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ON SOME AUSTRALIAN TERTIARY SPORES AND POLLEN GRAINS THAT EXTEND THE GEOLOGICAL AND GEOGRAPHICAL DISTRIBUTION OF LIVING GENERA

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Summary

Six distinct fossil spore types referable to *Schizaea*, three from the Lower Eocene of south-eastern Australia and three from Upper Pliocene coals of Papua, have been described; their affinities have been discussed.

The pollen of an Australian Eocene species of *Ephedra* has been described under the name *Ephedra notensis*. A new species of *Dacrydiumites*, *D. balmei*, has been instituted.

Pollen grains of the living genera *Alangium* and *Amylotheca* have been recorded from Upper Pliocene coals of Papua.

Introduction

Only a comparatively small proportion of the spores and pollen grains contained in Australian and Papuan deposits have as yet been classified (Cookson 1946, 1950, 1953a and b, 1954; Cookson and Pike 1953, 1954a and b). Of those already described some have been related to living species and have thus provided useful phytogeographical information that otherwise might not have been available. Others not so well characterised, or without living counterparts, have proved of stratigraphical interest.

The present paper is concerned with further examples of both categories obtained from two sets of deposits, one in Papua, the other in south-eastern Australia.

The Papuan types were recovered from Pliocene (probably Upper) hard brown coal seams that outcrop in creek-beds situated near the eastern and north-eastern margins of the Kikori-Purari delta. The Australian types were isolated chiefly from Early Tertiary estuarine deposits (Nelson Bore, Moonlight Head-Princetown district) and brown coals (Eastern View and Benwerrin) in south-western Victoria, early Tertiary beds in south-eastern Victoria and at Cootabarlow and Canopus Station in South Australia. For further details regarding the individual localities mentioned in this paper see Cookson and Pike (1954b) and Deflandre and Cookson (1955).

Whilst the system of nomenclature used in the present paper is essentially the same as in previous ones, it has become apparent from contact with overseas palynologists, that there is a general feeling that spores and pollen should be treated, like other plant organs, as form and organ genera and species rather than as sporotypes and sporomorphs (Erdtman, 1947). Following a letter from Dr. Alfred Traverse giving the substance of recent American discussions on this subject, I have decided to conform to the opinion of the majority and to abandon the use of the terms sporotype and sporomorph.

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Description and Distribution of Fossils

PTERIDOPHYTA

Order Filicales

Family Schizaeaceae

Genus **Schizaea** Sm.

Very little is known of the past history of the genus *Schizaea,* and what information there is has been derived from spore occurrences. The spores of many species have distinctive types of exospore sculpture which, when taken in conjunction with their bilateral, monolete form, provide a reliable basis for the reference of dispersed fossil spores to *Schizaea.*

Selling (1944) has critically discussed earlier references to schizaeacous remains, and has, himself, unqualifying referred two types of fossil monolete spores to *Schizaea.* One of these, *S. miocenica* from the Lower Miocene of Germany, has an alveolate exospore structurally similar to that of the living North American species *S. pusilla* Pursh. The other, *S. skottsbergii,* and its variety *mauiensis* form the late Quaternary peats of the Hawaiian Islands, also have the characteristic *S. pusilla* type of exospore. Both the Hawaiian spores are larger and have wider alveoli than either *S. miocenica* or the spores of *S. pusilla.* At the same time, Selling described two fossil monolete types with longitudinally ridged exospores under the names *Schizaea* (?) *palaeocenicus* and *Schizaea* (?) *eocenicus* respectively, thereby demonstrating the occurrence in European Paleocene and Eocene deposits of spores morphologically not far removed from those of such living species as *Schizaea laevigata* Mett, and *Schizaea digitata* (L.) Sw. Recently these fossil species were transferred to the form genus *Cicatricosa* Thoms. and Pflug by Krutzsch (1954) who associated them with two additional species *C. cretacius* Krutzsch and *C. virgatus* Pflug.

Finally spores from Lower Miocene to Pleistocene deposits in New Zealand have been compared by Couper (1953) with those of *Schizaea fistulosa* Labill., a component of the present New Zealand flora.

No records of the fossil occurrence of *Schizaea* in the Australian region are known. The recovery from Early Tertiary deposits in south-eastern Australia and from Upper Pliocene coals of Papua of spores more or less comparable with those of living species now foreign to those areas is, therefore, of some interest. Six types have been distinguished, three from the Australian and three from the Papuan deposits.

Schizaea reticulata n.sp.

(Holotype, Pl. VIII, figs. 1, 2)

Description. Spore large 75 x 60 μ in obliquely lateral view, bilateral, monolete scar inconspicuous, extending almost to the margin. Exospore not thickened in the region of the scar, reticulate, lumina c. 2·6 μ high and c. 2-2·5 μ wide, polygonal, muri relatively thin c. 1μ.

Occurrence. Nelson Bore, Victoria, at 3874 ft. (Paleocene).

Comments. The single specimen upon which this species is based superficially resembles the spores of *Schizaea pusilla, S. miocenica* and *S. skottsbergii.* However, the complicated exospore structure described by Selling for *S. pusilla* and seen by him in *S. miocenica* and *S. skottsbergii* does not exist in *Schizaea reticulata.* A careful comparison of the latter with acetolysed spores of *S. pusilla* (Nova Scotia:

By Tiberts Lake, Freeport, 28/8/1921, Fernald and Long 401. Ex Herb. Hot. Bot. Reg., Kew) has clearly shown that the exospore of *S. reticulata* is of a simpler and possibly more primitive type of construction than that of *S. pusilla*.

Schizaea fromensis n.sp.

(Holotype, Pl. VIII, fig. 3)

Description. Spore 70 x 50 μ in lateral view, monolete scar rather prominent extending for about three-quarters of the length of the longest equatorial diameter; exospore c. 2·6 μ thick, reticulate, lumina polygonal to round c. 1·5 μ, muri relatively wide.

Occurrence. Cootabarlow Bore near Lake Frome, South Australia, at 559 ft. (Eocene).

Comments. The mesh of the exospore reticulum of *S. fromensis* is smaller than that of *S. reticulata,* otherwise the structure of the exospore seems to be the same in both types.

Schizaea albertonensis n.sp.

(Holotype, Pl. VIII, fig. 4)

Description. Spore large 61-71 μ x 40-50 μ in lateral view, holotype 70 x 43 μ, bilateral, monolete scar bordered on either side by a ridge that extends for about three-quarters of the longest equatorial diameter. Exospore finely and closely reticulate, lumina c. 1 μ, muri narrow, composed of small columns separated by minute radiating channels.

Occurrence. Parish of Alberton West, south-eastern Victoria. Victorian Department of Mines Bore No. 137 at 160 ft. (probably Lower Eocene).

Comments. Schizaea albertonensis is of special interest in that the exospore structure approaches that of the living species *S. pusilla* and the two fossil species *S. skottsbergii* and *S. miocenica.* However, the mesh of the exospore reticulum of *S. albertonensis* is less than half that of *S. pusilla* and the muri are appreciably narrower. Consequently, the minute structure is less clearly visible than it is in *S. pusilla* and, as far as can be judged from Selling's descriptions, in *S. skottsbergii* and *S. miocenica.* A further link with these species is provided by the thickened ridges associated with the monolete scar.

S. albertonensis can be distinguished from *S. reticulata* and *S. fromensis,* the two Australian fossil species just described, by its distinctly finer reticulum and more complicated wall structure.

Schizaea punctata n.sp.

(Pl. VIII, figs. 5-7; holotype, fig. 5)

Description. Spores large 62-83 x 32-55 μ in lateral view, bilateral, monolete. Exospore c. 2 μ thick, deeply pitted, not thickened in the region of the scar, which extends almost to the margins.

Occurrence. Pliocene coal from Shu Creek, Papua (Australasian Petroleum Company's sample No. 511), and from the same sequence in the Era River, several miles east of the Shu Creek exposure.

Comments. The sculpture of this species is essentially similar to that of two tropical American species, *S. pennula* Sw. and *S. germani* (Fee) Prantl. (Selling, 1944, p. 41). However, comparison with acetolysed spores of *S. pennula* (Est Amazonas; Porto Curuchy, Rio Negro. 6/10/1945 coll. R. de Lemos Fraes 21113. Ex Herb. Hort. Bot. Reg., Kew) has shown that in *S. punctata* the pits are more closely crowded than they are in *S. pennula*. The spores of *S. punctata* are larger than those of either *S. pennula* or *S. germani*.

Schizaea papuana n.sp.

(Pl. VIII, figs. 8-12; holotype, fig. 9)

Description. Spores 24-47 x 44-80 μ in lateral view (Type, Pl. VIII, fig. 9, 47 x 70 μ), scar inconspicuous. Exospore with narrow, unevenly thickened, longitudinally or somewhat obliquely placed ridges, 1·5-5 μ high, the wider portions between the ridges faintly granular, sometimes the ornamentation, although linearly arranged, has an almost verrucose appearance.

Occurrence. Pliocene coals from Shu Creek, Era River and the Orloli region, Papua.

Comments. Schizaea papuana has been common in all the Pliocene Papuan coals examined. It is distinct from the spores of those of the living species of *Schizaea* described by Selling (1944), and its affinity with this genus is less certain than that of the preceding species. Furthermore, it is possible that spores of two species, one with practically complete ridges, the other with an almost verrucose exospore, have been included in *S. papuana*. However, both types occur in the same deposits and structurally seem to merge into one another, so that, as the figures show, it would be difficult to know where to draw the line of demarcation between them.

A somewhat comparable variation has been observed amongst the spores of the living species *Schizaea asperula* Wakefield. The majority of the spores of this species have a minutely and irregularly tuberculate exospore (Pl. VIII, figs. 14, 15), but in others localised areas, particularly in the region of the scar, are raised into relatively large tubercles (Pl. VIII, figs. 13, 16) reminiscent of those of *S. papuana*.

The only living species of *Schizaea* with striated exospores appear to be *S. laevigata, S. digitata, S. confusa* Selling, *S. melanesica* Selling, *S. inopinata* Selling, *S. spirophylla* Troll and *S. penicillata* Kunth. In none of these species are the exospore ridges uneven in height as they are in *S. papuana*.

Schizaea digitatoides n.sp.

(Pl. IX, figs. 1, 2; holotype, fig. 1)

Description. Spores bilateral, monolete, type in lateral view (Pl. IX, fig. 1) 45 x 29 μ. Exospore c. 1·5 μ obliquely striated, ridges narrow and closely arranged, occasionally bifurcate.

Occurrence. Pliocene coal from Era River, Papua.

Comments. Only a few spores of this type have been seen but every one has agreed closely with the spores of the living species *S. digitata* (L) Sw. (Papua, New Guinea: Copland King No. 110. Ex New South Wales Herbarium), a member of the present flora of New Guinea. It would seem very likely, therefore, that the fossil spores are either those of *S. digitata* itself, or of a very closely related extinct species. However, no certainty on this question can be reached, since another living species, *S. spirophylla* Troll, is said to have spores similar to those of *S. digitata*.

Family CYATHEACEAE

Genus **Cyathea** Sm.

Cyathea annulata Cookson

(Pl. IX, figs. 4, 5)

Cyatheacidites annulata Cookson, 1947, B.A.N.Z. Ant. Res. Exp. Reports, Ser. A., 2: pp. 129-142, Pl. XV, figs. 53, 54.

Description. This species was originally described from Tertiary lignites of the Kerguelen Archipelago as follows:

"Spores tetrahedral, trilete, rounded to subtriangular in polar view 40-56 x 32-56 μ, the distal wall also rounded. An annular flange 5·5-10·5 μ thick extends around the equator of the spore, the overall measurements of the proximal surface being 58-77 x 61-77 μ. Exospore thick, pitted and covered with irregular protuberances which are especially marked on the facets of the proximal wall, where they coalesce, more or less, to form three conspicuously thickened areas. The tetrad scar is distinct and extends to the periphery."

Spores which conform to this description can now be reported from Australian Tertiary deposits (Pl. IX, figs. 4, 5). The overall equatorial diameters of the various examples come within the range given for the Kerguelen specimens, with the exception of the one shown in Pl. IX, fig. 4, which measures as much as 101 μ across. The width of the flange is also comparable.

Occurrence. Victoria—Ligneous clay from the "fruit zone" near the floor of the Open Cut, Yallourn. Age: Oligocene. Ligneous clay, Beenak, near Yarra Junction. Age: ?Oligocene. New South Wales—Snowy Mountains Hydro-electric Authority's sample bag 295, Eight Mile Diggings, Drill Hole M572, 167-180 ft. Nat. Mus. Vic. No. P16790; sample bag 80, lowest lignite, Round Mountain Diggings, Nat. Mus Vic. No. P16791; New Chum Hill, Kiandra, soft ligneous shale 135 ft. below the basalt, Nat. Mus. Vic. No. P15710. Age: Lower Tertiary. Queensland—Carbonaceous clay under the basalt about 300 yds. below Curtis Falls, Cedar Creek, Mount Tambourine. Age: Uncertain, Pliocene according to Bryan and Jones (1945).

Comments. When first described the close agreement in every detail between *C. annulata* and the spores of *Cyathea vestita* Mart. from tropical South America was noted. Knox (1939, p. 454) has shown that the spores of *Lophosoria quadripinnata* have the same general type of construction, but lack the conspicuous excrescences present on the facets of the proximal surface of this species. Thus, since localised proximal thickenings are a conspicuous feature of *C. annulata,* there seems little doubt that a species of *Cyathea* closely related to *C. vestita* was relatively widely distributed in the southern hemisphere during the Tertiary period.

GYMNOSPERMAE

CLASS GNETALES

Family EPHEDRACEAE

Genus **Ephedra** Tourn.

Ephedra notensis n.sp.

(Pl. IX, figs. 6-10; holotype, fig. 6)

Description. Pollen grains ellipsoidal, without a furrow, 25-47 μ long and 14-28 μ broad. Exine firm, smooth and structureless with about 10-15 longitudinal ridges.

Occurrence and known range. Pebble Point Formation near Princetown, Victoria (Paleoocene); Rose Rivulet, Evandale, Tasmania (Gill and Banks, 1956); Nelson Bore, Victoria, at 2929, 2756, 2186 and 992 ft.; Castle Cove (basal clay), Aire Coast, Victoria; Alberton West (Vic. Dept. of Mines Bore 159 at 202 ft.); bore at Canopus Station, South Australia, between 548 and 572 ft.; bore of Associated Oil Corporation, Mount Gambier, South Australia, at 2110 ft.; Vic. Dept. of Mines No. 22366; bore at Cootabarlow, near Lake Frome, South Australia, at 559 ft. (Lower Eocene). *Ephedra*-like pollen grains have very recently been obtained from a sample taken at 3325 ft. from the Robe bore in South Australia the age of which is probably Lower Cretaceous.

Comments. The occurrence of pollen grains of this type in Australian deposits was recorded recently (Cookson, 1956). The suggestion was then made that the absence of a furrow pointed to an affinity with *Ephedra* rather than with *Welwitschia,* in the pollen grains of which a germinal furrow is invariably present. A very considerable variation in shape and range in size has been noticeable amongst the examples of *Ephedra notensis* observed, and it is possible that they represent more than one species. However, a closely comparable size-range has been evident also in an acetolysed pollen preparation of *Ephedra nana* P. Dusèn from the Palynological Laboratory, Stockholm, and the variation in shape could be accounted for by differences in the moisture content of the grains at the time of fossilization (Wodehouse, 1935, p. 288).

Although numerically *Ephedra notensis* has been of but infrequent occurrence, it has nevertheless provided a good indication that *Ephedra* was more widely distributed in the southern hemisphere during the Early Tertiary than it is at present. Pollen grains of the *Ephedra* type have been recorded from Cretaceous deposits in Iraq, Nigeria and Venezuela (Kugl, Muller and Waterbolk, 1955), from a Paleocene deposit near Hamburg (Thiergart, 1942), from the Eocene Green River shales, U.S.A. (Wodehouse, 1933), from Post-Glacial deposits and other sediments in Fuego-Patagonia (Auer, 1932; Auer, Salmi and Salminen, 1955), and from several European Post-Glacial deposits (Lang, 1951).

Class Coniferales

Family Taxaceae

Genus **Dacrydiumites** Cookson

Dacrydiumites balmei n.sp.

(Pl. IX, figs. 11-14; holotype, fig. 11)

Description. Pollen grains of large size and dense texture, overall length (Cranwell, 1940, p. 2B) 70-145 μ, width 65-117 μ; body more or less spheroidal 34-78 μ long and 34-75 μ wide; bladders 2 occasionally 3 more or less confluent not projecting far beyond the body, with relatively coarse radially arranged mesexinous fibres that sub-divide near the periphery to form a well defined reticulum; furrow indistinct, without a rim, furrow membrane with irregularly scattered thickenings; exine of the cap rather coarsely patterned.

Occurrence. In Paleocene-Lower Eocene deposits in the Parish of Alberton West, in south-eastern Victoria (Vic. Dept. of Mines Bore 138 at 208 and 203 ft., Bore 159 at 250 ft., Bore 137 at 165 and 136 ft. and Bore 135 at 193 ft.; at Lal Lal near Ballarat, Victoria (Vic. Dept. of Mines Bore 51 at 425-434 ft.); at Benwerrin,

Victoria (Brown Coal) and at Pebble Point near Princetown, Victoria (Melb. Univ. Geol. Dept. No. 3396).

Comments. The large Early Tertiary two-winged pollen grains described above have been referred to the genus *Dacrydiumites* on account of the radial arrangement of the internal fibrous thickenings of the air bladders, an arrangement that characterizes a number of the living species of the genus *Dacrydium,* but which does not appear to occur in any of the other genera of the Podocarpaceae.

This type of wing-construction has been noted by Cranwell (1940) in *D. cupressinum* Soland, *D. kirkii* F. Muell., *D. biforme* (Hook.) Pilger and *D. bidwillii* Hook. f.; by Erdtman (1943) in *D. elatum* Wall.; by Wodehouse (1935) in *D. gibbsiae* Stapf and by Cookson and Pike (1953) in *D. araucarioides* Brong. and Gris. and *D. balansae* Brong. and Gris. It also occurs in *D. taxoides* Brong. and Gris.

The pollen grains of *D. araucarioides, D. balansae, D. cupressinum, D. elatum, D. taxoides* and the two closely related species *Dacrydium praecupressinoides* Couper (New Zealand) and *Dacrydiumites florinii* Cookson and Pike (Australia) are distinct from those comprising *Dacrydiumites balmei* in that the mesexinous fibres in the air-bladders form more or less clearly defined peripheral loops instead of a reticulum as in the latter species.

The type of wing-construction in *D. kirkii, D. bidwillii* and *D. biforme,* on the other hand, is essentially the same as that of *Dacrydiumites balmei* but on a much smaller scale. However, the much smaller size of the grains themselves, the more regular and usually free air-bladders, the finer sculpture of the cap and the smooth furrow membrane are features in which these three living New Zealand species of *Dacrydium* are distinct from *Dacrydiumites balmei.*

Dacrydiumites balmei is readily recognizable by its large size and dense appearance. It appears to have had a restricted geological range, for as yet it has been observed only in the lowest deposits of the Victorian Tertiary succession.

The genus *Dacrydium* is not represented in the present flora of the Australian mainland but one species, *D. franklinii,* occurs in Tasmania. However, the occurrence of pollen grains, morphologically identical with those of two of the living species of *Dacrydium,* in a large number of Australian and Tasmanian Tertiary deposits shows that close relatives of these species, if not the actual species themselves, were previously widely distributed in these areas. The fossil pollen grains known as *Dacrydiumites florinii* (Cookson and Pike, 1953) agree with those of *D. cupressinum* (New Zealand) and the other members of Florin's group B (Florin, 1931), while those comprising *Dacrydiumites mawsonii* (Cookson, 1953) agree with the pollen of *Dacrydium franklinii.*

The discovery of yet a third species, *Dacrydiumites balmei,* enhances the position held by the fossil representatives of *Dacrydium* in the Early Tertiary flora of Australia.

The specific name is given in honour of Mr. B. E. Balme, Chief Palynologist of the Coal Research Section, C.S.I.R.O., New South Wales.

Dacrydiumites mawsonii Cookson f. **verrucosus** n.f.

(Pl. IX, figs. 15, 16)

Description. Grains small, morphologically similar to those of the type (Cookson, 1953, p. 66) including the development of prominent proximal tubercles, body varying in shape according to the degree of expansion. Exine of the cap raised into well defined and closely arranged verrucae.

Occurrence. In Paleocene-Lower Eocene deposits in the Parish of Alberton West, Victoria (Vic. Dept. of Mines, Bore 159 at 225 ft., Bore 137 at 165 ft., Bore 157 at 225 ft., and Bore 138 at 203 and 208 ft.

Comments. The forma *verrucosus* is readily distinguishable from the type, *Dacrydiumites mawsonii,* by the sculpture of the exine covering the cap of the grain. In *D. mawsonii,* as well as in the living species, *Dacrydium franklinii,* the exine of the cap is faintly granular not verrucate as in the proposed new form. Also, the forma *verrucosus* is, on the whole, rather smaller than *D. mawsonii.* However, until more is known about the occurrence and distribution of the verrucate type, it seems advisable to regard it as a form of *D. mawsonii* rather than as a distinct, though closely related, species.

DICOTYLEDONAE

Family ALANGIACEAE

Genus **Alangium** Lam.

Alangium javanicoides n.sp.

(Pl. X, figs. 1, 3, 5, 6; holotype, fig. 1)

Description. Pollen grains large, suboblate, equatorial diameter 58-70 μ usually tricolporate (occasionally tetracolporate), furrows narrowing towards the poles, pores oval to circular. Exine 3-4 μ, nexine thicker than sexine, considerably thickened around the colpae, sculpture a compact small-meshed OL pattern, outer surface smooth to roughish according to the degree of coarseness of the sexinous pattern.

Occurrence. Upper Pliocene coals of the Shu Creek and Orloli regions, Papua.

Comments. A comparison of *Alangium javanicoides* with pollen grains of other species of *Alangium* having $\pm$ smooth outlines, such as *A. nobile* (Clarke) Harms (Brit. Mus. Coll.), *A. chinense* (Loureiro) Harms (Brit. Mus. Coll.) and *A. javanicum* (Blume) Wangerin (Hortus Bogoriensis Coll.), has shown that it agrees most closely with those of *A. javanicum.* In fact, so close is the agreement that there is little doubt that *A. javanicoides* is very closely related to *A. javanicum* (Pl. X, fig. 4), if not specifically identical with it.

A fossil species of *Alangium, A. barghoornianum* Traverse (1955) was recently described from an Upper Oligocene lignite in Vermont, U.S.A. The sculpture of this species is quite distinct from that of *A. javanicoides.*

Family LORANTHACEAE

Genus **Amylotheca** van Tiegh

Amylotheca pliocenica n.sp.

(Pl. X, figs. 7, 8; holotype, fig. 8)

Description. Pollen grains triangular in polar view with blunt angles, straight to slightly concave sides and two sets of three demicolpae (Erdtman, G., 1952, p. 462) which do not meet at the poles. Equatorial diameter 42-50 μ. Exine thin, minutely spinulate except in fan-shaped areas situated between the distal ends of the demicolpae and the corresponding angles of the grain and between the proximal ends of the demicolpae.

Occurrence. Upper Pliocene coals of the Orloli and Shu Creek areas, Papua.

Comments. Since the pollen grains of the genus *Amylotheca* appear to be of uniform character, no attempt has been made to connect the fossil grains with any particular living species.

Several species of *Amylotheca* occur in the present flora of New Guinea, so that it is not surprising that this genus was a component of the Papuan Pliocene flora. The close similarity between *A. pliocenica* and the grains of the living New Guinea species *A. papuana* Danser (Arnold Arboretum, Carr No. 1552) is clearly indicated by Pl. X, figs. 8, 9.

Incertae Sedis

Genus **Triorites** Cookson

Triorites clavatus n.sp.

(Pl. X, figs. 10, 11; holotype, fig. 10)

Description. Grain large, triangular in polar view with straight or slightly concave sides, angulaperturate, ora 3, c. 13-18 μ in diameter, true apertures 10-13 μ below the surface, equatorial diameter of the holotype 73 μ and of the paratype (Pl. X, fig. 11) c. 81 μ. Exine clavate, 4-layered, 7-10 μ thick (without clavae). Sexine wider than nexine (4 μ and 3 μ respectively in the type) consisting of a thick "spongy" zone and a very thin homogeneous outer layer with rather widely-spaced clavae; the more detailed structure of the sexine is obscure, but seems to be comparable with the type represented by Erdtman (1952, fig. 4h, i).

Occurrence. Nelson Bore, Victoria, at 2874 ft., Lower Eocene.

Comments. Only two examples of this species have been found. These are essentially identical with one another, but in the paratype (Pl. X, fig. 11) the sharp line of demarcation between the sexine and nexine, so clearly marked in the type, is not evident. However, in certain areas the "spongy" portion of the sexine can be faintly distinguished.

T. clavatus is morphologically similar to *Triorites magnificus* (Cookson, 1950), originally described from the brown coal at Moorlands, and since recovered from coaly material at Noarlunga, South Australia, the sediments intersected by the Canopus bore, South Australia, between 960 and 925 ft., the Birregurra bore, Victoria, between 760 and 925 ft., Alberton West, Victoria (Vic. Dept. of Mines) Bore No. 138 at 179 ft. and at Darriman, Victoria (Frome-Broken Hill Ltd.) Bore 1 at 1941-1942 ft., and there is little or no doubt that they were produced by closely related plants. Both species have the same shape, type of ora and exine stratification, and structure, the chief distinction between them being the type of external ornament. In *T. magnificus* the thin outer portion of the sexine has a reticuloid structure, whereas in *T. clavatus* the ornament takes the form of rather widely-spaced finger-like outgrowths. In *T. clavatus,* as in *T. magnificus,* the outer layer of the sexine is delicate and liable to be destroyed (Pl. X, fig. 10). The origin of both species is obscure.

Genus **Tricolpites** Erdtman

Tricolpites gillii n.sp.

(Pl. X, figs. 12-15; holotype, fig. 12)

Description. Grain small, subangular with straight, slightly convex or slightly concave sides, and three rather widely open furrows that extend for varying

distances towards the poles, equatorial diameter 21-29 μ. Exine thin, tectate and finely granular.

Occurrence. Nelson Bore, Victoria, between 6233 and 1553 ft. (Upper Cretaceous to Lower Eocene); Pebble Point Formation, Victoria (Paleocene); Benwerrin coal, Victoria (Paleocene to Lower Eocene); Eastern View Coal Measures, Victoria (Paleocene to Lower Eocene); Lal Lal, Victoria, Vic. Dept. of Mines Bore 51 at 425-434 ft.; Parish of Alberton West, Victoria, Vic. Dept. of Mines Bore 159 at 250-192 ft. and Bore 157 at 225 ft.; Cootabarlow Bore, South Australia, at 559 ft. (Lower Eocene).

Comments. By its occurrence in the Upper Cretaceous section of the Nelson Bore-Core (6233-5304 ft.), *Tricolpites gillii* becomes one of the earliest of the Australian angiosperm pollen types. It has been recovered in small numbers along with *Triorites edwardsii* Cookson and Pike from all the Victorian Paleocene to Lower Eocene deposits that have been examined to date, and thus may ultimately prove of stratigraphical value.

The specific name has been given in honour of Mr. E. D. Gill, Curator of Fossils, National Museum of Victoria.

Conclusion

The occurrence in Australian Eocene deposits of spores representing species of *Schizaea* which no longer occur in Australasia, but which have affinities with northern types, is of phytogeographical interest. Especially is this so in connection with *Schizaea albertonensis,* the exospore structure of which suggests a link with the North American species *S. pusilla* and the extinct Hawaiian species *S. skottsbergii.* Similarly, the occurrence in Papuan Pliocene coals of spores (*S. punctata*) comparable with those of two tropical American species, *S. pennula* and *S. germani,* suggests that species of *Schizaea* having pitted spores were more widely distributed during the Tertiary period than they are now.

The question of the past distribution of *Ephedra* recently received brief mention by Lam (1955). This author, in referring to the suggestion made by Gams (1952) "that some *Casuarina* fossils had perhaps better be attributed to *Ephedra*", states that so far as he himself knows "*Ephedra* has not been reported from the present centre of the *Casuarina* area, Australia, either fossil or recent. Its locality nearest (through Antarctica) to the area of *Casuarina* (extending to Fiji, New Caledonia and Tasmania, one species widely dispersed by ocean currents) is southern Argentina".

There is little or no doubt that the pollen grains herewith referred to *Ephedra* belonged to a Tertiary species of that genus, but whether or not this species was indigenous to Australia is somewhat less certain. At present, however, there appears to be no evidence that these *Ephedra* pollen grains were carried to the site of sedimentation either by air or by seas.

In connection with the microflora preserved in the Pliocene coals of southern Papua, it can be stated that, as the elucidation of individual pollen types proceeds, it is becoming increasingly evident that many of the genera, and possibly even species, constituting the present flora existed in this area during the Upper Pliocene. Already pollen grains referable to *Dacrydium* (of the section to which *D. novo-guineense* Gibbs belongs), *Nothofagus* (*brassi* type), *Santalum, Myriophyllum* and *Gunnera* have been recorded (Cookson and Pike, 1953, 1954b and 1955). Now the genera *Schizaea, Alangium* and *Amylotheca* can be added to the list.

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Explanation of Plates

All the figures are from untouched negatives. Unless otherwise specified the magnifications are × *c.* 600.

PLATE VIII

Figs. 1, 2.—*Schizaea reticulata* n.sp. High and low focus of holotype. Nelson Bore, Victoria, at 3874 ft.
Fig. 3.—*Schizaea fromensis* n.sp. Holotype. Cootabarlow Bore, S.A., at 559 ft.
Fig. 4.—*Schizaea albertonensis* n.sp. Holotype. Alberton West, Bore No. 137 at 165 ft.
Fig. 5.—*Schizaea punctata* n.sp. Holotype. Era River, Papua.
Figs. 6, 7.—*Schizaea punctata.* High and low focus of a Paratype. Era River, Papua.
Figs. 8-12.—*Schizaea papuana* n.sp. Orloli and Shu Creek coals, Papua.
Fig. 9.—*Schizaea papuana.* Holotype. Orloli River, Papua.
Fig. 13-16.—*Schizaea asperula* Wakefield. Cheltenham district, Victoria. Nat. Herb. of Vic. collection.

PLATE IX

Fig. 1, 2.—*Schizaea digitatoides* n.sp. Holotype (fig. 1). Era River, Papua.
Fig. 3.—*Schizaea digitata.* Papua. Copeland King No. 110, New South Wales Herbarium.
Fig. 4.—*Cyathea annulata.* Kiandra, N.S.W. Nat. Mus. Vic. Sample No. P15710. × c. 455.
Fig. 5.—*Cyathea annulata.* Clay from "Fruit Zone", Yallourn Open Cut, Victoria. × c. 550.
Figs. 6-10.—*Ephedra notensis* n.sp. Holotype (fig. 6). Cootabarlow Bore, S.A., at 559 ft.; fig. 7, Roses Rivulet, Evandale, Tasmania; fig. 8, Nelson Bore, Victoria, at 990 ft.; fig. 9, Canopus Bore, S.A., at 548-572 ft.; fig. 10, Pebble Point Formation, Victoria.
Fig. 11.—*Dacrydiumites balmei* n.sp. Holotype. Alberton West, Victoria. Vic. Dept. of Mines Bore 138 at 203 ft.
Fig. 12.—*Dacrydiumites balmei.* A small example with fused air bladders. Alberton West, Victoria. Vic. Dept. of Mines Bore 159 at 250 ft.
Fig. 13.—*Dacrydiumites balmei.* Portion of a partially disrupted air bladder, showing the radial arrangement of the mesexinous fibres and their peripheral subdivision. Alberton West, Victoria. Vic. Dept. of Mines Bore 159 at 250 ft. × 1300.
Fig. 14.—*Dacrydiumites balmei.* Surface view of portion of an air bladder to show peripheral reticulum. × c. 800.
Fig. 15, 16.—*Dacrydiumites mawsonii* f. *verrucosus* n.f. Alberton West, Victoria. Vic. Dept. of Mines Bore 137 at 165 ft. Type (fig. 15).

PLATE X

Fig. 1.—*Alangium javanicoides* n.sp. Holotype. Orloli Region, Papua.
Fig. 2.—*Alangium javanicoides.* Shu Creek coal, Papua.
Fig. 3.—*Alangium javanicoides.* Equatorial view. Shu Creek coal, Papua.
Fig. 4.—*Alangium javanicum* Dans. An acetoylsed grain, Java, Indonesia. Hortus Bogoriensis collection.
Figs. 5, 6.—*Alangium javanicoides.* Surface views of exine at high and low focus. × *c.* 1300.

Figs. 7, 8.—*Amylotheca plioncenica* n.sp. Holotype (fig. 8). Orloli Region, Papua.
Fig. 9.—*Amylotheca papuana*. An acetolysed grain, Papua. Arnold Arboretum collection (Carr No. 15502).
Fig. 10.—*Triorites clavatus* n.sp. Holotype. Nelson Bore, Victoria, at 2874 ft.
Fig. 11.—*Triorites clavatus*. Paratype. Nelson Bore, Victoria, at 2874 ft.
Figs. 12-15.—*Tricolpites gillii* n.sp. Holotype (fig. 12). Nelson Bore, Victoria, at 6233 ft.; fig. 13, Alberton West, Bore 137 at 136 ft.; fig. 14, Pebble Point Formation, Victoria; fig. 15, Cootabarlow Bore, S.A., at 559 ft.

Museum Register Numbers

Following are the registered numbers in the palaeontological collection of the National Museum of Victoria of species illustrated in plates:

PLATE VIII

Fig.	Reg. No.	Fig.	Reg. No.	Fig.	Reg. No.
1, 2	P 17369	5	P 17372	10	P 17375
3	P 17370	6, 7	P 17373	11	P 17376
4	P 17371	8, 9	P 17374	12	P 17377

PLATE IX

Fig.	Reg. No.	Fig.	Reg. No.	Fig.	Reg. No.
1	P 17378	7	P 17383	12	P 17388
2	P 17379	8	P 17384	13, 14	P 17389
4	P 17380	9	P 17385	15	P 16855
5	P 17381	10	P 17386	16	P 17390
6	P 17382	11	P 17387		

PLATE X

Fig.	Reg. No.	Fig.	Reg. No.	Fig.	Reg. No.
1	P 17376	8	P 17394	13	P 16854
2	P 17391	10	P 17395	14	P 17398
3	P 17392	11	P 17396	15	P 17399
7	P 17393	12	P 17397		

Addendum

As the pollen grains described as *Dacrydiumites* are closely related to those of the living genus *Dacrydium*, it is here proposed that all pollen grains described under the name *Dacrydiumites* be referred to *Dacrydium*, viz:

Dacrydium mawsonii Cookson 1947
D. ruei Cookson 1947
D. florinii Cookson and Pike 1953
D. balmei Cookson 1957
D. mawsonii forma verrucosus Cookson 1957.