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STUDIES ON THE MORPHOLOGY OF POLLEN GRAINS OF THE LEGUMINOSAE - THE CAESALPINOIDEAE

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Summary

The morphology of the pollen grains of 19 species belonging to 11 genera of the Caesalpinoideae as seen under the light microscope has been described. Pollen tetrads were observed in three species of the genus *Afzelia*, viz. *A. africana*, *A. bella Harms* var. *bella Harms* and *A. bella* var. *gracilior* of the tribe Detarieae and in *Swartzia madagascari ensis* of the tribe Swartzieae. The remaining 15 species had monads. The significance of the evolution of pollen tetrads and polyads in unrelated taxonomic groups is discussed. All the four species of *Afzelia*, viz. *A. africana*, *A. bella* var. *bella*, *A. bella* var. *gracilior*, and *A. bracteata* and four of the remaining species, *Bauhinia tomentosa*, *Delonix regia*, *Peltophorum pterocarpum* and *Talbotiella gentii* had elaborate exine sculpturing, which is considered to be an advanced feature. Pollen of the remaining 11 species had granular or finely reticulate exines.

Introduction

The morphology of the pollen grains of 18 species belonging to 14 genera of the Caesalpinoideae occurring in Nigeria was described by Sowunmi (1973). All the genera with the exception of *Afzelia* had monads. The genus *Afzelia* had pollen tetrads. In a survey of 118 genera of the Caesalpinoideae of South America, Graham, Barker & Freitas da Silva (1980) observed pollen tetrads in only two of them, *Afzelia* and *Diptychandra* and all the rest had monads. Some pollen features which they described but which were not encountered during the work of Sowunmi (1973) were the viscin threads in the genus *Jacqueshuberia*, periporate grains in the genera *Hardwikia* and *Calophospermum*, and diporate grains with a single continuous colpus in the genus *Duparquetia*.

The present work was carried out to find out what other variations may exist in the morphology of the pollen of the Caesalpinoideae using specimens obtained in Ghana.

Experimental

Plant species

Fresh pollen was taken from *Bauhinia tomentosa* Linn., *Caesalpinia pulcherrima* (Linn.) Sw., *Cassia biflora* Linn., *C. fistula* Linn., *C. obtusifolia* Linn., *C. siamea* Lam, *Delonix regia* (Boj. ex Hook.) Raf., *Erythrophleum suaveolens* (Guill. & Perr.) Brenan, *Parkinsonia aculeata* Linn., *Peltophorum pterocarpum* (DC.) Backer and *Tamarindus indica* Linn. Pollen grains of the *Afzelia* species, *A. africana* Sm., *A. bella* Harms var. *bella*, *A. bella* var. *gracilior* Keay, *A. bracteata* T. Vogel ex Benth. and of the *Swartzia* species, *S. fistuloides* Harms, and *S. madagascariensis* Desv. and that of *Talbotiella gentii* Linn. were obtained from herbarium specimens of the Ghana Herbarium, Department of Botany, University of Ghana, Legon.

Treatment of the pollen grains

Pollen slides were prepared according to the standard acetolysis method (Erdtman, 1952). The acetolysed material was chlorinated (Erdtman, 1952) before mounting in glycerine jelly. The slides

were then sealed with nail varnish. Separate preparations were made from grains treated with 5 per cent KOH (Erdtman, 1952). Pollen measurements were taken under ×40 and ×100 objective lenses using a calibrated graticule and were based on 40 grains selected randomly from five slides for each species. Pollen terminology is after Erdtman (1969).

Results and discussion

The pollen units observed were only monads and tetrads. There was, however, a wide variation in exine sculpturing.

Afzelia africana *Sm. Herbarium material. Ghana Herbarium, Legon, Accra. Morton A1918*

Pollen grains isopolar, radially symmetrical, 3-colporate; syncolpate at one pole in some grains, each colpus alternating with a colpoid streak; colpi membranes finely reticulate. P/E (Polar axis/Equatorial axis) 1.10, prolate spheroidal; amb circular to sub-triangular.

Exine about 8.1 μm thick; sexine thicker than nexine; sexine coarsely reticulate, muri conspicuously curved. Size measurements: P54.4 ± 6.75 μm (range 44.8 - 64.0 μm); E49.6 ± 5.49 μm (range 41.6 - 57.6 μm).

Occasional tetrads were observed. Erdtman (1952) described the pollen of this species as occurring in tetrahedral tetrads. Sowunmi (1973), however, did not observe any tetrads in her material. The discrepancy could be due to the fact that the grains separate easily on acetolysis. It is also possible that the grains occur both as tetrads and monads, the latter outnumbering the former.

Afzelia bella *Harms var. bella (Fig. 1a and b). Herbarium material. Ghana Herbarium, Legon, Accra. Sour s.n.*

Pollen shed in tetrahedral and rhomboidal tetrads; tetrahedral tetrads triangular in shape; mean tetrad diameter 132.16 ± 10.46 μm (range 112.0 - 147.2 μm). Individual grains 3-colporate, mean widest diameter 81.07 ± 4.37 μm (range 76.8 - 86.4 μm).

Colpi short, broad at the equator and tapering to acute ends; colpi membranes finely reticulate. Ora circular in shape. Exine about 7.2 μm; sexine thicker than nexine; sexine very coarsely reticulate; muri conspicuously curved.

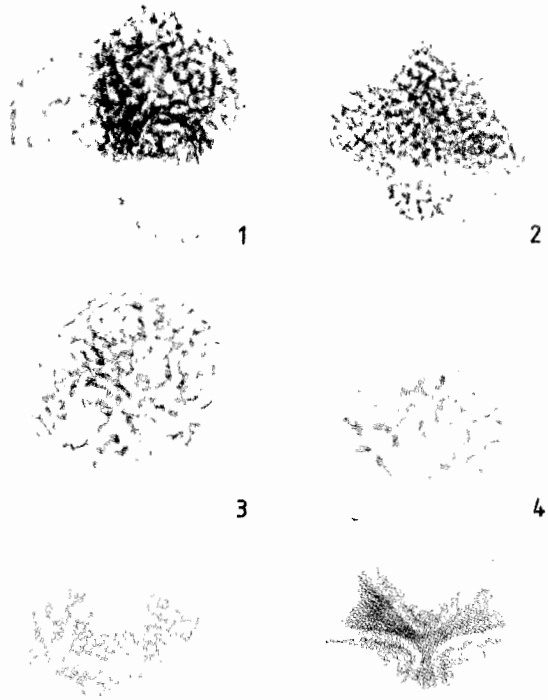

Fig. 1. Photomicrographs showing the nature of pollen in some species of the Caesalpinoideae: a. *Afzelia bella* var. *bella* (× 450), tetrahedral tetrad; b. *A. bella* var. *bella* (× 450), rhomboidal tetrad; c. *A. bella* var. *gracilior* (× 450), tetrahedral tetrad; d. *A.bella* var. *gracilior* (× 450), rhomboidal tetrad ; e. *Bauhinia tomentosa* (× 400); f. *Caesalpinia pulcherrima* (× 650).

Afzelia bella *var.* gracilior *Keay (Fig. 1c and d). Herbarium material. Ghana Herbarium, Legon, Accra. Andoh FH5815*

Pollen shed in tetrahedral and rhomboidal tetrads; tetrahedral tetrads circular to subtriangular in shape; mean tetrad diameter 124.82 ± 7.98 μm (range 105.6 - 131.2 μm). Grains failed to separate and, therefore, measurements could not be taken for individual grains. Exine thickness could not be easily measured, stratification indistinct; sexine very coarsely reticulate; muri very thick and conspicuously curved.

Afzelia bracteata *T. Vogel ex Benth. Herbarium material. Ghana Herbarium, Legon, Accra. Morton and Jarr. GC 52114*

Pollen grains isopolar, radially symmetrical, 3-colpate; colpi short with broadly acute ends; amb circular; mean widest diameter 62.25 ± 6.30 μm (range 51.2 - 70.4 μm). Exine thickness could not be determined, stratification indistinct; sexine very coarsely reticulate; muri conspicuously curved.

Erdtman (1952) reported the occurrence of rare tetrads in this species. Tetrads were not observed in the present study. However, a few dyads, about 10 per cent, were seen confirming the occurrence of compound grains in the species.

Bauhinia tomentosa *Linn. (Fig. 1e). Fresh material. Legon, Accra*

Pollen grains isopolar, radially symmetrical; 2-5-colpate. Colpi broad, very deep, dividing the grains into 2-5 lobes. P/E 1.35, prolate; amb variously lobed; equatorial outline circular to elliptic. Exine thickness difficult to measure; stratification indistinct; sexine possibly tectate, provided with two types of supratectal processes; bacula and verrucose. Size measurements: P140.80 ± 5.85 μm (range 131.2 - 150.5 μm). E104.64 ± 10.46 μm (range 80.0 - 115.2 μm).

Erdtman (1952) described the grains of *B. coronata* as 3-colporate; and those of *B. faberi* as 3-colporoidate; prolate. Sexine thicker than nexine; sexine striato-reticulate.

Caesalpinia pulcherrima *(Linn.) Sw. (Fig. 1f). Fresh materia. Legon, Accra*

Pollen grains isopolar, radially symmetrical, 3-colporate; syncolpate. Colpi very broad; margo present; colpi membranes granular; ora longitudinally elongated. P/E 0.93, oblate spheroidal; amb circular to triangular; equatorial outline elliptic. Exine about 6.5 μm; sexine thicker than nexine; sexine reticulate. Size measurements: P78.08 ± 2.70 μm (range 73.6 - 80.0 μm). E83.84 ± 2.52 μm (range 80.0 - 86.4 μm).

Cassia biflora *Linn. Fresh material Legon, Accra*

Pollen grains isopolar, radially symmetrical; 3-colporoidate; sometimes syncolpate. Colpi long, about 6.4 μm wide, constricted at the equator; tapering to broadly acute ends; colpi membranes psilate. P/E 1.20, subprolate; amb circular to broadly 3-lobed; equatorial outline elliptic. Exine about 2.0 μm; sexine slightly thicker than nexine; sexine finely granular. Size measurements: P35.52 ± 2.36 μm (range 32.0 - 38.4 μm), E22.08 ± 2.36 μm (range 19.2 - 25.6 μm).

Cassia fistula *Linn. Fresh material. Legon, Accra*

Pollen grains isopolar, radially symmetrical, 3-colporoidate; syncolpate. Colpi narrow with conspicuous margins; pore area faintly demarcated. P/E 1.39, prolate; amb circular; equatorial outline elliptic to rhomboidal. Exine about 2.0 μm; sexine and nexine of equal thickness; sexine granular. Size measurements: P41.92 ± 4.64 μm (range 35.2 - 48.0 μm), E30.08 ± 2.70 μm (range 25.6 - 35.2 μm).

Cassia obtusifolia *Linn. Fresh material. Legon, Accra*

Pollen grains isopolar, radially symmetrical; 3-colporoidate. Colpi broad with obtuse ends; sometimes constricted at the equator. Some grains have colpi meeting at one pole only, while others have them meeting at both poles. Colpi membranes psilate. P/E 1.22, subprolate; amb circular, equatorial outline circular to elliptic. Exine about 3.2 μm but thicker at the pores; sexine and nexine of equal thickness; sexine granular. Size measurements: P40.80 ± 6.27 μm (range 35.2 - 51.2 μm). E33.33 ± 3.73 μm (range 28.8 - 41.6 μm).

Cassia occidentalis *Linn. Fresh material. Legon, Accra*

Pollen grains isopolar, radially symmetrical; 3-colporoidate, sometimes syncolpate. Colpi long, about 3.5 μm wide with distinct margins; constricted at the equator and tapering to acute ends. P/E 1.20, subprolate; amb circular; equatorial outline elliptic. Exine about 3.2 μm, slightly thicker at the pores; sexine thicker than nexine; sexine finely granular. Size measurements: P54.40 ± 4.01 μm (range 44.8 - 60.8 μm); E45.23 ± 3.80 μm (range 38.4 - 51.2 μm).

Cassia siamea *Lam. Fresh material. Legon, Accra*

Pollen grains isopolar, radially symmetrical; 3-colporate, sometimes syncolpate. Colpi long with prominent margins and broadly acute ends. P/E 1.10, prolate spheroidal; amb circular; equatorial outline elliptic. Exine about 6.0 μm midway between pores and 3.2 μm elsewhere; sexine and nexine of equal thickness; sexine finely reticulate. Size measurements: P48.32 ± 2.80 μm (range 44.8 - 54.4 μm). E43.84 ± 1.55 μm (range 41.6 - 44.8 μm).

Delonix regia *(Boj. ex Hook.) Raf. Fresh material. Legon, Accra*

Pollen grains isopolar, radially symmetrical; 3-colporate. Colpi about 28.8 μm long and 6.4 μm wide with obtuse ends; colpi membranes finely reticulate. Ora transversely elongated. P/E 1.10, prolate spheroidal; amb circular; equatorial outline elliptic. Exine about 6.5 μm; stratification indistinct; sexine coarsely reticulate. Size measurements: P51.20 ± 1.51 μm (range 48.0 - 54.4 μm) E47.04 ± 1.55 μm (range 44.8 - 48.0 μm).

The observations recorded here agree generally with those of Sowunmi (1973).

Erythrophleum suaveolens *(Guill. & Perr.) Brenan. Fresh material. Legon, Accra*

Pollen grains isopolar, radially symmetrical; 3-colporate. Sometimes syncolpate either at one pole only or at both poles. Colpi narrow with acute ends; ora circular to slightly elongate with granulate opercula which projects beyond the general surface of the grain. P/E 0.92, oblate spheroidal; amb circular to elliptic. Exine about 2.6 μm; sexine and nexine of equal thickness; sexine finely reticulate. Size measurements: P21.69 ± 2.67 μm (range 19.2 - 25.6 μm); E23.47 ± 2.77 μm (range 19.2 - 28.8 μm).

Parkinsonia aculeata *Linn. Fresh material. Legon, Accra*

Pollen grains isopolar, radially symmetrical, 3-colporate. Colpi long, narrows, constricted at the equator; margins conspicuous. P/E 1.18, subprolate; amb circular to broadly 3-lobate. Exine about 3.2 μm, thinning sharply and abruptly towards the apertures; sexine thicker than nexine; sexine reticulate, reticulum fainter and finer towards the apertures. Size measurements: P33.87 ± 2.54 μm (range 32.0 - 38.4 μm); E28.80 ± 1.93 μm (range 25.6 - 32.0 μm).

Observations made in this study agree with those of Sowunmi (1973).

Peltophorum pterocarpum *(DC.) Backer. Fresh material. Legon, Accra*

Pollen grains isopolar, radially symmetrical; 3-colporate. Colpi short, about 6.5 μm wide medially, tapering to broadly acute ends; colpi membranes

finely reticulate; ora elongated longitudinally. P/E 1.10, prolate spheroidal; amb circular. Exine thickness difficult to measure; stratification indistinct; sexine coarsely reticulate, reticulum finer around the apertures; muri curved. Size measurements: P74.67 ± 4.89 μm (range 70.4 - 80.0 μm), E71.46 ± 4.89 μm (range 67.2 -76.8 μm).

Swartzia fistuloides *Harms Herbarium material. Ghana Herbarium, Legon, Accra*

Pollen grains isopolar, radially symmetrical, 3-colporate. Colpi long, about 3.4 μm wide, constricted at the equator and tapering to acute ends; colpi membranes smooth. P/E 1.29, subprolate; amb circular to triangular. Exine about 3.5 μm sexine and nexine of equal thickness; sexine finely reticulate. Size measurements: P25.28 ± 1.82 μm (range 22.4 - 28.8 μm), E19.52 ± 1.82 μm (range 16.0 - 22.4 μm).

Swartzia madagascariensis *Desv. Herbarium material. Ghana Herbarium, Legon, Accra. J.K. Morton A3904*

Pollen grains isopolar, radially symmetrical. 3-colporate, sometimes syncolpate. Colpi long, about 6.4 μm wide, tapering to broadly acute ends; sometimes constricted at the equator. Colpi membranes finely granular. P/E 1.53, prolate; amb circular to triangular. Exine about 1.5 μm; sexine and nexine of equal thickness; sexine finely reticulate. Size measurements: P30.40 ± 3.46 μm (range 25.6 - 35.2 μm), E19.84 ± 3.30 μm (range 16.0 - 25.6 μm).

About 15 per cent of the grains treated with KOH were in the form of tetrahedral and rhomboidal tetrads. However, there is no published information on the occurrence of pollen tetrads in the genus *Swartzia*. This could probably be due to the fact that the grains separate easily on acetolysis and a number of them become distorted. These distortions also made it difficult for Sowunmi (1973) to determine the dimensions of colpi and ora in the grains she studied.

Talbotiella gentii *Hutch. and Greenway. Herbarium material. Ghana Herbarium, Legon, Accra. Irvine GC3072*

Pollen grains isopolar, radially symmetrical; 3-colporate; sometimes syncolpate. Colpi long, about 3.2 μm wide medially, tapering to acute ends; colpi membranes (granular?). Ora elliptic, elongated longitudinally, extending beyond colpal margins. P/E 1.23, subprolate; amb circular to broadly 3-lobed. Exine about 3.5 μm; sexine and nexine of equal thickness; sexine striato-reticulate. Size measurements: P43.52 ± 2.24 μm (range 41.6 - 48.0 μm), E35.52 ± 2.36 μm (range 32.0 - 38.4 μm).

Tamarindus indica *Linn. Fresh material. Legon, Accra*

Pollen grains isopolar, radially symmetrical; 3-colporate; mostly syncolpate. Colpi long, about 3.4 μm wide, sometimes constricted at the equator, margins conspicuous; colpi ends acute. Ora elongated transversely, rectangular in shape (6.4 × 3.2 μm). P/E 1.15, subprolate; amb circular. Exine about 3.2 μm; sexine and nexine of equal thickness; sexine striate. Size measurements: P38.40 ± 3.37 μm (range 32.0 - 41.6 μm), E33.28 ± 3.09 μm (range 28.8 - 38.4 μm).

Conclusion

In the family Leguminosae, compound grains, ranging from tetrads to polyads of 64 grains, are most typical of the sub-family Mimosoideae. In the sub-family Caesalpinoideae tetrads, the largest group, have been reported in the genera *Afzelia* (Tribe: Detarieae; Erdtman, 1952; Sowunmi, 1973) and *Diptychandra* (Tribe: Caesalpinoideae; Guinet, 1965; Graham, Barker & Freitas da Silva, 1980). In the present study, tetrads were observed in a third genus *Swartzia* (Tribe: Swartzieae).

The occurrence of the pollen tetrads does not indicate close affinity between the genera or the tribes since pollen tetrads have developed inde-

pendently in many taxonomically unrelated groups. Graham, Barker & Freitas da Silva (1980) suggested that this has probably been in response to the selective factor of pollination efficiency. In any plant with more than one ovule per ovary, and not exclusively wind pollinated, tetrads and polyads will likely be selected for, or at least not selected against, since they permit multiple fertilization from a single pollination event. Walker (1971) pointed out that morphologically permanent tetrads, polyads and pollinia are significantly correlated with a high number of ovules per ovary.

A notable feature of the pollen of most of the members of the Caesalpinoideae investigated in this work is the elaborate exine sculpturing as was observed in the species of *Afzelia - A. africana, A. bella* var. *bella* (Fig. 1a and b), *A. bella* var. *gracilior* (Fig. 1c and d) and *A. bracteosa* as well as *Bauhinia tomentosa* (Fig. 1e), *Delonix regia, Peltophorum pterocarpum* and *Talbotiella gentii*. Walker (1976) suggested that elaborate exine sculpturing seems to be associated with entomophily, while pollen grains with smooth surfaces are largely characteristic of anemophilous plants. Sculpturing may aid in attaching pollen to the insect pollinator as well as holding individual pollen grains together as "functional polyads". Sculpturing combined with adhering oil droplets frequently encountered in pollen of entomophilous plants probably produce functional polyads simulating natural polyads.

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