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SOME ENDOGONACEAE FROM SOUTH WESTERN AUSTRALIA

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Fourteen species in the genera *Gigaspora*, *Acaulospora*, *Entrophospora*, and *Glomus* were collected in agricultural soils from south Western Australia. Most spores resembled those of species which have been described from collections made elsewhere. One new species, *Gigaspora decipiens*, is described and suggestions for the modification of the description of *Gigaspora calospora* are advanced. Two species of *Glomus* are briefly and informally described.

The distribution of species of the Endogonaceae is currently of particular interest because of the role some of these fungi can play in plant nutrition through their ability to form mycorrhizas (Abbott & Robson, 1982; Mosse, 1973; Tinker, 1978). Though the effectiveness of a fungus in a mycorrhiza does not appear to be related to its taxonomic position, the distribution of the fungi in agricultural soils is important to a full understanding of their ecology in relation to agriculture and may be relevant in any future studies dealing with the possibility of introducing more effective species into soils. Here is presented a summary of the results of an extensive survey for Endogonaceae in agricultural soils in south Western Australia.

MATERIALS AND METHODS

Soil samples of approximately 3 kg from the top 100 mm of soil were collected from more than 250 agricultural soils in the area bounded by Geraldton, Morawa, Southern Cross and Albany in Western Australia. Spores of several isolates of each species were used to inoculate subterranean clover to produce pot cultures (Gilmore, 1968) using the methods and the potting soil described by Abbott & Robson (1979). These pots provided an opportunity to examine spores at various developmental stages. Spores were extracted from each soil using wet-sieving and centrifugation techniques (Gerdemann & Nicolson, 1963; Tommerup & Kidby, 1979) and examined in water, lactophenol, AH miracle mounting fluid (Cunningham, 1972) and/or PVA mounting fluid (Walker, 1979). Air drying soil, rubbing soil through sieves, the use of soil dispersants (e.g. sodium hexametaphosphate) or the use of Tommerup & Kidby's (1979) technique may lead to spore damage, e.g. the loss of thin outer walls, and were therefore avoided where critical morphological details might have been affected. As far as possible, descriptions are based on spores from pot cultures.

Roots were collected from the field, or from subterranean clover (*Trifolium subterraneum* L.) grown in field soils in the glasshouse, and stained with trypan blue using a modification (Abbott & Robson, 1981) of Phillips & Hayman's technique (1970). Photographs were taken with an Orthomat-W camera mounted on a Leitz–Wetzlar Ortholux II microscope fitted with Nomarski Interference; a selection are presented here and others have been incorporated in a slide collection (Hall & Abbott, 1983). Collection numbers refer to material deposited in the herbarium of the Biological and Chemical Research Institute, Rydalmere, NSW, Australia and localities are given in brackets.

RESULTS

Collections of spores of the following ten species did not differ in morphology from the range of form given in the published descriptions; reference herbarium specimens and information regarding their collection sites have been deposited in the herbarium of the Biological and Chemical Research Institute:

Gigaspora coralloidea Trappe, Gerd. & Ho (Gerdemann & Trappe, 1974)

Acaulospora laevis Gerdemann & Trappe (1974)

A. trappei Ames & Linderman (1976)

Entrophospora infrequens (Hall) Ames & Schneider (Hall, 1977; Ames & Schneider, 1979)

Glomus fasciculatum (Thaxter sensu Gerd.) Gerd. & Trappe (Gerdemann, 1965; Gerdemann & Trappe, 1974)

G. caledonium (Nicol. & Gerd.) Gerd. & Trappe (Nicolson & Gerdemann, 1968; Gerdemann & Trappe, 1974)

G. macrocarpum Tul. & Tul. (Gerdemann & Trappe, 1974)

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G. monosporum Gerd. & Trappe (Gerdemann & Trappe, 1974; Hall, 1977; Abbott & Robson, 1979)

G. albidum Walker & Rhodes (1981)

G. tenue (Greenall) Hall (Greenall, 1963; Hall, 1977) – observed in infections.

One new species of *Gigaspora* was found and is described below. The description of *Gigaspora calospora* (Nicol. & Gerd.) Gerd. & Trappe (Nicolson & Gerdemann, 1968; Gerdemann & Trappe, 1974) was found to be deficient and suggestions as to how it should be modified are made. Two further species of *Glomus* were collected and are described but as pot cultures have either been unsuccessful or have not been attempted, only brief descriptions of their spores are presented.

Gigaspora decipiens Hall & Abbott sp.nov. (Figs 1–4)

(Etym. *decipiens* – deceiving, refers to the quite different structure of the spore wall of juvenile and mature spores which originally made us suspect there were two species).

Sporae ectocarpae; iuveniles incolores, luteolae vel pallide flammeae; germinantes incolores, pallide et prasine luteae, luteae vel pallide brunneae; globosae vel raro irregulares, 320–490 μm diam.

Tunicae triplices sporae novae, 20–35 μm crassae, duae tunicae externae subaequales, intima tenuissima; extrema fragilis ab internis flexibilibus aegre separata. Tunica sporarum veterum 34–47 μm crassa, externae iuvenili ab internis non diutius separabili, 2–3 laminae inseparabiles atque paene subaequales suppositae; mediae iuvenili usque ad undecim laminae inseparabiles suppositae; intima iuvenilis iden sporis senescentibus permanet, sed superficies interior materia verruciformi ornata. In tunica cellulae ante germinandum non efformatae.

Hypha subtendens pallide brunnea, bulbosa, ad 65 μm lata, saepe una vel pluribus hyphis basalibusque lateralibus *ca* 9 μm latis *ca* 22 μm longis. Vesiculae in humo 33–54 μm diam paene sphaericae, singillatim vel in glomerulis compactisque sphaericis usque ad 20 numero, quaque ab hypha spirata ad hypham principalem *ca* 10 μm latam adiuncta; spinis rectis vel saepius duplicibus usque ad 10 μm altis et *ca* 2 μm latis ulterius ornata. Endomycorrhizas cum arbusculis efformans sine vesiculis.

Specimens examined: Holotype Hall 1007 (Harvey, Western Australia), also Hall 1178, 1179, 1194, 1195 (Harvey).

Spores ectocarpic; colourless, yellowish or pale orange when young; colourless, pale greenish yellow, yellow or light brown at germination or when stored in dry soil; globose or rarely irregular, 320–490 μm diam. Young spore walls 20–35 μm thick of 3 layers; outer two layers subequal, innermost very thin; outermost brittle, separable with difficulty from flexible inner layers. Wall of old spores 34–47 μm thick, juvenile outer wall layer replaced by 2–3 inseparable approximately subequal laminations no longer separable from inner layers; middle juvenile layer replaced by up to 11 inseparable laminations; innermost juvenile layer remains unchanged as spores age but inner surface becomes encrusted with warty material before spore germination. Compartments in wall not formed prior to germination. *Subtending hypha* light brown, bulbous, up to 65 μm wide, often with one or more attached lateral hyphae *ca* 9 μm wide × *ca* 22 μm long. Auxiliary cells in soil 33–54 μm diam. Approximately spherical, single or in tight spherical clusters of up to 20, each attached by a helically coiled hyphae *ca* 10 μm wide; distally covered in simple or forked spines up to 10 μm high and *ca* 2 μm wide. Forms endomycorrhizas with arbuscules but without vesicles.

Re-isolated from pot cultures established with spores wet-sieved from soil collected from Harvey, W. A. Original site was an irrigated (over summer) permanent Kikuyu grass (*Pennisetum clandestinum* Hochst. ex Chiov.) pasture with considerable accumulation or organic matter.

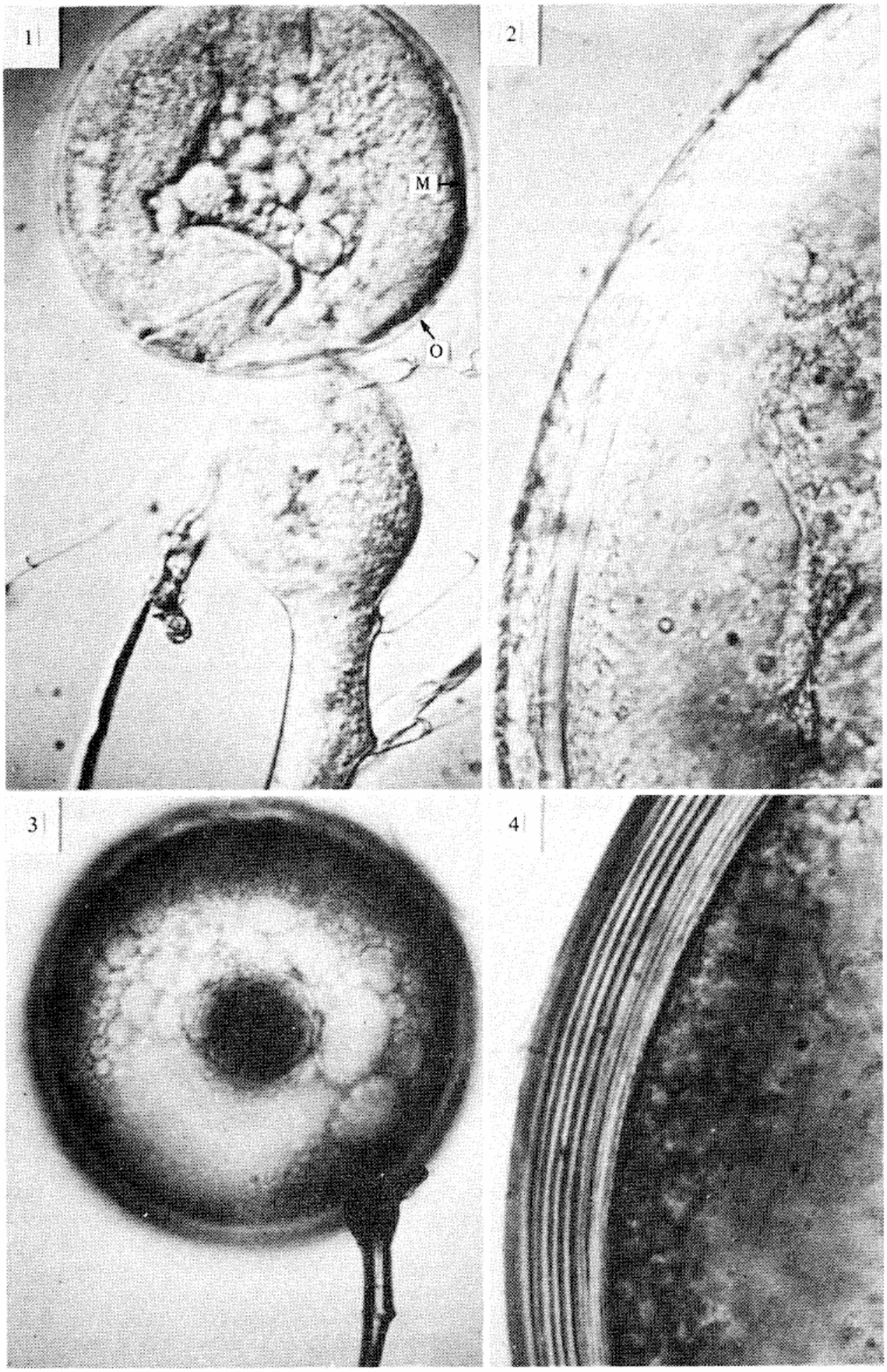
G. decipiens superficially resembles the other colourless-spored species of *Gigaspora*–*G. margarita* Becker & Hall, *G. candida* Bhattacharjee *et al.*, *G. albida* Schenck & Smith, *G. gilmorei* Trappe & Gerdemann, *G. pellucida* Nicolson & Schenck, and *G. rosea* Nicolson & Schenck. *G. gigantea* (Nicol. & Gerd.) Gerdemann & Trappe often becomes pale brown with age and might be confused with *G. decipiens*. *G. gilmorei* is distinctive as it produces germ-tubes that originate from germinate compart-

Fig. 1. Developing spore of *Gigaspora decipiens* on bulbous hyphal base. Outer two wall layers (O) fused and separate from membranous innermost layer (M) which surrounds the spore contents. (Nomarski Interference) (× 450).

Fig. 2. Spore wall of *G. decipiens*; spore had reached final size but wall layers were still developing. Middle wall layer becoming laminated with the innermost membranous layer appressed to its inner surface. (Nomarski Interference) (× 340).

Fig. 3. Fully developed spore of *G. decipiens* (× 160).

Fig. 4. Wall of fully developed spore of *G. decipiens*. Outer juvenile layer now composed of two laminae, middle juvenile layer replaced by ten laminae and innermost membranous layer just visible on the inner surface of the wall. (Nomarski Interference) (× 445).



Figs.1–4. For caption see opposite

ments and its auxiliary cells are ornamented with crowded knobs, not spines. The colourless spore wall of *G. margarita* is up to 24 μm thick, composed of 4–10 similar layers and with little difference in the appearance of the walls of juvenile and mature spores except for the number of layers. *G. decipiens*, however, has a spore wall which changes as the spores age, is much thicker (up to 47 μm) and has up to 15 layers of dissimilar thickness which may be coloured. Also, *G. margarita* has auxiliary cells with short, warty projections, whereas those of *G. decipiens* are ornamented with simple or forked spines. *G. decipiens* produces spores which are larger (320–490 μm), thicker-walled (20–47 μm) and with more layers (up to 15) than those produced by *G. albida*, *G. pellucida* and *G. rosea*. Whilst spores of both *G. gigantea* and *G. decipiens* become yellow to light brown with age, it is unlikely that the two could be confused as *G. gigantea* has only a two layered wall which is rarely more than 7 μm thick. The description of *G. candida* is rather brief and omits details of the mode of germination. However *G. candida* differs from *G. decipiens* in having smaller spores (200–300 μm) and thinner spore walls (*ca* 7 μm thick) composed of only two layers.

The juvenile and mature spores of *G. decipiens* were referred to as WUM 7 and WUM 6 respectively by Hall & Fish (1979) and treated as separate species. However, examination of spores from pot cultures established with only mature yellow spores convinced us that the two 'species' were merely stages in spore development. The morphology of *G. decipiens* within roots of subterranean clover and of auxiliary cells are illustrated elsewhere (Abbott, 1982).

GIGASPORA CALOSPORA (Nicol. & Gerd.) Gerd. & Trappe, *Mycologia Mem.* 5: 28 (1974). (Figs 5, 6).

In their description of *G. calospora*, Nicolson & Gerdemann (1968) stated that the spore wall is composed of 2 layers – 'with an outer wall 3–4 μm and thin inner membrane' and that 'germ-tubes (were) produced directly through the spore wall'. It therefore appeared that our species, despite all the similarities, was distinct from *G. calospora*. However, examination of microscope slides of the type (Farlow Herbarium) made by C. Walker satisfied us that the description of *G. calospora* was incomplete, as a very thin outer wall layer can be present (Fig. 6) and prior to germination compartments are formed (Fig. 5). The following additional details apply to spores of *G. calospora* collected in Western Australia: *Spores* ellipsoid or irregular, (210–) 160–290 (–520) μm. Wall of three layers; outer colourless *ca* 1·5 μm thick, often difficult to discern, tightly adhering to middle layer; middle layer coloured 2·5–6·5 (–9) μm thick; innermost layer colourless, *ca* 2 μm thick, but up to 4 μm during germination; separable from middle layer. Compartments form between middle and inner layers prior to germination; *ca* 10 μm (radial measurement) × 20–50 μm (tangential measurement); group of compartments palmate in face view, up to 160 μm across.

Specimens examined: Hall 1004 (Brookton); Hall 1005, 1015 (Badgingarra); Hall 1017 (Badgingarra); Hall 1018 (Williams); Hall 1024 (Brookton); Hall 1026 (York).

GLOMUS sp. (smooth, thick-walled, white spore).

Spores ectocarpic, colourless, 110–169 μm diam, surface covered with minute echinulations or minute ridges *ca* 1 μm high. Wall double *ca* 4 μm thick, outer layer much thicker than inner. *Subtending hypha* simple, up to 7 μm wide, fragile and often lost during sieving. Septum absent. This species was assigned the number WUM 4 in Hall & Fish's key (1979). It resembles *G. scintillans* Rose & Trappe (1980) and further work may prove it to be so. Several attempts at establishing pot cultures were unsuccessful.

Specimens examined: Hall 1042 (Hyden); Hall 1165 (Porongurup).

GLOMUS SP. (smooth, thick-walled, white spore). (Figs 9, 10).

Spores ectocarpic, white, globuse, 125–200 μm diam. Wall smooth (Fig. 10) but often with adhering debris (Fig. 9), *ca* 16 μm thick, of two inseparable layers which continue down subtending hypha; outer thicker than inner; inner layer tinged yellow in lactophenol. *Subtending hypha* simple to

Fig. 5. *Gigaspora calospora* spore from Western Australia with germination compartments (C)(× 300).

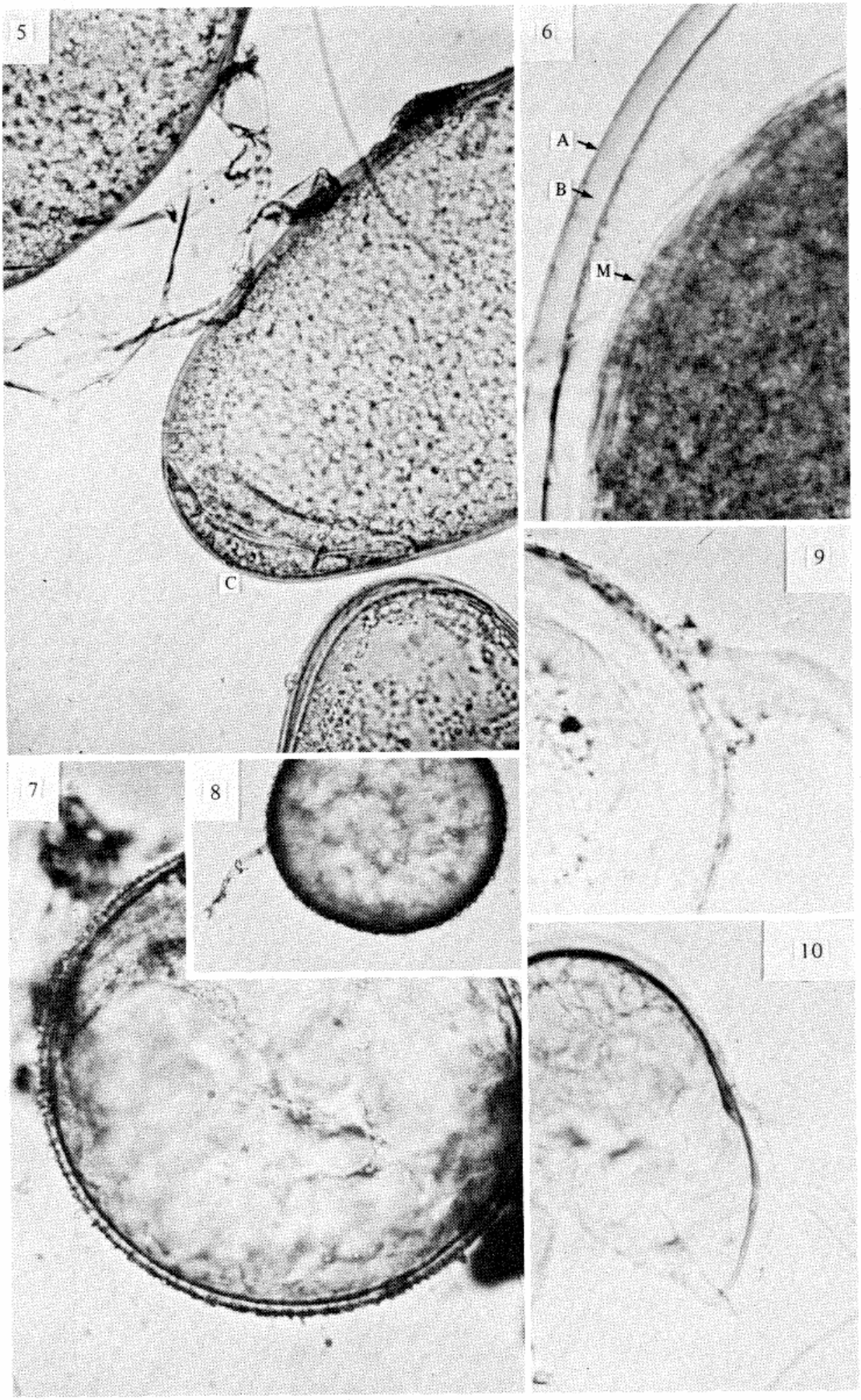
Fig. 6. *G. calospora* spore from type collection with two outer wall layers (A, B) separated from membranous inner layer (M) (× 450).

Fig. 7. *Glomus* sp. WUM 4 spore with the surface ornamented with minute echinulations (× 385).

Fig. 8. *Glomus* sp. WUM 4 showing the simple subtending hypha (× 300).

Fig. 9. *Glomus* sp. WUM 5 smooth, thick-walled white spore, with adhering debris (× 465).

Fig. 10. *Glomus* sp. WUM 5 smooth, thick-walled white spore without adhering debris, squashed to show spore wall with thick colourless outer and thinner coloured inner layers (× 300).



Figs. 5–10. For caption see opposite

slightly funnel-shaped; persistent, up to 25 μm wide a point of attachment.

This species was referred to as WUM 5 in Hall & Fish's key (1979) and resembles *G. clarum*. Insufficient spores have been collected for setting up pot cultures.

Specimens examined: Hall 1157 (Porongurup); Hall 1131, (Harvey).

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