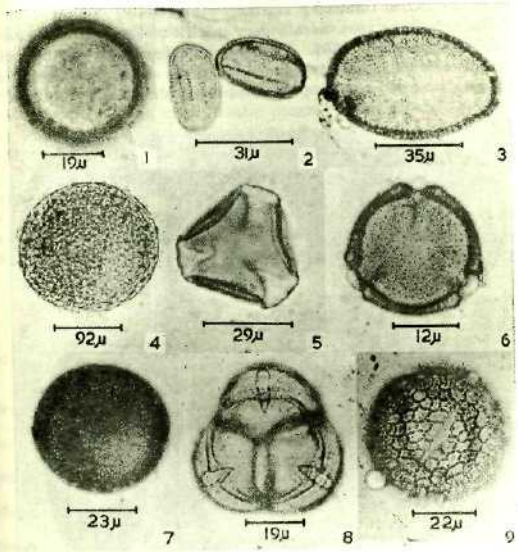


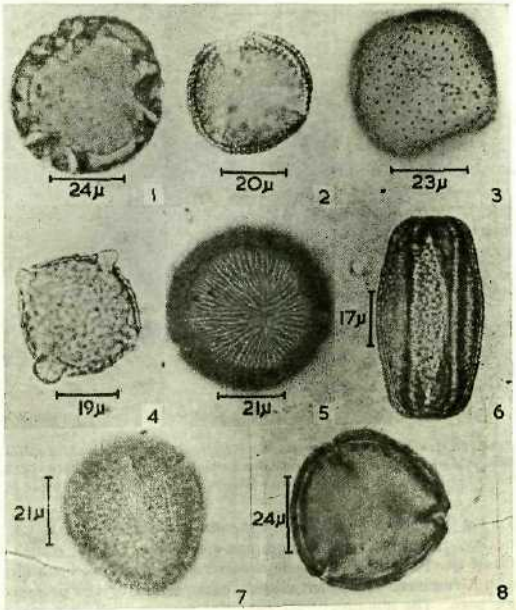
Plate I. 1-i). 1. *Imperota eylindriea.* 2. *Pitcairnia iittegrifolia.* 3. *Lejitochiton qiiitoewsia. A. Geostachys rnpestris.* B. *Andira* sili-i-[illegible]*ensis.* 0. *Ixonanthes reticulata.* 1. *Jatrophn porlagrica.* S. *RhodtHlevdron U[illegible]Iriie.* !l. *Nyetanth.es arbor-Math.*

Among the species investigated the corporate (325!,), colpate *(2i'/< j,* poi-ate (20^,), sulcate (12%) and non-aperturate (10%) grains are found and the percentage of their occurrence is mentioned within the brackets. Gramineae has pollen grains characterised by the presence of a single pore. The non-aperturate condition is seen both in mono- and dieots.

The thickest exine is seen in *Boerliaavia diffusa* (5.4 ;,m) and thinnest in case of *Geostachys i-iipestris* (0.6 y.m). The smallest and largest grains

seen presently are those of *Weinmannia bhimei* (10.2 x 0.3 ;im) and *Geostachys rupestris* (diameter 87.2 y.m) respectively.

Pollen characters are generally very specific and said to be genetically controlled (Wodehouse 1935). The external characters of the pollen, for example the diameter, size, number of pores or furrows sculpture of exine are somewhat variable at least in some plants as a result of the



Plat* II 1-S 1 *Rauwolfia vomitoria.* *2. leotamu Kingiflora.* 3. *Ckrodendi'on speciosis'sinmm* 4 *Brunfelsia calycina.* 5. *Datura *uavcolew>. S. Crosiandra tindul'ue-folia.* 7 *Pseuderanthemum retittulatum. S. Ehretia microphyUa.*

climatic effects on the pollen forming plants or directly upon the process of pollen formation (Kurtz & Liverman 1958). High temperature, repeated cooling of flower buds, variation in the moisture contents of the soil or arid condition may effect the size of the grains, or number uf germ pores on them (Kurtz & Liverman 1%8). Polyploid condition is another factor that causes variations in pollen size and viability within a given species. Among the cultivated plants such variations are common. Some workers claim that the position of the flower on the plant, the size of the anther, and the time of flowering also influence the pollen size. Among[1] the plants presently studied such variations are noticed in the following genera: *Portulaca*, *Ixonanthes*, *Nyctanthes*, *Datura* and *Cros&andra*. The exine pattern of the pollen of *Nyctanthes arbor-trigtis* found locally is retipilate and do not possess any excrescence, in contrast to that found in Thailand which have a reticulate pattern with more or less piloid excrescences (Erdtman 1952).

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ON SOME COLOURLESS FLAGELLATES FROM JAVA AND BRASIL

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ABSTRACT

Two new monotypie genera *(Kaakimonas bogoTiensis* and *Hoehnemastix saepatilensiB)* and aiK other new species (four in *Tetramitus* and two in *Balliamonas)* of colourless flagellates are described based on samples collected in Bogor and Sao Paulo.

ABSTRAK

15ua *ntnYgn* inonotipe *{KtzäKi'itioiiaB hoffOTicnsts* dan *nochyiswtastix xaopatilpnsis)* dan enam jenis (empat dalam *Tetramitus* — antara lain *Tetrumiius indowe&iae*___dan dua dalam *Baltiatnwiasi* flaeellata tak berwarna telah dipertelakan untuk pertama kali berdasarkan contoh-contoh yang dikumpulkan di Bogor (Jawa) dan Sao Paulo (Brasilia).

The colourless flagellates described in the present note have been cultivated and studied in the Instituto de Botanica, Sao Paulo. They were isolated from samples collected by Dr. M. Kizaki in Bogor (Java) in 1971 and by the present author in Sao Paulo, Brasil. All illustrations presented were made from living specimens and all type specimens studied are preserved in the Cryptogamic Herbarium of the IiiKtituto de Botanica, Sao Paulo, Brasil.

The eight species described are distributed among four genera which can be distinguished as follows.

1. Cells 3 times broader than its length, with *2* sw•imming flagelks. *Kizakimonas* gen. nov.
2. Cells fusiform, with 2 anterior and one poster]or flageiles. *BaUiamantui* Sltvortzov
3. Cells elongate to fusiform, with 3 s.nterior flagelles of different length. *Haohnenastix* gen. nov.
4. Colls elongate ovate to fusiform, witl• 4 anterior• flagelles of different sizes. *Tetramitus* Perty

Kizakimonas Skvortzov, *gen. nov.*

Fam. Ampbimonadaceae, Ord. Protomastiginae.

Monada solitaria, libere jiatantes, compresso-lanceolata, cum antico et postico oppositis convexie, 3 plo latius quam longius; membrana

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