Fossil remains of fungi, algae and other organisms from Jamaica

J. H. Germeraad

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Fungal remains and other fossils from Cainophytic strata of Jamaica have been compared with species described in mycological and algological publications. Only in a few cases morphologically related taxons have been encountered. The stratigraphic significance of these Jamaican fossils is unknown as yet.

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Introduction

The palynological sampling survey made in Jamaica February-March 1975, has been sponsored by the Netherlands Organisation for the Advancement of Pure Research (Z.W.O.) at The Hague, The Netherlands, and has been provided with excellent transport facilities by the Mines and Geology Division of the Ministry of Mining and Natural Resources of Jamaica. The Progress Reports on the palynological investigation of the samples collected in Jamaica are mentioned in the list of references (Germeraad, 1978, 1979).

In the sample-residues from the Jamaican Cainophytic strata fungal remains and other dark brown fossils were frequently observed. As far as possible single grain slides were made, the grains were arranged in morpho-types, each with a unique JAM-number; the fossils were photographed and their morphological features were described and measured. Subsequently the types were compared with species described in the botanical and palaeobotanical literature to which ample reference is made in this article. A rather complete bibliography (about 700 titles) of all related literature can be obtained from the author upon request.

As so many palynologists are unfamiliar with the subject, and in order to stimulate the investigation of fungal remains, illustrations from publications of various authors have been copied and added to elucidate the text. As regards the post-war articles permission to do so was generously granted by Dr E. Müller of the Eidgenössische Technische Hochschule in Zürich, by Dr J. A. von Arx of the Centraal Bureau Schimmelcultures in Baarn and by Dr E. S. Luttrell of the Georgia Experiment Station of the University of Georgia, and the editor in chief of Mycologia, New York Botanical Garden, Bronx, New York.

From the very beginning of this study the expert guidance and constructive criticism of Dr R. A. Maas Geesteranus (Rijksherbarium, Leiden) were highly valued by the author, especially so, as the difficulties of identification were encountered at several levels:

1) The literature to be consulted is widely scattered. Apart from a series of handbooks on the classification of fungi in which in general only the genera and sometimes the type-species are defined, the majority of the species are described not only in the vast literature on mycology and palaeobotany, but also in a wide range of periodicals that cover subjects from geology to phytopathology and allergology. Quite helpful proved the Bibliography of Systematic Mycology.

2) A part of the literature found in reference lists is rather old, not easy to consult, and often deals almost exclusively with the fungus-host relationship sensu lato, while in old palaeobotanical publications microscopical details are often scarce or of little use.

3) In the description of extant fungus species the characteristics of the organs which are (partly) fossilizable, are not or very rarely specifically mentioned as such; much more emphasis is placed on biological aspects like growth, reproduction and host relationship.

4) The number of living fungus species with fossilizable parts or spores is only a fraction of the number of totally unfossilizable species; it is not known whether, in the Cainophytic, the relatives of this majority never had fossilizable parts or spores.

5) The majority of the fungal spores have a simple structure and are hard to distinguish from each other; they may be spherical or spindle-shaped, without or with septa, sometimes in irregular arrangement. Therefore it is questionable whether good stratigraphic markers will be found among the simple fossil spores.

6) An ornamentation is lacking in most spores; if present, rather simple verrucae, echinae, or reticula prevail. These ornamental features have often been described as though not having much detail, and therefore are not very promising for stratigraphic studies either, nor useful for determining the taxon of the fossil specimen; more conspicuous features are needed.

7) Of some fossil structures the fungal origin seems doubtful. In a few cases an algal origin may be assumed. Supporting evidence may come from physicochemical analysis (Good & Chapman, 1978; van Gijzel, 1966, 1967) but such investigations are scarce as yet. Those fossils that are assumably neither fungal nor algal will be even more difficult to identify.

The geological history of Jamaica

The geology of Jamaica is complex and, of course, can be explained here only in a highly condensed, simplified way (see geological map, Fig. 1). For more detailed information the reader is referred to the literature on the geology of Jamaica, among which the Synopsis by Zans et al. (1962) is recommended. From the viewpoint of a palynologist the floral changes which are related to the vertical movements of the island and the changing possibilities of plant-migration from nearby regions are the most fascinating aspects.

The oldest palynomorphs observed are of Carboniferous-Permian age, found in reworked position in Upper Cretaceous tuffs and shales (Germeraad, 1979a). The Upper Cretaceous flora itself has its own, probably insular character, differing essentially from the known Venezuelan, Colombian and Brazilian floras (Germeraad, Hopping & Muller, 1968; Herngreen, 1975a,b, 1976; Germeraad, 1978b). From the restricted information available at present, the floral changes within the Jamaican Upper Cretaceous and up into the Palaeocene appear gradual, with a distinct impoverishment in the Palaeocene, suggesting a gradual downward movement of the island with a reduction in the number of different environments. The Lower Eocene part of the Richmond Formation in the eastern section of the island contains beautifully preserved pollen grains and spores, in contrast with the sporomorphs of the nearby Palaeocene Providence Shales, thus supporting the assumption that this part of the Lower Eocene did not participate in the preceding tectonic cycle of the Upper Cretaceous and Palaeocene. The entirely different composition of the Eocene flora also suggests that a more or less complete submergence took place between the Palaeocene and this part of the Eocene, followed by the immigration of a new vegetation. In younger Eocene strata the flora shows an enrichment, obviously owing to the rising of this or a neighbouring island with a greater number of different types of environment. However, somewhere in the Middle Eocene a new downward movement started, not only noticeable in the increasingly marine facies of the spreading Yellow Limestone Formation, but also obvious from the decreasing number of pollen types. The almost complete disappearance of pollen in the above-lying White Limestone Formation suggests the (near-)total submergence of the island. The assumption of the field-geologists that the boundaries between the formations mentioned (Richmond Formation, Yellow Limestone Formation, White Limestone Formation) should not be regarded as time-levels, is confirmed by the palynological investigation (Germeraad, 1978a).

The next emergence of the island by young tectonic movements, starting in Miocene time and continuing, be it at a slower pace, afterwards, resulted in the geomorphology that, in broad outlines, exists today. In the southeast of the island the rising post-Eocene sediments slumped downwards, possibly already before

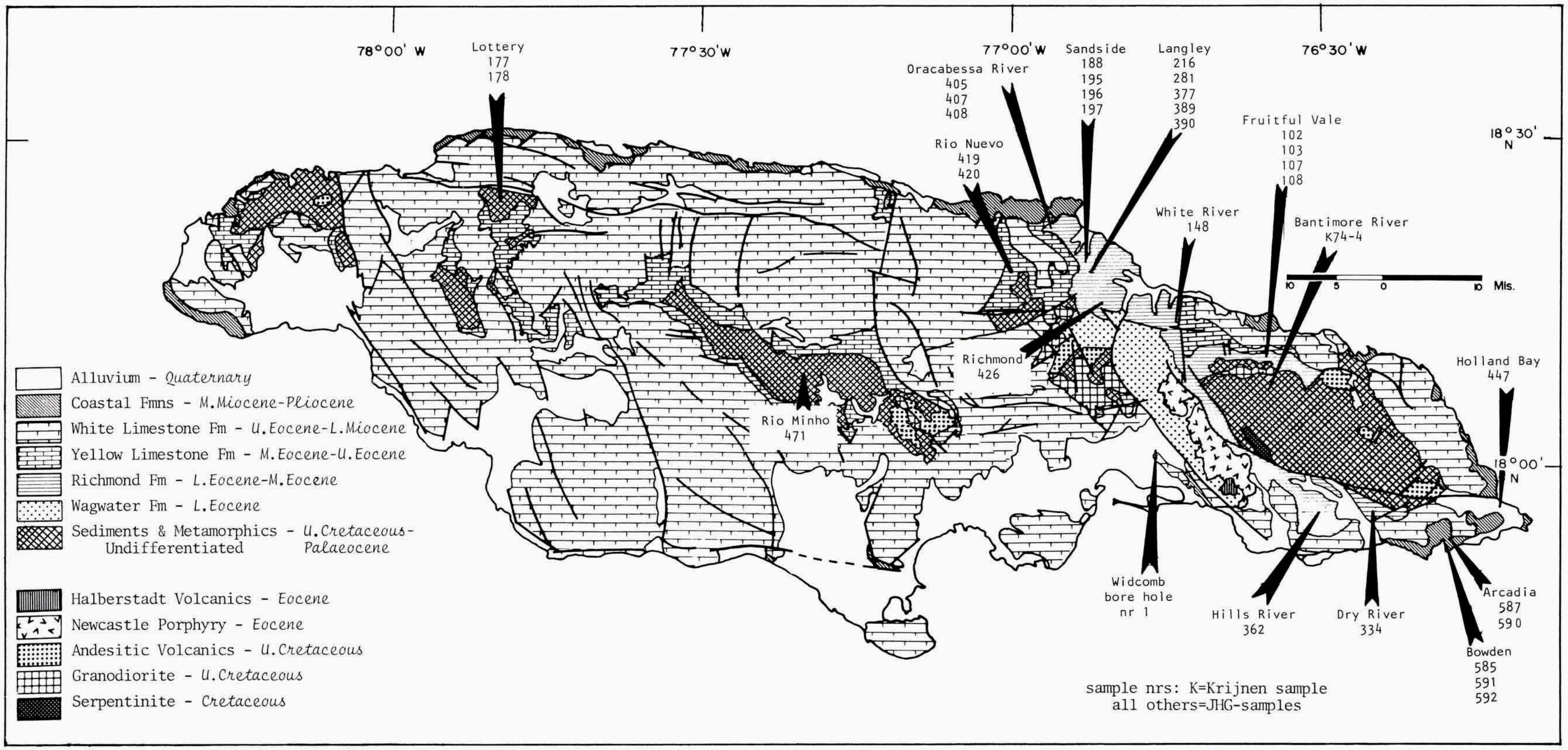


Fig. 1. Geological map of Jamaica, a slightly modified copy of the map of Wright (1974, p. 11).

emerging above sealevel, and these aggregated masses now compose the Bowden Formation. At many places along the coast today Pliocene - Quaternary sediments are found raised above sealevel; they generally contain very few pollen. In the peat deposits of the Great Morasses at the east and west end of the island and in the marshy deposits at Bowden a Holocene flora has been observed, very much resembling the Recent one.

From the geological map it can be seen that the eastern part of the island, with the Blue Mountains as its centre, is different from the rest of Jamaica. In this respect especially the Upper Cretaceous is intriguing, because a difference in the floras of east and west Jamaica may explain part of the pre-Tertiary tectonic history of the island (e.g. a possible post-Cretaceous unision of the two parts). As yet no pollen have been found in the available samples, but new material has lately been collected by Dr J. P. Krijnen.

Palaeobotanical results

The stratigraphic results of studies like the present one are very limited owing to the restricted amount of material examined as yet (Sheffy & Dilcher, 1971, p. 49). As stated above the simple-structured fossils appear less promising; the emphasis should be laid on the study of more conspicuous forms. In time a compilation of the pan-tropical, or even worldwide data may yield, for some types, valuable stratigraphic ranges which may be interpreted either as a time-range or as a range resulting from geographically imposed environmental or sedimentary influence (Fig. 2).

Morphological classification

It would have been preferable to present the descriptions of the observed fossils in an arrangement based on assumed taxonomic position. Unfortunately that is not easily done. The following morphological interpretational classification seems feasible:

I. Microthyrioid structures, comprising fungi and perhaps algae and lichenes: types JAM. 2003, 2007, 2008, 2010, 2011, 2040, 2042, 2044.
II. Non-microthyrioid fungal perithecia: types JAM. 2052, 2091.
III. Fungal spores, conidia, or other structures: types JAM. 2005, 2006, 2012, 2013, 2025, 2029, 2033, 2046, 2047, 2048, 2049, 2054, 2063, 2068, 2075.
IV. Fern sporangia: type JAM. 2009.
V. Fossiles incertae sedis: types JAM. 2050, 2051, 2053, 2058, 2067, 2089.

MICROTHYRIOID STRUCTURES

Isolated, more or less circular disks composed of radially arranged cells, resembling at first glance the fruitbodies of Microthyriales (Fungi) detached from their

	JAM. type numbers	Upper Cretaceous	Palaeocene	Lower Eocene	Middle Eocene	U. Eocene-Oligocene	Miocene-Pliocene	Young fissure fillings	Holocene
	2046								R
	2048								R
	2054								F
	2063								F
	2050								C
	2051								R
	2053								F
	2058								R
	2075							R	
	2052						R		
	2047						R		
	2049						R		
	2029					F			
	2013				F				R
	2091				R				
	2012			R	?R				R
microthyroid structures	2011				R				
	2042				R				
	2044				R				
	2003			F	F	R			
	2007			F	R				
	2008			F					
	2010			F	R				
	2040			R					
	2100			R	R	R			
	2005			C					
	2006			R					
	2025			R					F
	2033			R					
	2009			F					
	2068	R							
	2067	R							
	2089	R							

Fig. 2. Stratigraphic position of the most conspicuous fossil remains of fungi, algae, and other organisms as yet observed in the samples collected by J. P. Krijnen and J. H. Germeraad. Palynological types are numbered 2003 - 2100. R = rare (1 - 2 specimens), F = frequent (3 - 6 specimens), C = common.

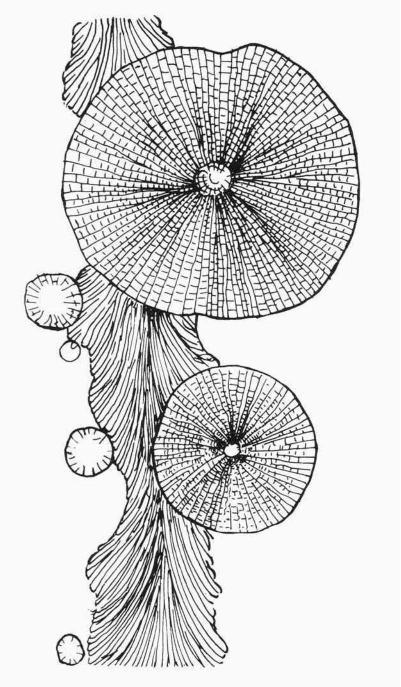


Fig. 3. Fungal structure with microthyrioid fruitbodies in various stages of development (*Trichothyrium fimbriatum* Speg., × 270; drawing after Arnaud, 1918, pl. 26).

host tissue during the process of sedimentation, have been found in the fossil state and described under various names by many palynologists. In this study the non-circular, lobed microthyrioid structures, in Jamaica as yet not found as complete individual fossils, have been omitted.

It was Kirchheimer (1942) who fervently argued in favour of a distinction between two groups of fossils as first postulated by Köck (1939): 1) those structures without an ostiole but with pores in the upper wall of the radial and central cells (Figs 7 - 9), which he referred to the Trentepohliaceae (Algae), most likely to the genus *Phycopeltis;* 2) those structures with an ostiole (Figs. 12, 13) but without pores in the upper wall, which according to Kirchheimer should be referred to the Microthyriales and other groups of fungi. (The taxonomic position of those types without pores or ostiole would remain questionable).

Kirchheimer specifically stated (p. 191) that as yet no thalli of *Phycopeltis* (partly) made of chitine-like walls have been observed: according to him the known extant species all have upper walls consisting of cellulose, a substance that will not fossilize under normal conditions of sedimentation.

After Kirchheimer several authors discussed and sometimes agreed with the idea of an algal origin for the first group of fossil remains. However, in 1965 Dilcher restored the old concept that all fossil microthyrioid structures should be placed in the fungi, not in the algae. His objections against the algal origin comprise (1) the absence of more or less globose gametangial cells in the stroma (the holes found by Kirchheimer remain an uncertain factor; Figs. 10, 11), and (2) Kirchheimer's own argument concerning the character of the wall material. Dilcher (1965, p. 23) also mentions the supporting opinions of Chaves Batista and R. Thompson; the latter was said to be engaged in monographing the genus *Phycopeltis,* but unfortunately this monograph could not be consulted as yet by the author. Although from Dilcher's remarks it may be concluded that without doubt Thompson did not encounter any living *Phycopeltis* closely resembling the fossil

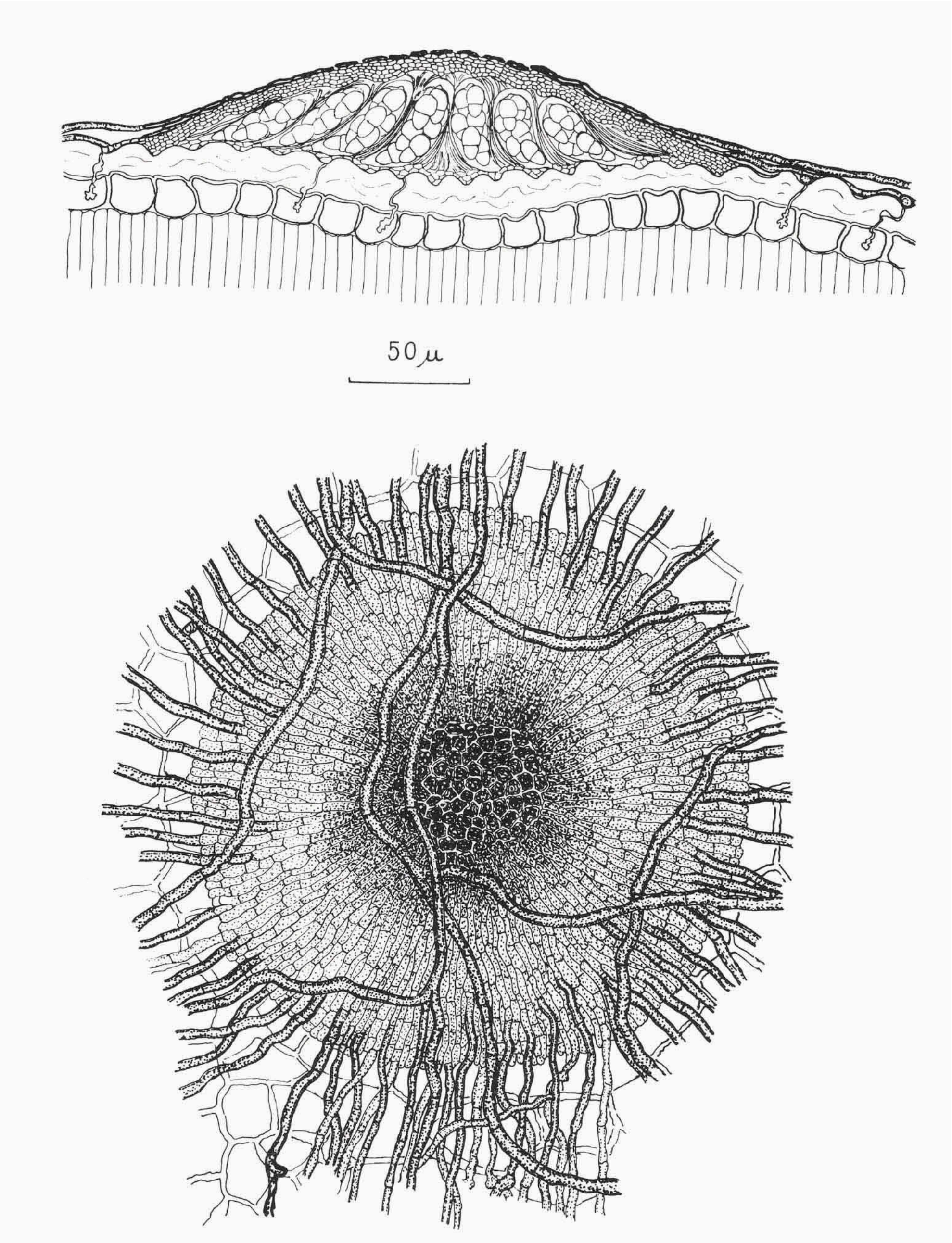


Fig. 4. Fungal hyphae spreading from a fruitbody *(Calothyriopsis conferta* (Theissen) von Höhnel; after Müller & von Arx, 1962, f. 210).

microthyrioid structures, this in itself does not fully prove the fungal origin of these fossils, although already in 1953 — apparently unknown to Dilcher — Gerdemann published his discovery of a fungus with pores in the upper wall of the central and radial cells, named *Leptodiscus terrestris,* well-illustrated in 1960 by McVey & Gerdemann (Fig. 7). On the other hand, Good & Chapman (1978) subjected the wall material to chemical and spectro-photometric analyses, as a

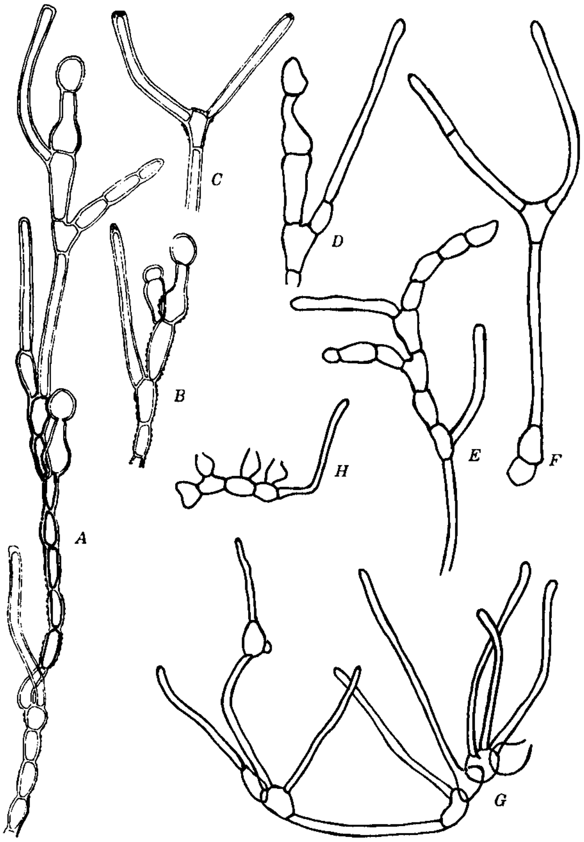


Fig. 5. Hyphae-like cell-strings in the thallus of epiphytic algae (A - F: *Trentepohlia prolifera* de Wildem., × 400; G - H: *Trentepohlia bogoriensis* de Wildem., × 400; after Printz, 1939, pl. 18).

result of which they found that the wall material of *Phycopeltis epiphyton* did not consist of cellulose, chitin, or lignin, but reacted chemically and physically like sporopollenin. This would make fossilization of *Phycopeltis* possible, and actually supports the idea of Kirchheimer that some fossil microthyrioid structures could be of algal origin.

Maas Geesteranus (Rijksherbarium, Leiden) suggested that a search be made for equivalent structures in the Lichenes. Santesson (1952, p. 23) mentions that of the symbiotic algae of the obligately foliicolous lichens, Trentepohliaceae occur in 109 lichen species (46.2 %). He states (op. cit., p. 24) that of this group in 81 lichen species (34.4 %) the algae appear to be identifiable as *Phycopeltis,* in 14 lichen species (5.9%) as *Trentepohlia,* and in another 14 lichen species (5.9%) as *Cephaleuros.* Apparently the Trentepohliaceae and in particular *Phycopeltis* have been quite successful in meeting the requirements of symbiosis with fungi. There is no reason to believe that this was not the case during the Tertiary. An epiphytic lichen structure in the fossil state therefore also may consist of an algal thallus attached to the host leaf by fungal hyphae, thus very much resembling a microthyriaceous fruitbody, as the chlorophyll, of course, will have been lost.

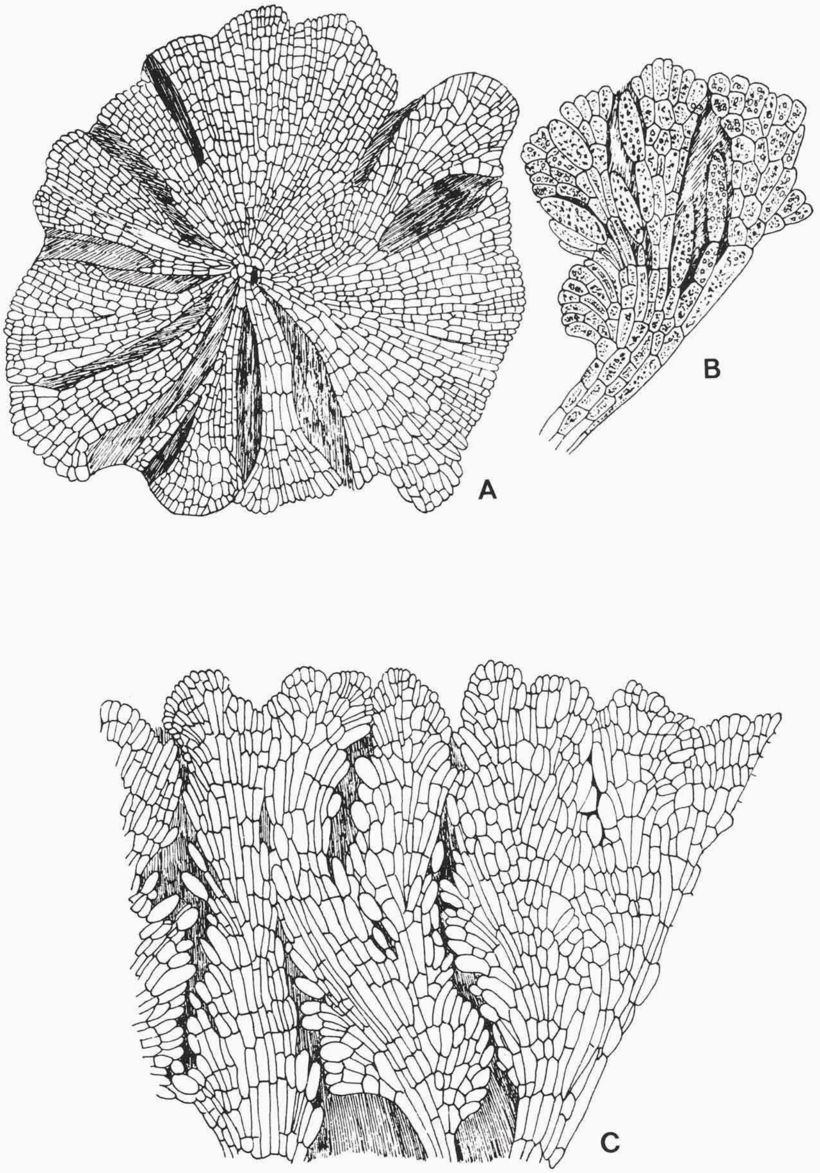


Fig. 6. Algal cell growth tending towards microthyrioid structures (A, B: *Phycopeltis aurea* Karsten, A × 150, B × 250; C: *Phycopeltis Treubii* Karsten, × 100; after Printz, 1939, pls. 21, 20, = after Karsten, 1891).

Even in Recent material errors in identifaction of the larger taxon have been made. Stevens & Manter (1925, p. 286) have drawn attention to the genus *Eremothecella* Sydow which von Höhnel (1918) found to be a lichen, later identified by Zahlbruckner as *Arthoniopsis*. This is a subgenus of *Arthonia* Ach. in which genus the symbiotic alga most frequently appears to be a *Phycopeltis* (Santesson, 1952, p. 68 - 91). As the matter, so far, is not exhaustively investigated, further study will be necessary.

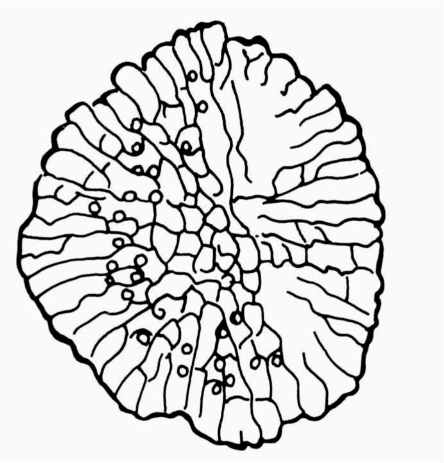


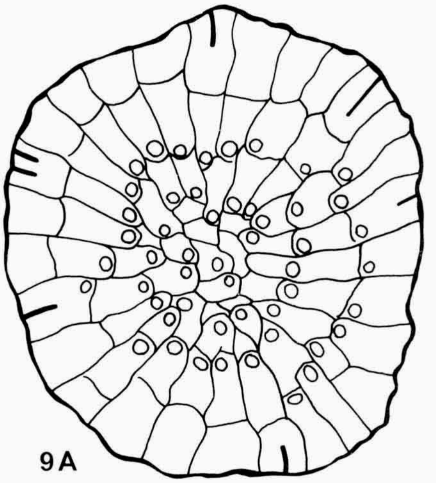
Fig. 7. The pores in the fruitbody of a fungus serve as an exit for the spores (*Leptodiscus terrestris* Gerdemann, 1953, × 450; drawing after McVey & Gerdemann, 1960, f. 14).

With the data available at present it appears possible to provide a list of relevant genera of fungi and algae, both extant and fossil (Table 1). In this list the less conspicuous, questionable group of microthyrioid structures without pores and without ostiole is incorporated. No doubt many of its species should be considered juvenile specimens, as it is known that the ostiole in fungal fruitbodies is formed at maturity. No such a mature condition is known to exist in *Phycopeltis* as regards the appearance of pores in the upper wall of the radial cells. As these pores serve as an exit for the gametes, a mature condition may be assumed to be present.

Apart from the major problem whether a fossil is an alga or a fungus, there is the question of the validity of the relationship of the various genera and species with microthyrioid structures. For the distinction of the extant taxa it appears that use is made principally of biological criteria such as growth, reproductive processes, and host relationship, phenomena that generally cannot be observed in or reconstructed from (isolated) fossils (Cookson, 1947, p. 208). It

Table 1. List of relevant genera of extant and fossil fungi and algae.

	Recent	Fossil
Group A	*Phycopeltis* *Leptodiscus* *Mycoleptodiscus*	*Callimothallus* *Cribrites*
Group B	*Asterina* *Microthyriella* *Microthyriolum* *Plochmopeltidella*	*Asterothyrites* *Microthyriacites* *Microthyrites* *Phragmothyrites*
Group C	*Actinopelte* *Asterina* *Ferrarisia* *Haplopeltis* *Leptothyrium* *Manginula* *Microthyrium* *Parasterina* *Stomiopeltis* *Trichopeltina* *Vizella*	*Asterothyrites* *Brefeldiellites* *Dictyotopileos* *Entopeltacites* *Mariusia* *Microthallites* *Notothyrites* *Plochmopeltinites* *Shortensis* *Stomiopeltites* *Trichothyrites*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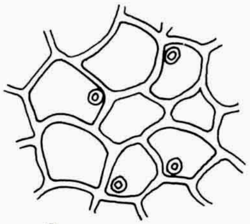
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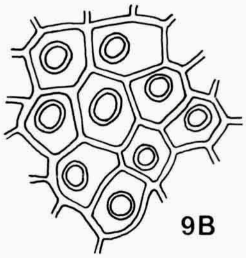
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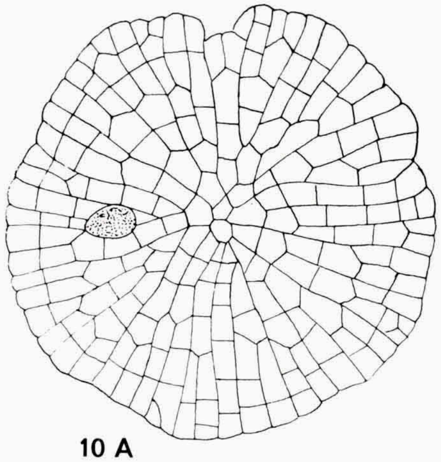
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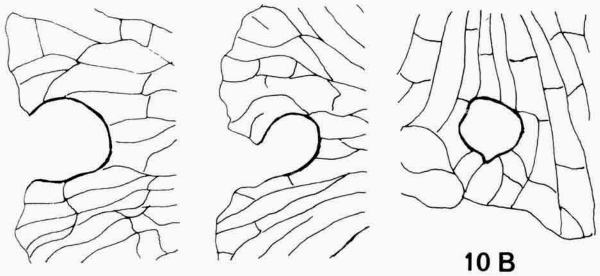
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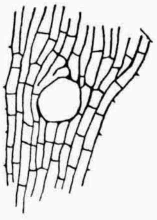
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Fig. 8. The pores in the gametangial cells of algal thalli function as an exit for the gametes *(Phycopeltis epiphyton* Millardet, × 500; drawing after Millardet, 1870, f. 31).

Fig. 9. Some fossil microthyrioid structures have pores that resemble those of fungal fruit-bodies or algal thalli (A: *Callimothallus pertusus* Dilcher, × 1000, drawing after Dilcher, 1965, pl. 6, f. 44; B: *Microthyriella fungosa* Dilcher, × 1000, drawing of a few enlarged cells after Dilcher, 1965, pl. 15, f. 120).

Fig. 10. The decay of the wall of gametangial cells (A) in algae may result, after Kirchheimer, in gametangial holes (B). (A: *Phycopeltis arundinacea* (Mont.) de Toni, × 300, after Printz, 1939, pl. 19; B: *Phycopeltis microthyrioides* Kirchh., × 600, drawing after Kirchheimer, 1942, f. 8).

Fig. 11. Holes resembling the gametangial holes of Kirchheimer may be formed when during the growth of a fungal thallus an obstacle is met *(Trichopeltis reptans,* its thallus grows around a circular trichome, × 500; after Stevens, 1925, f. 17e).

is therefore unknown whether or not asci or conidiophores occurred under the shield, whether or not paraphyses existed, whether or not asci, during the process of ripening, were elongated towards the ostiole to release their spores. Also unknown is which layers existed below the shield and what functions they had. The assumed relationship with an extant genus has occasionally been indicated by replacing the last few letters of the name of the recent genus (-um, -a) by the suffix -ites. There are no reasons to expect that in time all these assumptions will prove to be correct. In a few cases the exclusively morphological features combined with the physico-chemical properties of the wall material, examined by the chemical and spectro-photometric analyses of Good & Chapman and by the fluorescence analysis of van Gijzel, may be helpful to distinguish between the fossil groups and to recognize the relationship with the recent taxa.

For isolated circular microthyrioid structures, features like the shape of the ostiole and of the cells surrounding the ostiole, the position and characteristics of the pores in the upper wall of the radial cells, the presence of one or more cell layers, the straight, undulating, or curved walls of the radial cells (Fig. 15), and the features of the margin may be of diagnostic value (Figs. 16 - 18). It seems likely that the lamellae perpendicularly attached to the outer wall of the marginal cells (Figs. 9A, 10A, 12A, 15A, 19) are an indication of a state of growth (although in *Microthyrium maculicolum* Doidge the lamellae occur halfway the centre and the margin), but it remains uncertain whether or not this feature has any value for the identification of the taxa. As yet it seems difficult to give more weight to any of these characteristics above the others, in order to establish a system of closer or farther relationship of the basic taxa. Any attempt in this direction should be regarded as hazardous, although it will appear to be practical and necessary for further investigation.

The following morphological subdivision of isolated circular microthyrioid structures therefore should be considered as a provisional classification:

A Porate, non-ostiolate (perhaps fungi, algae and lichens)
  I Pores proximal (Figs. 7, 8, 9A) — most types
  II Pores central (Fig. 9B) — *Cribrites aurea, Microthyriella fungosa, Microthyriacites* types 1 and ?2 of Sen, 1966, *Phycopeltis epiphyton*
  III Pores distal — not yet observed
B Non-porate, non-ostiolate (very common, often juvenile specimens)
C Ostiolate, non-porate (probably all fungi)
  I With one central ostiole only (Figs. 12 - 13) — most types
  II With one central ostiole surrounded by secondary ostioles (Fig. 14) — *Microthyriella hibisci.*

Groups C I and C II could be subdivided perhaps as follows: 1) ostiole round (Fig. 12), 2) ostiole stellate or slit-shaped (Fig. 13).

A further subdivision is possible on the differences in marginal features (Figs. 3, 6A, 9A, 12, 15B, 16, 18), the distribution of thicker or thinner walls, the number of cell layers, the shape of the cells, and of the radial walls.

Note — Among the non-circular microthyrioid structures groups A, B and C also occur, e.g. *Phycopeltis expansa* and *Phycopeltis Treubii* belong to group A; *Trichothyrium reptans* and *Trichopeltinites fusilis* belong to group C.

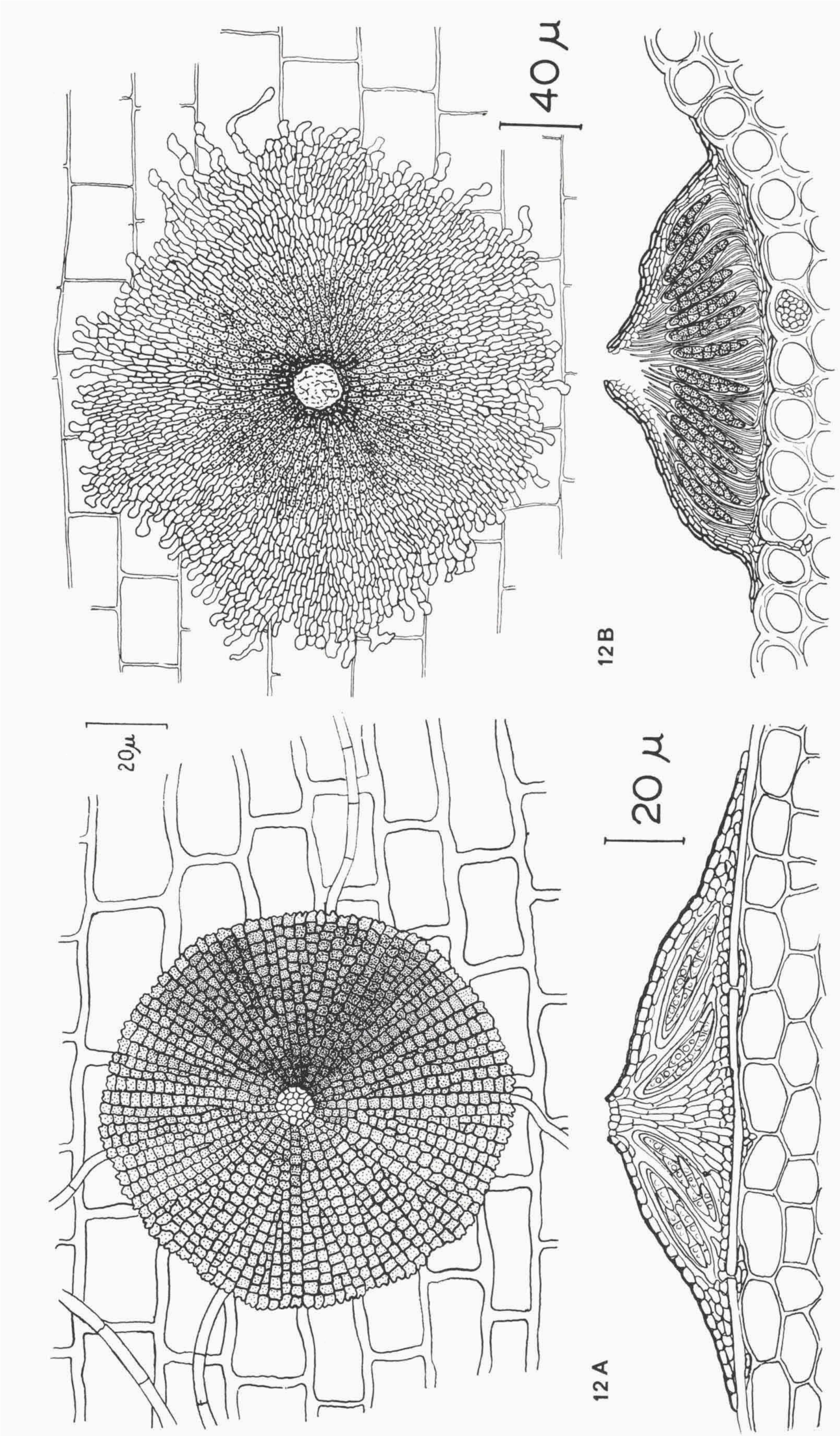


Fig. 12. The central ostiole of the fungal fruitbody functions as an exit for the spores (A: *Microthyrium microscopicum* Desm., after Müller & von Arx, 1962, f. 203, 204; B: *Arnaudiella genistae* (Fuck.) E. Müller, after Müller & von Arx, 1962, f. 206).

Table 2A. Porate microthyrioid structures found in the Tertiary of Jamaica.

central part thick-walled, thin-walled around	outer margin with lamellae	cells near margin rather long	distinct annuli around pores	type JAM. 2003
central part thin-walled, thick-walled around	outer margin not preserved	cells near margin short	no annuli around pores	type JAM. 2100
central part thin-walled, thick(er)-walled around	outer margin without lamellae	cells near margin short except a few	annuli around pores	type JAM. 2008
thick-walled throughout	outer margin without lamellae	cells near margin short	distinct annuli around pores	type JAM. 2042
thin-walled throughout	outer margin with long lamellae	cells near margin long	distinct annuli around pores	type JAM. 2010
thin-walled throughout	outer margin without lamellae	cells near margin long	indistinct annuli around pores	type JAM. 2040

Table 2B. Non-porate, non-ostiolate microthyrioid structures found in the Tertiary of Jamaica.

central part thick-walled, thin-walled around	outer margin with lamellae	cells near margin long	type JAM. 2011
thin-walled throughout	outer margin with long lamellae	cells near margin rather long	type JAM. 2007
thin-walled throughout	outer margin with long lamellae	cells near margin very long	type JAM. 2044

Table 3A. Comparison of the Jamaican types of group A with species described in the literature.

Comparison with the fossil species described in the literature, belonging morphologically to group A I:

Callimothallus australis Lange, 1978, (Eocene, Australia) is circular but not centro-symmetrical. Not comparable with any Jamaican type.
Callimothallus pertusus Dilcher, 1965 (Eocene, USA) resembles types JAM. 2003, 2008, 2042 and 2100, and only slightly type JAM. 2010.
Callimothallus pertusus Dilcher, 1965, in: Selkirk, 1975 (Lower Miocene, N.S.W., Australia); fig. 1 resembles type JAM. 2010.
Callimothallus pertusus Dilcher, 1965, in: Lange, 1978 (Eocene, Australia), the specimens are circular but not centro-symmetrical.
Microthyriacites sahnii Rao, 1958 (Miocene, India), central part more than one cell-layer thick.
Microthyriella fungosa Dilcher, 1965, in: Lange, 1978 (Eocene, Australia), juvenile specimens with radial cells not elongated and less proximal position of pores.
Phycopeltis microthyrioides Kirchheimer, 1942 (Oligocene, Germany) resembles types JAM. 2003, 2008, 2042 and 2100, and only slightly type JAM. 2010, but none of these types have the gametangial holes as seen in many but not all of Kirchheimer's specimens.

Comparison with one extant species described in the literature, belonging morphologically to group A I:

Leptodiscus terrestris Gerdemann, 1953 = *Mycoleptodiscus terrestris* (Gerdemann, 1953) (Recent, Australia), cells more rounded at their distal ends than in any Jamaican type.

Comparison with the fossil species described in the literature, belonging morphologically to group A II:

Cribrites aurea Lange, 1978 (Eocene, Australia), with large pores perforating shield entirely; cells not so much radially arranged, neither elongated.
Microthyriacites sp. type 1 Sen, 1966 (Eocene, India) pores in the centres of the cells.
Microthyriacites sp. type 2 Sen, 1966 (Eocene, India) pores in the centres of the cells, but not so distinct as in type 1.

Comparison with some extant species described in the literature, belonging morphologically to group A II:

?*Microthyriella fungosa* Dilcher, 1965, in: Lange, 1978, juv. spec. fig. 39 (Eocene, Australia) pores distinctly not located at the proximal end of the cells.
Phycopeltis epiphyton Millardet, 1870 (Recent, Germany); fig. 31 especially shows that the position of the pores is irregular and only one pore appears proximally located; if any fossil resembles this recent alga-species it is *Microthyriella fungosa* Dilcher, 1965, pl. 15, 118 - 120, especially f. 120.
Phycopeltis epiphyton Millardet, 1870, in: Printz, 1939 (Recent, pan-tropical), pores not clearly illustrated; slightly resembles type JAM. 2040.
Phycopeltis epiphyton Millardet, 1870, in: Good & Chapman, 1978 (Recent, pan-tropical), fig. 7 shows — by acetolysis — corroded and bleakened central part bordered by thick-walled marginal cells.

Table 3B. Comparison of the Jamaican types of group B with species described in the literature.

Comparison with the fossil species described in the literature, belonging morphologically to group B:

Asterina eocenica Dilcher, 1965 (Eocene, USA) resembles type JAM. 2011.
Asterothyrites delicatissimus Cookson, 1947 (?Oligocene-Miocene, Australia) slightly resembles type JAM. 2011, but Cookson's species has no entire marginal wall as it passes into the surrounding hyphal tissue(?).
Asterothyrites minutus Cookson, 1947 (?Oligocene-Miocene, Australia), resembles type JAM. 2011.

Asterothyrites sinuatus Cookson, 1947 (?Oligocene-Miocene, Australia), slightly resembles type JAM. 2011, but Cookson's species has an irregular outer margin.
Entopeltacites irregularis Selkirk, 1972 (Lower Miocene, N.S.W., Australia) resembles type JAM. 2008, but Selkirk's species has no pores.
Microthyriacites baqueroensis Martinez, 1967 (Lower Cretaceous, Argentine) has very long radial cells.
Microthyriacites cooksoni Rao, 1958 (Eocene and Miocene, India) resembles type JAM. 2011, but Rao's species has a more conspicuous central portion of compact cells (Rao, p. 45).
Microthyriacites edwardsi Rao, 1958 (Miocene, India) resembles type JAM. 2044.
Microthyriacites fimbriatus Cookson, 1947 (Oligocene-Miocene, Australia) resembles type JAM. 2011.
Microthyriacites grandis Cookson, 1947 (?Oligocene, Australia) has a rather thick-walled appearance.
Microthyriacites sp.*(?grandis)* Cookson, 1947, pl. 13, f. 18, 19 (?Oligocene-Miocene, Australia) is rather thick-walled.
Microthyrites dysodilis Pampaloni, 1902 (Miocene, Italy) is rather poorly illustrated.
Pediastrum sp. in: Davis, 1916 (Eocene, USA), a ?juvenile specimen.
Phragmothyrites delicatus Selkirk, 1975 (Lower Miocene, N.S.W., Australia) slightly resembles type JAM. 2011, but Selkirk's species is thin-walled with less slender marginal cells.
Phragmothyrites eocenica Edwards, 1923 (Eocene, Scotland, UK) slightly resembles types JAM. 2008 and 2009, but Edwards' species has less elongated radial cells.
Phragmothyrites cf. *fimbriatus* Cookson, 1947, in: Selkirk, 1975 (Lower Miocene, N.S.W., Australia).
Phragmothyrites hibernicus Johnson, 1941 (Lower Tertiary, Ireland) with air-hyphae and intercellular mycelium.
Phragmothyrites kiandrensis Selkirk, 1975 (Lower Miocene, N.S.W., Australia) resembles type JAM. 2010, but Selkirk's species has no pores.
Plochmopeltidella antiqua Dilcher, 1965 (Eocene, USA) is endoparasitic and has strongly undulating radial walls and an irregular outer margin.

Comparison with some extant species described in the literature, belonging morphologically to group B:
Calothyriopsis conferta (Theissen) von Höhnel, 1919, in: Müller & von Arx, 1962 (Recent, tropical America) with long hyphae extending from the margin.
Cirsosiella globulifera (Pat.) Arnaud, 1918 (Recent, SE Asia) outer margin with extending radial cells.
Lembosia bromeliacearum Rehm, 1900, in: Arnaud, 1918 (Recent, South America) has a margin with acuminate extensions.
Lembosia rubiacearum Arnaud, 1918 (Recent, South America) has a margin with acuminate extensions.
Manginulopsis lunariae Chaves Batista & Peres, 1963 (Recent, Brasil) with hardly elongated radial cells.
Microthyrium maculicolum Doidge, 1942 (Recent, South Africa) with straight radial walls and lamellae not at outer margin; slightly resembling types JAM. 2008 and 2010.
Microthyrium ranulisporum Doidge, 1942 (Recent, South Africa) outer margin with extending radial cells, radial walls undulating.
Palawaniella orbiculata = *Seynesia orbiculata* Doidge, 1942 (Recent, South Africa) with undulating radial walls, and lamellae at outer margin.
Phycopeltis aurea Karsten, 1891, in: Printz, 1939 (Recent, SE Asia) has a circular shield composed of fan-shaped segments.
Phycopeltis expansa Jennings, 1896, in: Schmidle, 1897 (Recent, New Zealand) is circular, but not centro-symmetrical.
Prillieuxina winteriana (Pazschke) Arnaud, 1918 (Recent, Brasil) has extending radial cells and straight radial walls.
Seynesiella juniperi (Desm.) Arnaud, 1918 (Recent, Europe) is very dark.

The microthyrioid types found in Jamaica may be related to, but are not necessarily identical with, the following fossil and/or extant species:

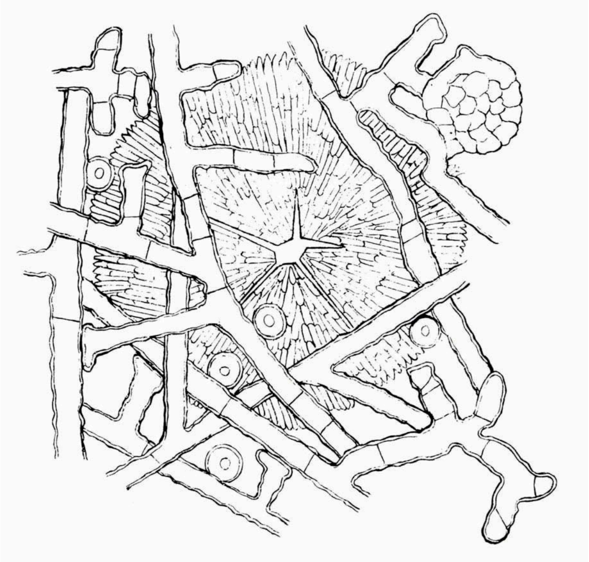


Fig. 13. The exit of the fruit-bodies of the Asterinaceae is generally stellate or slit-shaped (*Asterina camelliae* Sydow & Butler, × 250; after Sydow & Butler, 1911, pl. 17, f. 2).

Types JAM. 2003, 2008, 2042 and 2100
Callimothallus pertusus Dilcher, 1965 — from the Eocene of Tennessee, USA; or ?*Phycopeltis microthyrioides* Kirchheimer, 1942 — from the Oligocene of Germany (gametangial holes are lacking in the Jamaican types).

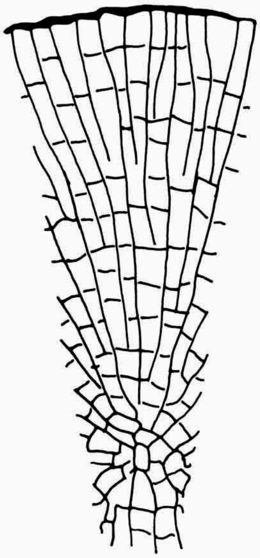
Type JAM. 2010
Callimothallus pertusus Dilcher, 1965, in: Selkirk, 1975, pl. 6, f. 1 — from the Lower Miocene of Kiandra, N.S.W., Australia.

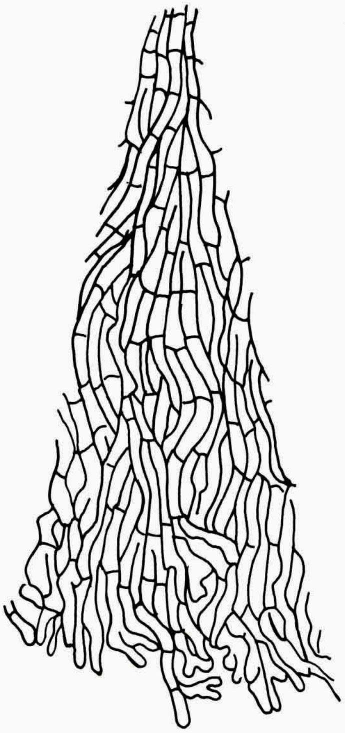
Type JAM. 2011
Asterothyrites minutus Cookson, 1947 — from the ?Oligocene-Miocene of Kiandra, N.S.W., Australia;
or *Microthyriacites cooksoni* Rao, 1958 — from the Miocene of Palana and south Arcot, India;
or *Microthyriacites fimbriatus* Cookson, 1947 — from the Oligocene-Miocene of Traralgon, east of Yallourn, Australia;
or ?*Phragmothyrites delicatus* Selkirk, 1975 — from the Lower Miocene of Kiandra, N.S.W., Australia.

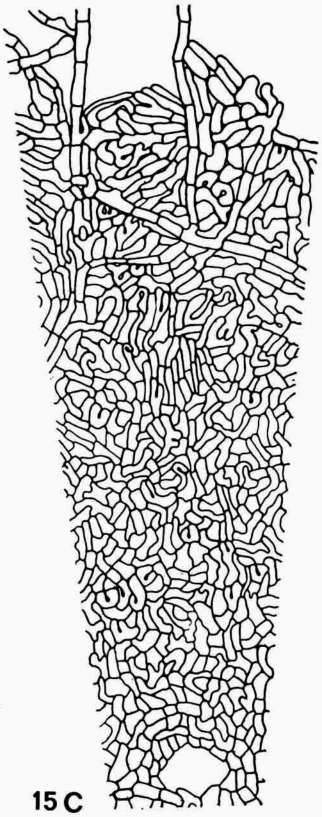
Type JAM. 2040
Phycopeltis epiphyton Millardet, 1870, in: Printz, 1939 — Recent, pan-tropical.

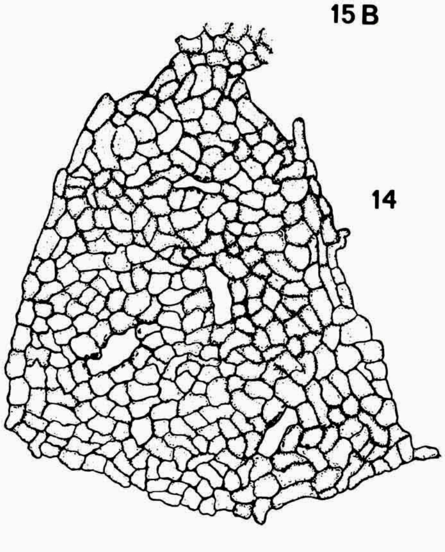
Type JAM. 2044
Microthyriacites edwardsi Rao, 1958 — from the Miocene of India.

Thus, the types found in Jamaica are to be placed in two groups:
A1) characterized by proximally located pores in the upper wall of the cells, types JAM. 2003, 2008, 2010, 2040, 2042, and 2100;
B) defined by the absence of such pores and by the absence of a central ostiole, types JAM. 2007, 2011, and 2044 (as type 2007 is an incomplete specimen it may belong to a non-centro-symmetrical taxon).









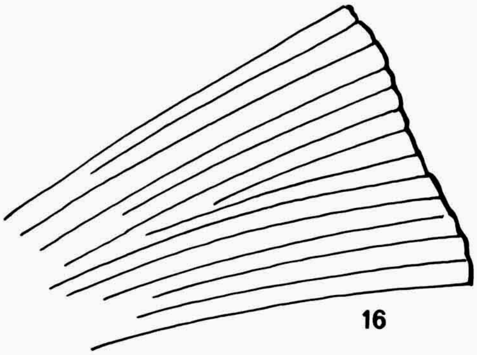


Fig. 14. Secondary ostioles have been observed in one fungus species, *Microthyriella hibisci* Stevens (× 700, after Stevens, 1925, f. 20). This is an a-typical feature of the genus *Microthyriella.*

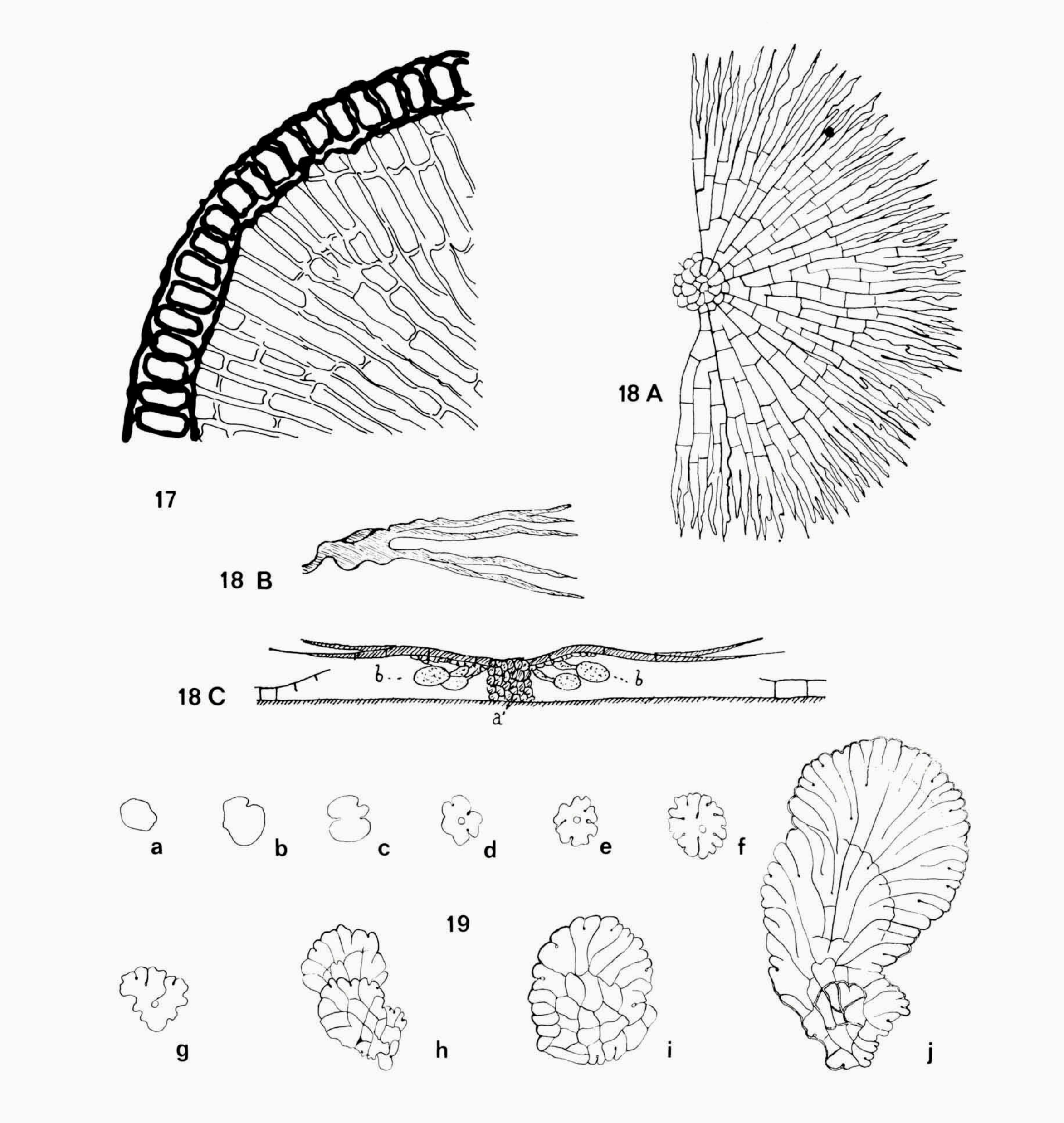
Fig. 15. Radial walls in microthyrioid structures may be (A) straight, (B) undulating, or (C) strongly curved (A: *Microthyrium maculicolum* Doidge, 1920, × 700, drawing after Doidge, 1942, pl. 3, f. b; B: *Microthyrium ranulisporum* Doidge, 1927, × 700, drawing after Doidge, 1942, pl. 3, f. a; C: *Stomiopeltis,* × 700, after Luttrel, 1946, f. 12).

Fig. 16. Marginal cells may be short as in *Microthyrium maculicolum* Doidge, 1920 (see Fig. 15), or very long, as in *Microthyriacites bacqueroensis* Martinez, × 150 (drawing after f. 3 of Martinez, 1968, pl. 1).

Morphological descriptions

Type JAM. 2003 (Pl. 1, figs. 1, 2)

?Fungal fruitbody, a subcircular shield, almost centro-symmetrical, 75 μm in diameter; with annulate pores at proximal end in the upper wall of almost all radial cells, absent in the central cells; pores 0.5 - 1 μm in diameter, annulus 0.3 μm thick; cells varying from 3 × 3μm in the centre to 15 × 4 μm near the margin; walls in centre 0.8 μm thick; 0 - 3 radial lamellae per marginal cell attached to the outer wall; lamellae 2 - 5 μm long, 0.5 - 1 μm thick; no gametangial cells or corresponding holes sensu Kirchheimer.



From the Lower Eocene part of the Richmond Formation at Sandside, locality JHG-188; also observed in comparable strata at Fruitful Vale, locality JHG-103; and in the Middle or Upper Eocene Yellow Limestone Formation at Rio Nuevo, locality JHG-420, and in the same formation of the White River section, locality JHG-148.

Type JAM. 2100 (Pl. 1, fig. 3)

?Fungal fruitbody, a subcircular shield, almost centro-symmetrical, 55 μm in diameter; with pores without annuli in the upper wall of almost all cells, also in the central cells; position of the pores distinctly proximal in the radial cells at some distance from the centre; pores 1.5 - 2 μm in diameter; cells varying from 3 × 4 μm in the centre to 7 × 3 μm near the margin; walls in the centre 0.5 μm thick; radial and tangential walls near the margin 1 μm thick; radial lamellae attached to the outer wall of marginal cells unknown as true mature margin is probably absent; no gametangial cells or corresponding holes sensu Kirchheimer.

From the Middle or Upper Eocene Yellow Limestone Formation at Rio Nuevo, locality JHG-420; also observed in the Lower Eocene part of the Richmond Formation in Hills River, locality JHG-362.

Type JAM. 2008 (Pl. 2, fig. 2)

?Fungal fruitbody, a subcircular shield, almost centro-symmetrical, 55 μm in diameter; pores proximally located in the upper wall of many radial cells; pores 1 - 1.5 μm in diameter, annulus 0.5 μm thick; cells varying from 2 × 2 μm in the centre, to 5 × 3 μm at the margin, a few cells elongated to 10 × 2 μm; walls of central cells 0.5 μm thick, walls of marginal cells distinctly thicker, about 0.8 - 1 μm; no lamellae; no gametangial cells or corresponding holes sensu Kirchheimer.

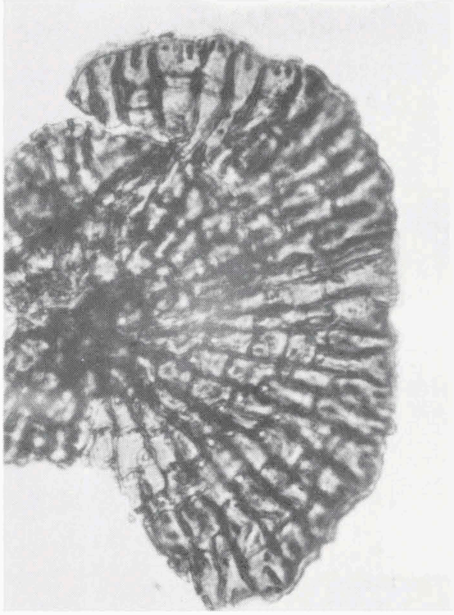
From the Lower Eocene part of the Richmond Formation near Fruitful Vale, locality JHG-103.

Fig. 17. After acetolysis of thalli of *Phycopeltis epiphyton* Millardet the marginal cells appeared well-preserved in sharp contrast with the more inward radial cells, probably owing to different wall material (drawing after Good & Chapman, 1978, f. 7; × 700). Fossilization of thalli of *Phycopeltis* might have had comparable results; in case the interior part is not well-preserved the remnants will superficially resemble the remains of a fern sporanguim like type JAM. 2009.

Fig. 18. The margin of the thallus of *Actinopelte japonica* Saccardo is strongly ornate with long extensions of the marginal cells (× 400, after Theissen, 1913, f. 6). Other types of margins are (sub)fimbriate like in *Microthyrium ranulisporum* Doidge, 1927 (see Fig. 15B), irregular as in *Arnaudiella genistae* (Fuck.) E. Müller (see Fig. 12B), crenulate as in *Microthyrium microscopicum* Desm. (see Fig. 12A), lobed as in *Phycopeltis aurea* Karsten (see Fig. 6A), or simply smooth as in *Trichothyrium fimbriatum* Speg. (see Fig. 3) and in *Callimothallus pertusus* Dilcher (see Fig. 9A).

Fig. 19. Lamellae perpendicular to the outer margin are common in young specimens and characteristic for a growth stage as illustrated in *Phycopeltis sp.* (× 700, after Köck, 1939, pl. 3, f. 1 - 10). In some species like *Callimothallus pertusus* Dilcher (see Fig. 9A) these lamellae are frequent at the margin. In *Microthyrium maculicolum* Doidge (see Fig. 15A) these lamellae have been observed in cells at a certain distance from the margin. Many species show no lamellae at all, e.g. *Phycopeltis arundinacea* (Mont.) de Toni (see Fig. 10A) and *Microthyrium microscopicum* Desm. (see Fig. 12A).

Plate 1



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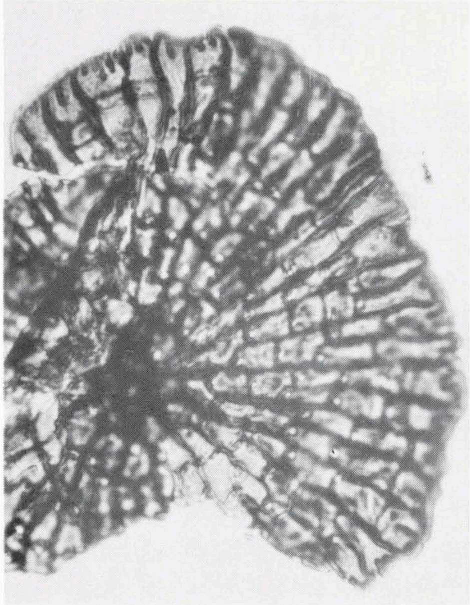

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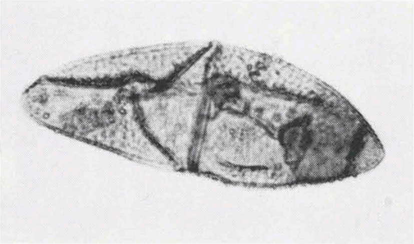

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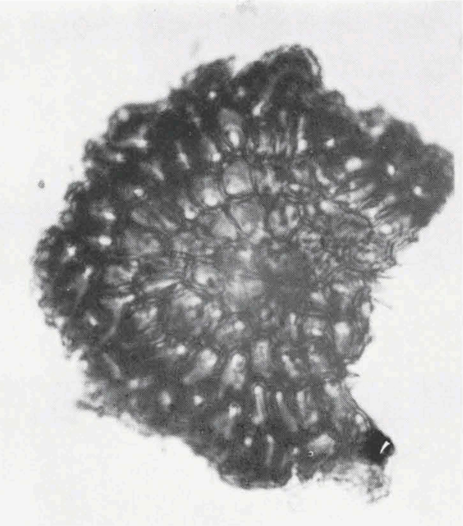

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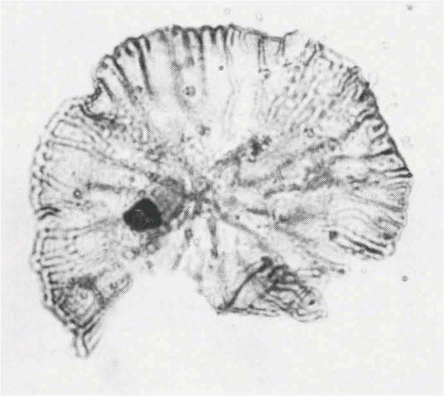

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Type JAM. 2042 (Pl. 3, figs. 1, 2)

?Fungal fruitbody, a subcircular shield, almost centro-symmetrical, 87 μm in diameter; with annulate pores in the upper wall of almost all cells, also in the central cells; position of the pores distinctly proximal in the radial cells; pores 1 - 1.5 μm in diameter; cells varying from 2 × 2 μm in the centre, to 5 × 4 μm near the margin; radial and tangential walls aways about 1.5 μm thick; no radial lamellae observed where the outer margin is well preserved; no gametangial cells or corresponding holes sensu Kirchheimer.

From the Middle or Upper Eocene Yellow Limestone Formation at Rio Nuevo, locality JHG-419.

Type JAM. 2010 (Pl. 2, figs. 6,7)

?Fungal fruitbody, a subcircular shield, almost centro-symmetrical, 60 μm in diameter; with annulate pores at proximal end in upper wall of almost all cells except the marginal cells; pores 1 - 1.5 μm in diameter, annuli 0.5 μm thick; cells varying from 3 × 3 μm in the centre to 12 × 4 μm at the margin; walls everywhere 0.5 μm thick; 0 - 3 lamellae per marginal cell attached to the outer wall, lamellae 1 - 5 μm long, 0.5 μm thick; no gametangial cells or corresponding holes sensu Kirchheimer.

From the Middle Eocene part of the Richmond Formation at Langley, locality JHG-390; also observed in the Lower Eocene part of the same formation at Sandside, localities JHG-195, 196 and 197, and in the same strata at Fruitful Vale, localities JHG-102 and 108.

Type JAM. 2040 (Pl. 3, fig. 5)

?Fungal fruitbody, a subcircular shield, rather juvenile?, centro-symmetrical, 35 μm in diameter; with ?annulate pores in a few cells only, proximally located, 1 - 1.5 μm in diameter; cells in the small centre about 4 μm large, all cells around approximately radially arranged, 10 × 6 μm; radial and tangential walls curved,

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Plate 1

Figs.1, 2. Type JAM. 2003, from the Lower Eocene part of the Richmond Formation at Sandside, locality JHG-188, × 1000.

Fig. 3. Type JAM. 2100, from the Middle or Upper Eocene Yellow Limestone Formation at Rio Nuevo, locality JHG-420, × 1000.

Fig. 4. Type JAM. 2044, from the Middle or Upper Eocene Yellow Limestone Formation in Rio Nuevo, locality JHG-420, × 1000.

Fig. 5. Type JAM. 2068, from Upper Cretaceous strata in Rio Minho, East of Frankfield, Central Inlier, locality JHG-471, × 1000.

Fig. 6. Type JAM. 2013, from the Middle Eocene part of the Richmond Formation at Langley, locality JHG-390, × 1000.

Plate 2

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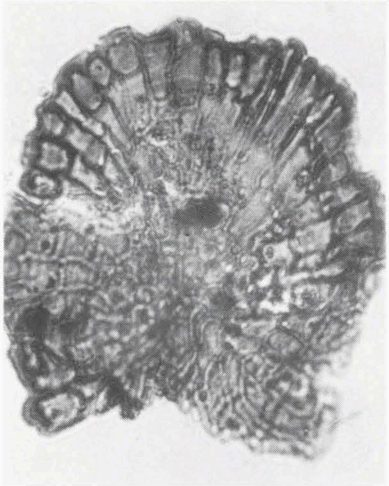

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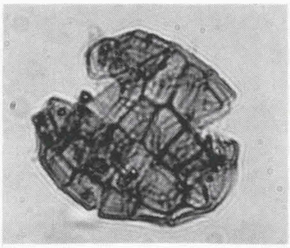

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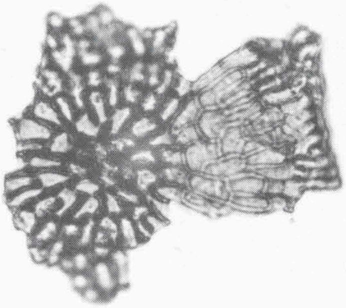

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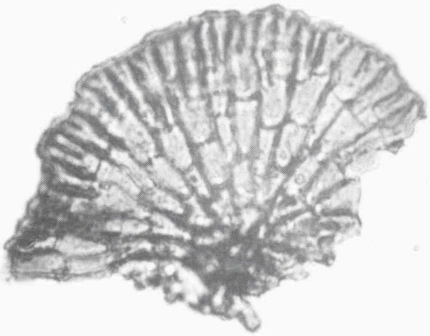

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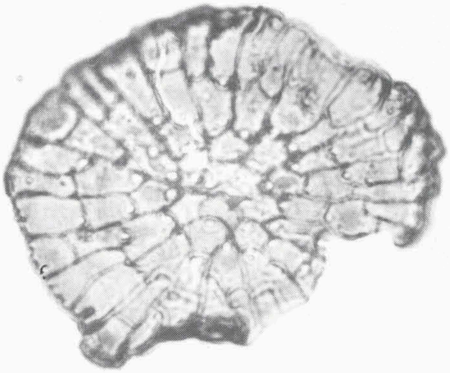

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about 0.5 μm thick; no lamellae at the outer margin; no gametangial cells or corresponding holes sensu Kirchheimer.

From the Lower Eocene part of the Richmond Formation in the Oracabessa River, locality JHG-408; only one specimen.

Type JAM. 2011 (Pl. 2, fig. 1)

?Fungal fruitbody, a circular shield, centro-symmetrical, 50 μm in diameter; no pores, no ostiole; cells varying from 3 × 3 μm in the centre to 12 × 4 μm at the margin; walls of central cells 1 μm thick, walls of cells at the margin 0.5 μm thick; margin smooth, with 0 - 1 lamella per marginal cell radially attached to the outer wall; lamellae 2 - 5 μm long, 0.5 μm thick; no gametangial cells or corresponding holes sensu Kirchheimer.

From the Middle Eocene part of the Richmond Formation at Langley, locality JHG-390.

Type JAM. 2007 (Pl. 2, figs. 4, 5)

?Fungal fruitbody, in the shape of a shield, probably centro-symmetrical, 88 μm in diameter; no pores; no ostiole; cells varying in size from 3 × 2 μm in the centre to 10 × 2 μm near the margin; walls in the centre about 1 μm thick, near the margin 0.5 μm thick; margin smooth, with 0 - 1 lamella per marginal cell radially attached to the outer wall, lamellae up to 6 μm long, 0.5 μm thick; no gametangial cells or corresponding holes sensu Kirchheimer.

From the Lower Eocene part of the Richmond Formation in Hills River, locality JHG-362; also observed in the Middle or Upper Eocene Yellow Limestone Formation in Rio Nuevo, locality JHG-420.

Plate 2

Fig. 1. Type JAM. 2011, from the Middle Eocene part of the Richmond Formation at Langley, locality JHG-390, × 1000.

Fig. 2. Type JAM. 2008, from the Lower Eocene part of the Richmond Formation near Fruitful Vale, locality JHG-103, × 1000.

Fig. 3. Type JAM. 2063, from Holocene strata at Bowden, locality JHG-592, × 1000.

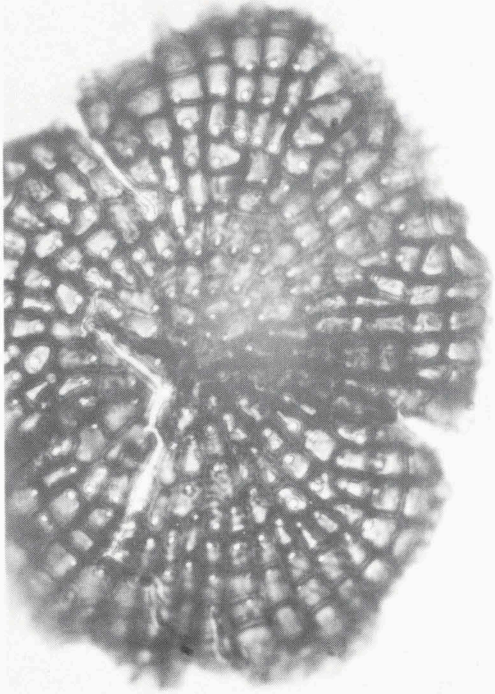
Fig. 4. Type JAM. 2007, from the Lower Eocene part of the Richmond Formation in Hills River, locality JHG-362, × 1000.

Fig. 5. Type JAM. 2007, from the Middle or Upper Eocene Yellow Limestone Formation at Rio Nuevo, locality JHG-420, × 1000.

Fig. 6. Type JAM. 2010, from the Middle Eocene part of the Richmond Formation at Langley, locality JHG-390, × 1000.

Fig. 7. Type JAM. 2010, from the Lower Eocene part of the Richmond Formation at Fruitful Vale, locality JHG-196, × 1000.

Plate 3



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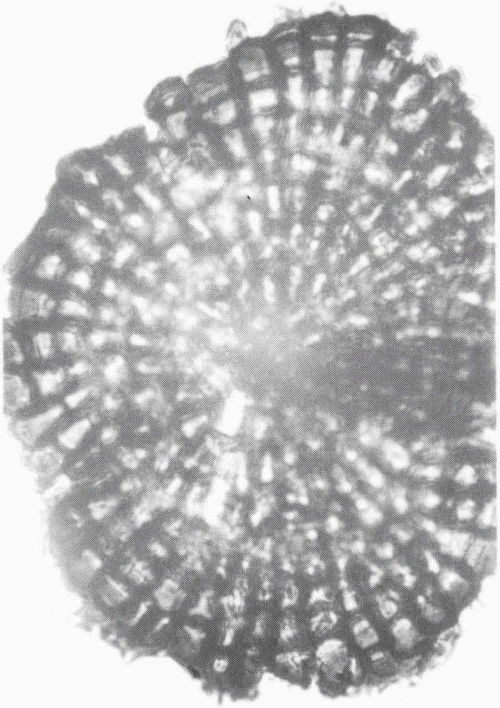

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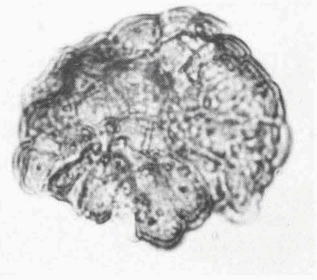

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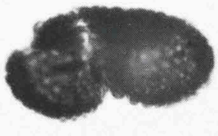

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Type JAM. 2044 (Pl. 1, fig. 4)

?Fungal fruitbody, a subcircular shield, almost centro-symmetrical, 48 μm in diameter; no pores; no ostiole; cells varying from 3 × 3 μm in the centre (a few only), tot 15 × 5 μm at the margin; all walls 0.5 μm thin; margin smooth, with 0 - 3 lamellae per marginal cell radially attached to the outer wall, lamellae 1 - 5 μm long, 0.5 μm thick; no gametangial cells or corresponding holes sensu Kirchheimer.

From the Middle or Upper Eocene Yellow Limestone Formation in Rio Nuevo, locality JHG-420.

NON-MICROTHYRIOID FUNGAL PERITHECIA

The two types observed in Jamaica are no doubt of fungal origin. Much more trouble gives the determination at the generic level, because so many extant taxa produce perithecia of similar shape but with different biological characteristics like growth, reproduction and host-relationship.

Type JAM. 2052 (Pl. 4, fig. 5)

Perithecium flattened by compression during the process of fossilization, originally probably globose or discoidal, 58 μm in diameter; ostiolate, the aperture about 20 μm in diameter, slightly protruding; wall 1.5 μm thick, consisting of ?interwoven hyphae which are about 1 μm in diameter; outer wall surface irregularly rugulate-reticulate.

Collected from the southern equivalent of the Buff Bay Formation (Miocene-Pliocene) at Arcadia, locality JHG-587.

Taxonomic-morphological relationships — Among the Fungi Imperfecti (Barnett & Hunter, 1972) many Sphaeropsidales produce comparable perithecia, as *Peyronellaea* (p. 168), *Coniothyrium* (p. 182), *Ascochyta* (p. 186). Also the Pseudosphaeriales (Müller & von Arx, 1962) provide many morphologically related forms, like *Otthia* (p. 273), *Microthelia* (p. 282), *Herpotrichia* (p. 302), *Coleroa*

Plate 3

Figs. 1, 2. Type JAM. 2042, from the Middle or Upper Eocene Yellow Limestone Formation at Rio Nuevo, locality JHG-419, × 1000.

Figs. 3, 4. Type JAM. 2009, from the Lower Eocene part of the Richmond Formation at Langley, locality JHG-281, × 1000.

Fig. 5. Type JAM. 2040, from the Lower Eocene part of the Richmond Formation in the Oracabessa River, locality JHG-408, × 1000.

Fig. 6. Type JAM. 2033, from the Lower Eocene part of the Richmond Formation at Sandside, locality JHG-188, × 1000.

Plate 4

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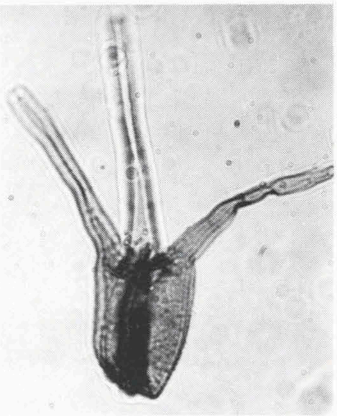

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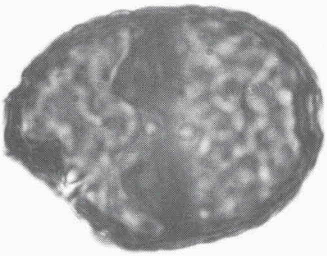

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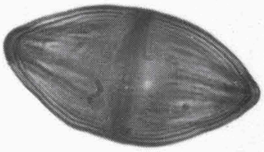

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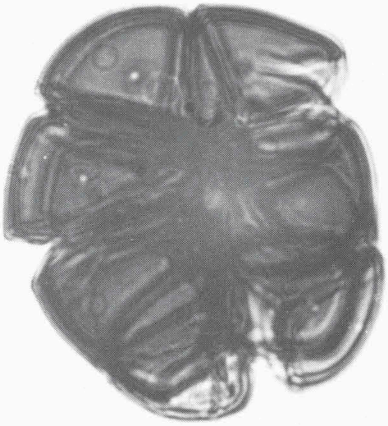

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(p. 413), *Botryostroma* (p. 462), *Lizonia* (p. 500). Among the Amphisphaeriaceae (Müller & von Arx, 1962) *Amphisphaeria* (p. 691). *Lilliputia gaillardi* Boud. & Pat., 1900, according to Hughes (1951, p. 21, pl. 1, f. 9) a synonym of *L. rufula* (Berk. & Broome, 1873), original name *Chaetomium rufulum,* shows a superficial resemblance to type JAM. 2052. Hughes states that the apex is composed of about three rows of coarse cells and that the ostiolum, if present, is very inconspicuous; moreover the size of *Lilliputia* (800 μm) is of a different order.

Type JAM. 2091 (Pl. 4, fig. 1)

Perithecium pear-shaped, largest diameter 176 μm; ostiolate, aperture about 15 μm in diameter (slightly damaged); wall consisting of interwoven hyphae, giving an irregular rugulate-reticulate impression; wall thickness 5 - 6 μm, hyphae less than 2 μm in diameter.

Collected from the Middle Eocene part of the Richmond Formation at Langley, locality JHG-377.

Taxonomic-morphological relationships — Some Sphaeropsidales of the Fungi Imperfecti (Barnett & Hunter, 1972) produce comparable structures as in *Phoma* (p. 166), *Phomopsis* (p. 168) and *Diplodia* (p. 186). Comparable perithecia are also produced by many Sphaeriaceae like *Chaetosphaeria, Ohleria* and *Melanomma* (Berlese, 1984, vol. I, genera-plate 9), and *Fenestella* (Berlese, 1984, vol. II, pl. 106 - 112). *Chaetosphaeria* (Müller & von Arx, 1962, p. 583, f. 231) has no hyphal structure but is composed of cells. Some resemblance shows *Gelasinospora calospora* (Mouton) C. & M. Moreau (Ellis, 1960; Maniotis, 1965, f. 1 - 8) but it has no ostiole and the perithecium is about 800 μm large.

Plate 4

Fig. 1. Type JAM. 2091, from the Middle Eocene part of the Richmond Formation, locality JHG-377, × 650.

Fig. 2. Type JAM. 2049, from the southern equivalent of the Buff Bay Formation (Miocene-Pliocene) at Arcadia, locality JHG-590, × 1000.

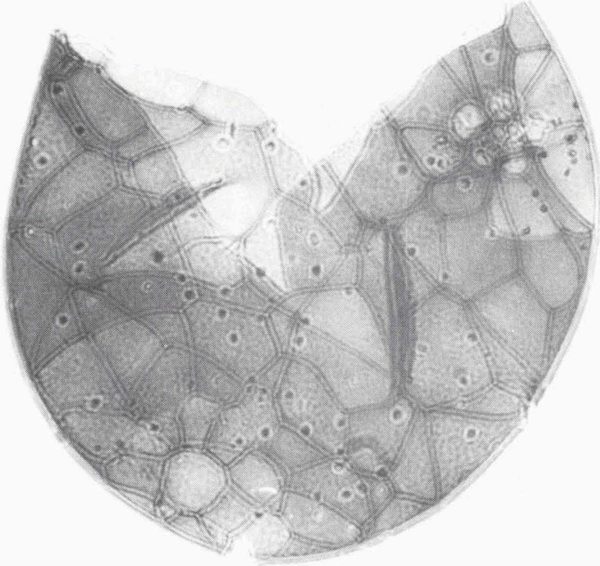
Fig. 3. Type JAM. 2048, from Holocene strata near Bowden, locality JHG-591, × 1000.

Fig. 4. Type JAM. 2025, from the Lower Eocene part of the Richmond Formation at Richmond, locality JHG-426, × 1000.

Fig. 5. Type JAM. 2052, from the southern equivalent of the Buff Bay Formation (Miocene-Pliocene) at Arcadia, locality JHG-587, × 1000.

Fig. 6. Type JAM. 2012, from Holocene strata near Bowden, locality JHG-591, × 1000.

Plate 5



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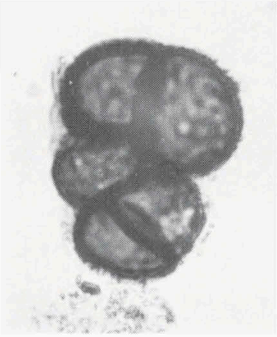

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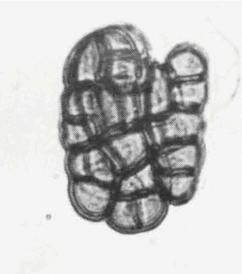

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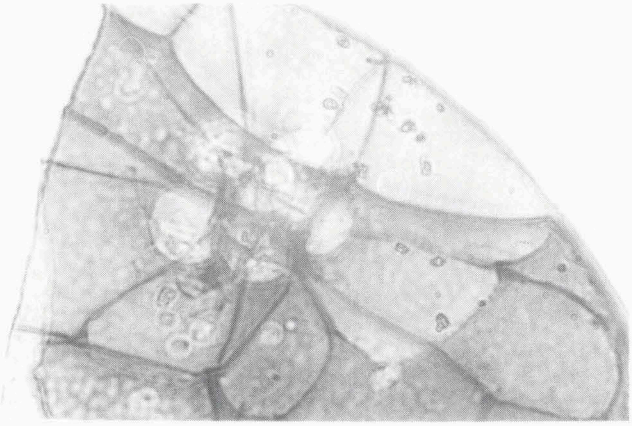

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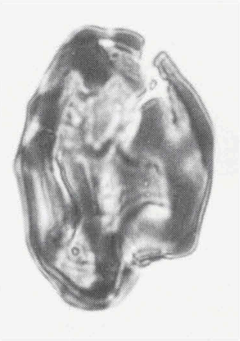

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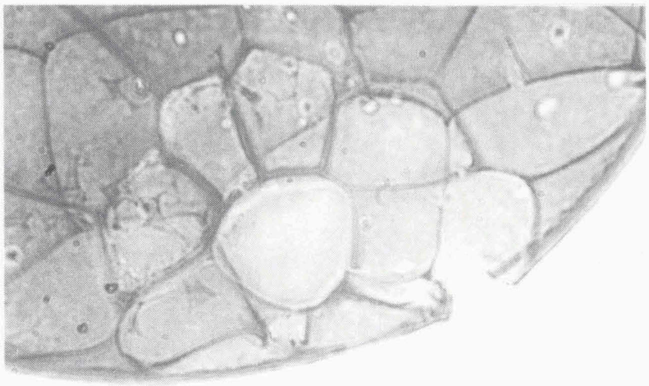

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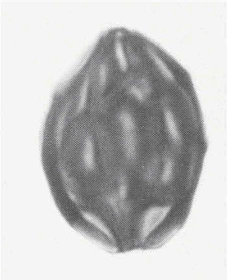


7

FUNGAL SPORES, CONIDIA, OR OTHER STRUCTURES

Type JAM. 2005 (Pl. 5, fig. 7)

Ascospore or conidium, oval with bluntly pointed apex and slightly rounded-truncate antapex, largest diameter 28 μm; diporate, sometimes one pore indistinct, seemingly monoporate; largest, antapical pore slightly intruding, 6 μm wide; apical pore less distinct owing to the protruding apex; wall consisting of a 1 μm thin continuous layer (except at the apices) covered by a coarse reticulum (which at low magnification gives a striate impression); muri with rounded crests, 2 - 3 μm wide and high, 1 μm higher where muri anastomose; lumina elliptical, largest diameter 5 - 9 μm in approximately polar direction, 3 - 5 μm in perpendicular direction.

Collected from the Lower Eocene part of the Richmond Formation in the Oracabessa River, locality JHG-407. Also observed in similar strata at Sandside, localities JHG-196, 197; at Langley, locality JHG-216; and near Richmond, locality JHG-426.

Morphological relationships — Closely related to the Eocene *Striadiporites sanctaebarbarae* Elsik & Jansonius, 1974, in all respects except that the apical pore in type JAM. 2005 is less clear to indistinct. *Striadiporites reticulatus* Varma & Rawat, 1963 (p. 137, pl. 1, f. 21) from the Lower Miocene of India has smaller lumina. *Striadiporites* sp. (Jansonius, 1976, pl. 1, f. 3) from the Palaeogene of arctic Canada has much thinner muri and is more pointing at both polar ends. Type JAM. 2005 differs basically from *Gelasinospora retispora* Cain, 1950 and from *G. reticulispora* (Greis-Dengler) C. & M. Moreau (van Geel, 1972, 1976) by the presence of pore(s) in type JAM. 2005 and by the smaller lumina (2 - 4 μm wide) in the *Gelasinospora* species.

Plate 5

Figs. 1-3. Type JAM. 2051, from Holocene strata near Bowden, locality JHG-591; fig. 1: × 500; figs. 2 - 3: × 1000.

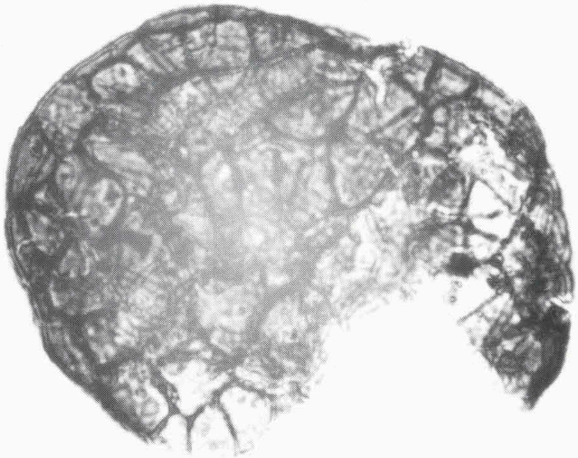
Fig. 4. Type JAM. 2047, from the southern equivalent of the Buff Bay Formation (Miocene-Pliocene) at Arcadia, locality JHG-587, × 1000.

Fig. 5. Type JAM. 2029, from the Upper Eocene Swanswick Limestone in Widcomb bore hole no. 1 at 110′ depth, × 1000.

Fig. 6. Type JAM. 2006, from the Lower Eocene part of the Richmond Formation in the Oracabessa River, locality JHG-407, × 1000.

Fig. 7. Type JAM. 2005, from the Lower Eocene part of the Richmond Formation in the Oracabessa River, locality JHG-407, × 1000.

Plate 6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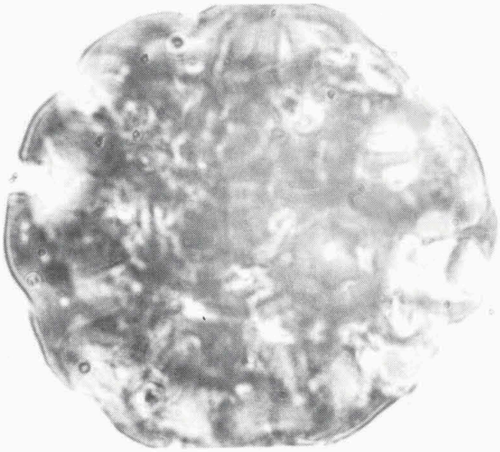
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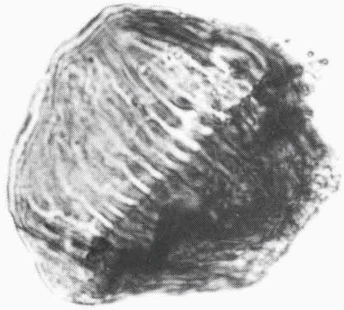
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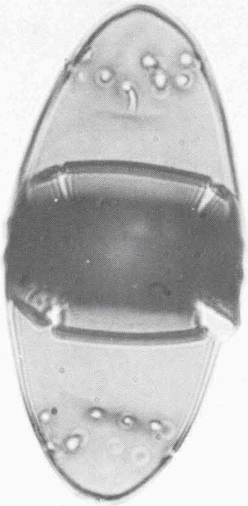
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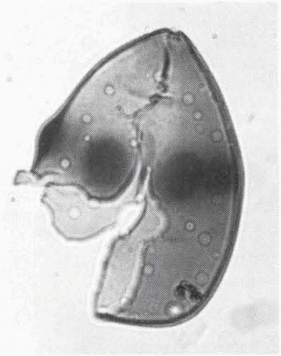
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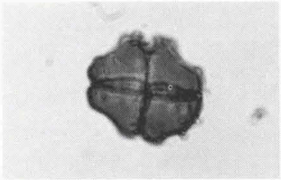
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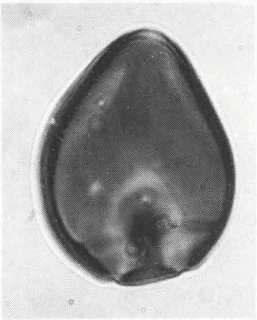
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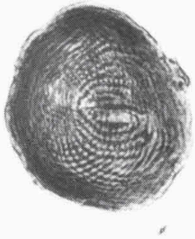
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Type JAM. 2006 (Pl. 5, fig. 6)

Morphologically very close to type JAM. 2005 but less close to *Striadiporites sanctaebarbarae* by the much wider lumina (up to 8 × 15 μm), the wider antapical pore (14 μm), and the larger overall diameter (35 μm).

From the Lower Eocene part of the Richmond Formation in the Oracabessa River, locality JHG-407.

Morphological relationship — Perhaps within the variability of type JAM. 2005 (see Corner, 1947).

Type JAM. 2012 (Pl. 4, fig. 6)

Fungal ?conidium, ovoid in shape, largest diameter 52 μm; consisting of 12 - 25 cells; each cell approximately 15 μm large; wall psilate, 1.5 μm thick at the outer side; septa 1 μm thick; each cell has a distinct pore in the outer wall; pores 1 - 1.5 μm in diameter, surrounded by an 1 μm thick annulus.

From the Holocene strata near Bowden, locality JHG-591. Also found in the Lower Eocene part of the Richmond Formation in Dry River, locality JHG-334, and in the Middle Eocene part of the Richmond Formation at Langley, locality JHG-390.

Type JAM. 2013 (Pl. 1, fig. 6)

Fungal spore or conidium, a string of cells separated by centrally perforated septa; length of string 72 μm and more (often broken into pieces), width 8 - 10 μm;

Plate 6

Fig. 1. Type JAM. 2046, from Holocene strata at Bowden, locality JHG-585, × 1000.

Fig. 2. Type JAM. 2054, from Holocene strata near Bowden, locality JHG-591, × 1000.

Fig. 3. Type JAM. 2089, from Upper Cretaceous strata at Lottery, Sunderland Inlier, locality JHG-177, × 1000.

Fig. 4. Type JAM. 2058, from Holocene strata near Bowden, locality JHG-592, × 1000.

Fig. 5. Type JAM. 2053, from Holocene strata near Bowden, locality JHG-591, × 1000.

Fig. 6. Type JAM. 2075, from younger Tertiary and Quaternary fissure fillings in the Chepstow Limestone from Bantimore River, west of Bloomfield, locality Krijnen K74-4, × 1000.

Fig. 7. Type JAM. 2050, from Holocene strata near Bowden, locality JHG-592, × 1000.

Fig. 8. Type JAM. 2067, from Upper Cretaceous strata at Lottery, Sunderland Inlier, locality JHG-178, × 1000.

septa 2 - 3 μm thick, 10 - 12 μm apart; outer wall less than 1 μm thick, psilate; pores in septa all protruding into one direction, giving the impression of a thicker central part of the septa.

From the Middle Eocene part of the Richmond Formation at Langley, locality JHG-390. Also observed in the same strata at Langley, locality JHG-389; moreover from Holocene strata at Bowden, locality JHG-591.

Morphological relationships — Van der Hammen (1954) established the genus *Pluricellaesporites* in which he distinguished five species, all from the Upper Cretaceous Guaduas Formation in Colombia. The species *P. filiformis* (pl. 21) has the same type of cell-arrangement as type JAM. 2013, but the pore-structure in the septa is different. Of all the species described by Elsik (1968, pl. 3) from the Palaeocene of Texas only the type named 'Hyphae type 2' comes very close to type JAM. 2013. Jansonius (1976, p. 131, pl. 1, f. 9, 11) illustrates two specimens from the Palaeogene of arctic Canada which are morphologically related to type JAM. 2013. Also rather similar seems *P.* aff. *psilatus* Clarke, 1965 described by Srivastava (1968, p. 1115, pl. 1, f. 1 - 3) from the Maestrichtian Edmonton Formation in Alberta, Canada. *Reduviasporites* described by Wilson (1962) from the Permian of Oklahoma, only superficially resembles type JAM. 2013.

Type JAM. 2025 (Pl. 4, fig. 4)

Fungal spore or conidium, spindle-shaped, bilaterally and axially symmetrical, iso-hemispherical, 33 × 17 μm; one septum, 3 μm thick, ?perforate in the centre; pore 4 μm wide; wall 0.8 μm thick but at the apices 1.5 μm thick; striate, striae 1.5 μm thick, 4 μm apart, gradually fading out towards the septum.

From the Lower Eocene part of the Richmond Formation at Richmond, locality JHG-426. Also observed in Holocene strata at Holland Bay, locality JHG-447, and at Bowden, locality JHG-591.

Morphological relationships — *Cookeina tricholoma* Wolf (1966, p. 150, pl. 1, f. 28; 1967, p. 402, f. 4, nr 44) both from the Holocene of Tanzania, Africa. Also resembling *Fusiformisporites pseudocrabbii* Elsik (1968, p. 270, pl. 2, f. 13, 14) from the Palaeocene of Texas, USA, and *Fusiformisporites rugosus* Sheffy & Dilcher (1971, pls. 14 + 16, f. 73) from the Eocene of Tennessee and Kentucky, USA.

Type JAM. 2029 (Pl. 5, fig. 5)

Fungal structure, largest diameter 28 μm, consisting of 30 - 40 cells; apparently in coiled arrangement, non-planispiral; cells 6 - 7 μm in diameter; wall thickness 1 μm; each cell with a pore of 1 - 1.5 μm diameter with slightly thickened rim or annulus.

From the Upper Eocene Swanswick Limestone in Widcomb bore hole no. 1 at 110′ depth.

Morphological relationships — The type sligthly resembles *Dictyosporium* Corda (Barron, 1968, p. 152; Barnett & Hunter, 1972, p. 142) which is a conidium that branches to a multicellular stage, arising from a single basal cell, usually

U-shaped, but in *D. toruloides* of irregular shape. *Dictyosporium* is a soil fungus that belongs to the Moniliales of the Fungi Imperfecti.

Type JAM. 2033 (Pl. 3, fig. 6)

Fungal spore or conidium, ?asymmetrical, constricted ellipsoidal, 20 × 10 μm; one septum 1.5 μm thick; wall 0.5 μm thick; densely covered with gemmae, each 1.5 μm thick and high.

From the Lower Eocene part of the Richmond Formation at Sandside, locality JHG-188.

Morphological relationships — *Englerulaster asperuliporus* (Gaillard) Theissen, 1912 (Arnaud, 1918, p. 184, pl. 39), a finely gemmate, Recent species. *Englerulaster macowanianus* (Thum.) Arnaud, 1918 (p. 183, pl. 39) is psilate.

Type JAM. 2046 (Pl. 6, fig. 1)

Fungal structure subglobose, 77 × 50 μm large, consisting of compactly aggregated, irregularly distributed cells; each cell 6 - 8 μm in diameter; cell walls less than 0.5 μm thick, no perforations in the walls.

From Holocene strata near Bowden, locality JHG-585.

Morphological relationship — only slightly resembling ?*Coniosporium* from the Holocene of Tanzania, Africa (Wolf, 1966a, p. 60, pl. 3, f. 29).

Type JAM. 2047 (Pl. 5, fig. 4)

Fungal structure of irregular shape, largest diameter 30 μm; consisting of 5 - 6 subglose cells, 10 - 12 μm in diameter, with 1.5 μm wide perforations in the outer walls and 1 μm wide pores in some of the septa; wall 1 - 2 μm thick, covered with minute ?gemmae, 0.5 μm in diameter.

From the southern equivalent of the Buff Bay Formation (Miocene-Pliocene) at Arcadia, locality JHG-587.

Morphological relationship — *Pluricellaesporites clarkei* Srivastava (1968, p. 1116, pl. 1, f. 7) from the Maestrichtian Edmonton Formation of Alberta, Canada.

Type JAM. 2048 (Pl. 4, fig. 3)

Fungal spore or conidium, ovoid, 40 × 30 μm; one septum, 3 μm thick, folded at the central pore which is 3 μm wide; septum 3 μm thick near the outer wall, with an 8 μm thickening around the septal pore; septal pore with an 1 μm thick membrane; outer wall 2 μm thick, consisting of an 1 μm thick continuous layer covered with verrucae, each 2 - 3 μm wide, less than 1 μm high; space between verrucae 3 - 4 μm; two apical pores, each 6 μm wide, with distinct, 2 μm thick annuli.

From Holocene strata near Bowden, locality JHG-591.

Type JAM. 2049 (Pl. 4, fig. 2)

Fungal conidiophore with conidia, largest diameter 48 μm; conidiophore beaker-shaped, 20 × 13 μm; wall less than 1 μm thick; three conidia spreading from the apical end of the conidiophore, conidia varying in size from 32 × 4 μm to 40 × 6 μm; wall of the conidia less than 1 μm thick; the two 'lateral' conidia of the type specimen have two septa, each less than 0.5 μm thick; apical end of the conidia open, 2 μm wide; conidiophore scabrate except at apical end; scabrae less than 0.5 μm large; septa between conidiophore and conidia less than 0.5 μm thick.

From the southern equivalent of the Buff Bay Formation (Miocene-Pliocene) at Arcadia, locality JHG-590.

Morphological relationships — *Acaulopage tetraceros* Drechsler (1935, p. 194, f. 4 A - G) and *Tetraploa aristata* Berk. & Br. (van Geel, 1976, p. 52, pl. 17, f. 89) closely resemble type JAM. 2049; both species have some septa in the conidia; the first species has a conidiophore 20 × 8 μm in size; the latter species is somewhat more coarsely ornate than type JAM. 2049. *Clavariopsis aquatica* Tubaki (Barnett & Hunter, 1972, p. 136) is psilate.

Type JAM. 2054 (Pl. 6, fig. 2)

Fungal structure discoidal, diameter 64 μm; consisting of many cells arranged in a slightly concentric way; wall 2 μm thick in the outer margin; septa between the cells 1 - 1.5 μm thick; perforations in the outer wall (and in septa?) 1.5 μm large.

From Holocene strata at Bowden, locality JHG-591. Also observed in the same strata at Bowden, locality JHG-592.

Type JAM. 2063 (Pl. 2, fig. 3)

Fungal structure compressed ovoid, 27 μm in largest diameter; consisting of many cells more or less arranged in rows parallel to the longest axis, each cell rather (rect)angular in shape, 6 × 9 μm, without perforations; outer wall 1 μm thick; septa between cells less than 1 μm thick.

From Holocene strata at Bowden, locality JHG-592.

Type JAM. 2068 (Pl. 1, fig. 5)

Fungal spore or conidium, spindle-shaped, hetero-hemispherical, 48 × 20 μm; central septum 1.5 μm thick, without pore; at one apex a 10 μm wide, 1.5 μm thick annulus or small perforated septum; the other apex thin-walled or with a faint pore; wall less than 1 μm thick, covered with 0.5 μm large gemmae at 1.5 μm distance from each other.

From the Upper Cretaceous strata in Rio Minho, east of Frankfield, Central Inlier, locality JHG-471.

Type JAM. 2075 (Pl. 6, fig. 6)

Fungal conidium, a smooth tetrad, overall diameter 14 μm, slightly constricted at the separating walls, concave at the intermediate surfaces; inner walls 1 μm thick; outer wall 1 μm thick; no pores.

From younger Tertiary and Quaternary fissure fillings in the Chepstow Limestone from Bantimore River, west of Bloomfield, locality Krijnen K74-4.

Morphological relationships — This form most closely resembles *Spegazzinia tessarthra* (Berk. & Curt.) Saccardo (in: Roquebert, 1978, especially pl. 2, f. 6). *Spegazzinia intermedia* Ellis, 1976 (p. 475, f. 378) is more lobate and quite variable. *Sp. sundara* Subramanian, 1956 (in: Ellis, 1976, p. 465, f. 377) is similarly lobed like the preceding species. *Sp. parkeri* Sivasithamparan, 1974 (p. 427 - 429; in Ellis, 1976, p. 476, f. 379) has conidia without any lobation.

FERN SPORANGIA

Type JAM. 2009 (Pl. 3, figs. 3, 4)

Sporangium of a polypodiaceous type, more or less circular, 55 μm in diameter; inner part consisting of two side-walls formed by a series of 20 × 2 μm parallel thin-walled cells; ring-cells thick-walled, 6 × 3 μm, walls 1 μm thick; outer margin straight, psilate; inner margin ribbed by the extending 'septa'.

From the Lower Eocene part of the Richmond Formation at Langley, locality JHG-281. Also from the same formation at Fruitful Vale, locality JHG-107.

FOSSILES INCERTAE SEDIS

Type JAM. 2050 (Pl. 6, fig. 7)

?Fungal structure, pear-shaped, 33 μm, possibly only half of the structure; with ?operculate, ?antapical pore above which a dark body is visible; wall psilate, 2.5 - 3 μm thick except at apex where it is about 1 μm thick; dark body round, about 5 μm in diameter; ?connected with the 9 μm wide ?operculum.

From Holocene strata at Bowden, locality JHG-591. Also observed in the same strata, locality JHG-592.

Type JAM. 2051 (Pl. 5, figs. 1 - 3)

?Fungal structure, almost spherical, slightly oval, largest diameter 160 μm; consisting of many angular cells, the smallest with a diameter of 8 μm, arranged around one 'pole' which is situated not quite opposite the other 'pole'; this other one has five circular, faintly annulate pores, about 8 μm in diameter, all proximally located in the cells surrounding this 'pole'; on the pole itself occur three small angular cells, about 5 μm in size, each with a pore of 2 μm in diameter; the widest cells, 20 - 25 μm in size, are found around the 'equator'; outer wall psilate, 1.5 μm thick; septa between cells much thinner, 0.5 μm; the inner part of the structure seems to have been destroyed during the process of fossilization.

From Holocene strata at Bowden, locality JHG-591.

Type JAM. 2053 (Pl. 6, fig. 5)

?Fungal spore, pear-shaped, largest diameter 38 μm; hetero-hemispherical, with a 1 μm wide (?ant)apical pore at the more pointed end, and without any aperture at the blunt side; on the equator 5 - 6 radio-symmetrically arranged, thickened circular areas are bulging out 2 - 3 μm from the outer surface; thickened areas approximately circular, 5 - 6 μm in diameter; wall psilate, 1 μm thick.

From Holocene strata at Bowden, locality JHG-591. Also observed in the same strata, locality JHG-592.

Type JAM. 2058 (Pl. 6, fig. 4)

?Fungal structure, ellipsoidal, iso-hemispherical, largest diameter 64 μm; septum with a thick and approximately 5 μm wide annulus around a vague, large central pore with a ?membrane; wall around annulus thin, about 1 μm near the outer wall; outer wall psilate, 0.5 μm thick all over the grain, except at the two circular series of perforations, at about 9 μm distance from each pole; perforations 1 μm wide, annuli around them 0.5 μm wide and less than 0.5 μm thick; perforations at 4 - 5 μm distance from each other.

From Holocene strata at Bowden, locality JHG-592.

Type JAM. 2067 (Pl. 6, fig. 8)

?Fungal spore or ?fern spore, spherical, 23 μm in diameter; aseptate; with two ?pores, approximately opposite each other; pores elongated, 6 × 2 μm with slightly costate rim along the long margins, each rib approximately 4 μm long and 1 μm broad; wall 1 μm thick, covered with fine, parallel striae, 0.5 μm wide and 0.5 μ apart, arranged in a peculiar pattern.

From Upper Cretaceous strata at Lottery, Sunderland Inlier, locality JHG-178.

Type JAM. 2089 (Pl. 6, fig. 3)

?Fungal spore or ?fern spore, approximately spherical, 40 μm in diameter; aseptate; pores not observed; wall 1.5 μm thick, covered with 1 μm wide grooves at distances of 2 - 2.5 μm, converging towards the ?polar areas which are almost psilate.

From Upper Cretaceous strata at Lottery, Sunderland Inlier, locality JHG-177.

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