Comparison of this fungus with presently described species in *Glomus* (Becker & Gerdemann, 1977; Daniels & Trappe, 1979; Gerdemann & Trappe, 1974; Hall, 1977; Nicolson & Schenck, 1979; Rose, Daniels & Trappe, 1979; Rose & Trappe, 1980; Tandy, 1975; Trappe, 1977; Trappe, 1979; Walker & Rhodes, 1981) showed that it had not previously been described, and it is here named *Glomus occultum*.

Glomus macrocarpum var. *geosporum* was found in most of the field sites from which the new species was identified. These and other collections were studied in relation to the type collection, and their relationship to *Glomus macrocarpum* Tul. & Tul. considered.

THE NEW SPECIES

GLOMUS OCCULTUM Walker sp. nov. (Figures 1 and 2)

Sporocarpia ignota. Chlamydosporae singulae vel laxe fasciculatae in solo vel confertim fasciculatae in corte radicellae efformatae; ovoideae, obovoideae, subangulateae vel irregulares, interdum globosae vel subglobosae, 15-100 x 20-120 µm, hyalinae vel albae, sporae tunica stratis duobus; exteriore ± 1 µm crasso; interiore (1-)1.5-2.5(-5) µm crasso, interdum duplo laminato. Hypha affixa infundibuliformis, 5-50 µm longa, ad basem sporae 3-10 µm lata, ad 2-5 µm deminuta, interdum septo distale clausa.

Sporocarps unknown. *Chlamydospores* borne singly or in loose clusters in the soil, or in compact clusters in the cortex of roots, often broader than long, ovoid to obovoid, subangular to irregular, less frequently globose to subglobose, 15-100 x 20-120 µm, hyaline to white. Cyanophilous in cotton blue. Inamyloid in Melzer's reagent.

Subtending hypha funnel-shaped to simple, 5-50 µm long, 3-10 µm wide at spore base, tapering to 2-5 µm; attached axially or eccentrically and recurved to straight, sometimes closed distally by a septum.

Spore wall 1- to 2-layered with an additional rough outer deposit of granular material which sloughs with age. Outer deposit up to 2 µm thick except at the spore base where it may be greatly thickened. Outer wall when present less than 1 µm thick, often indistinct. Inner wall (1-)1.5-2.5(-5) µm thick, usually of two sometimes indistinct laminations.

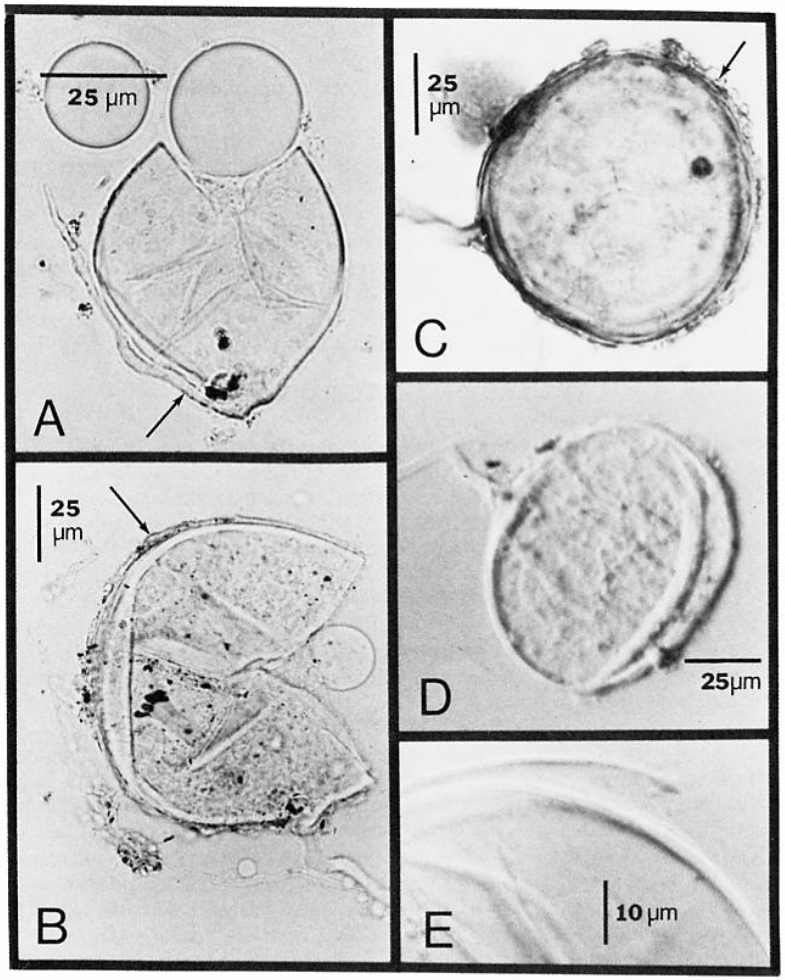

Figure 1.

Chlamydospores of *Glomus occultum*. A) A subangular spore with a recurved subtending hypha (arrowed). B & C) Spores showing the outer coat in the process of sloughing (arrowed). D) A spore showing the broader-than-long nature of many specimens. E) Spore broken open to show the outer wall separated from the inner wall.

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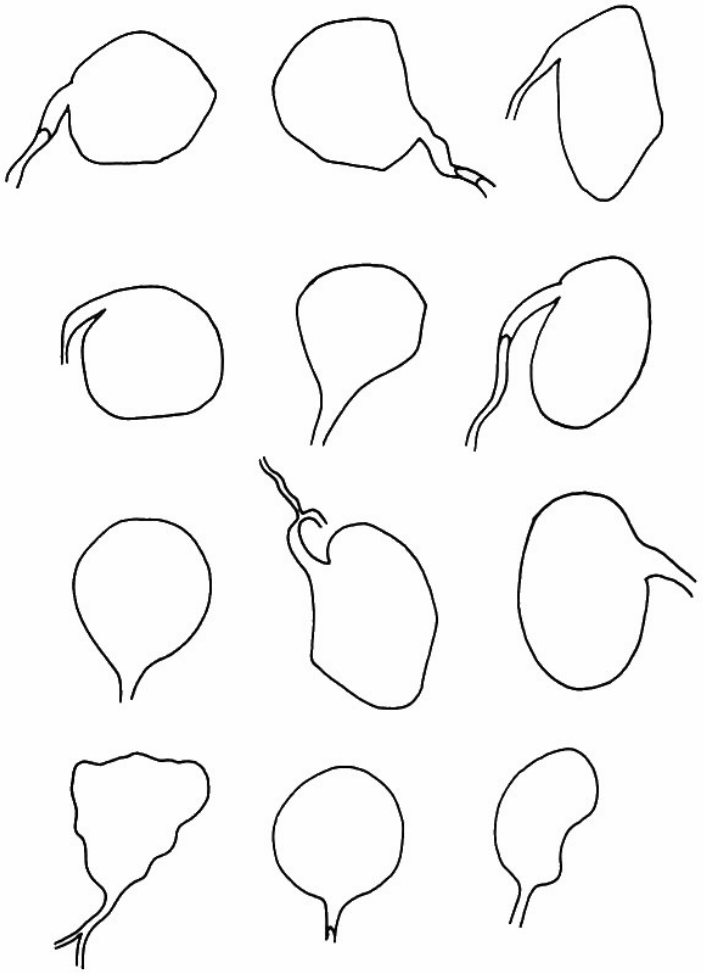

Figure 2.

Some examples of the different shapes taken by spores of *Glomus occultum*. Note the subangular nature and eccentrically connected subtending hypha in some specimens. These drawings are not to scale: examples of these shapes can be found among spores throughout the size-range of species.

DISTRIBUTION AND HABITAT

Hypogeous in an old meadow in central Iowa, a polder in The Netherlands, and reclaimed coal-mining spoils in Yorkshire, England.

Known associated with the roots of potted *Sorghum vulgare* Pers., and *Asparagus officianalis* L. that were mycorrhizal with *Glomus fasciculatum* (Thaxter sensu Gerdemann) Gerdemann & Trappe and *Gigaspora gigantea* (Nicolson & Gerdemann) Gerdemann & Trappe. Associated in the field with roots of *Populus* spp., *Setaria* spp., *Bromus inermis* Leyss., *Juglans nigra*, *Alnus glutinosa* (L.) Gaertn., *Acer pseudoplatanus* L., *Sonchus arvensis* L., *Cirsium arvense* (L.) Scop., *Phragmites communis* Trin., *Polygonum persicaria* L., *Equisetum arvense* L., and several other grass species.

MCYORRHIZAL ASSOCIATIONS

Forms vesicular-arbuscular mycorrhizae in pot culture with *Populus* x *euramericana* (Dode) Guinier, *Sorghum vulgare*, *Zea mays* L., *Triticum aestivum* L., *Glycine max* (L.) Merrill, *Trifolium* sp., and *Lycopersicon esculentum* Mill. Associated in the field with mycorrhizal roots of various grasses and trees.

ETYMOLOGY

Latin, *occultum*; hidden, referring to the obscurity of the spores caused by their small size, angular shape, and lack of coloration.

COLLECTIONS EXAMINED

HOLOTYPE: IOWA - Marshall Co., Rhodes, Iowa State University Rhodes Farm, among roots of grasses and poplars. A pot culture with hybrid poplar has been established in the Forestry greenhouse, Iowa State University, and spores from this have been deposited as the holotype at Oregon State University (OSC) (Walker #140, 25.vii. 1979). An isotype has been deposited in the herbarium at Iowa State University (ISC). PARATYPES: OREGON - Benton Co., Corvallis, Ornamental Plants Research Laboratory greenhouse (Walker #104, 12.iv.1979) (OSC). THE NETHERLANDS - Lelystad, Oostelijk Flevoland (Walker #266, 17.vii.1980) (OSC). ENGLAND - West Yorkshire, Castleford, Whitwood Main Colliery (Walker #262, 25.ix.1980) (OSC, FH, K). OTHER: ILLINOIS - Jackson Co., Southern Illinois University Progeny Test Center (Fardelmann 015C; collection of D. Fardelmann, Iowa State University). There was insufficient material in this last collection to be lodged in a herbarium.

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DISCUSSION OF *GLOMUS OCCULTUM*

Glomus occultum is distinguished from most other described species in the genus by its colorless ectocarpic chlamydospores that often are subangular in outline, and which may have the subtending hypha recurved and eccentrically attached (Figure 2). However, the subangular outline seems to be less pronounced in pot-cultured material than in field collections. The collection from Holland sporulates exceedingly sparsely, and has spores which are smaller than those of the other collections (mean 30 x 27 µm compared with 80 x 92 µm), but this is considered to be infraspecific variation.

Glomus pallidum Hall and *G. clarum* Nicolson & Schenck also have hyaline, ectocarpic chlamydospores (Hall, 1977; Nicolson & Schenck, 1979), but the former has, in comparison with the latter, spores which are generally smaller, have a narrower size-range, and a simpler wall structure consisting of a single laminated wall. The inner wall of *G. occultum* normally is bilaminate, although the laminations often are difficult to detect. *G. clarum* spores are larger (290 µm maximum diameter) than those of *G. occultum*, and their walls become yellow with age, a rare event with *G. occultum*. The walls of these two species are reversed in relative thickness, i.e., for *G. clarum* the outer wall is thicker than the inner wall, while for *G. occultum* the outer wall, when present, is thin and sometimes difficult to see. *G. clarum* spores may have an outer mucilaginous coat that is described as becoming verrucose and folded with age, with folds up to 5 µm in height. The outer covering occurs on all young spores examined in *G. occultum*, and sloughs with age without folding or becoming verrucose. No such outer wall occurs on the spores of *G. pallidum*. The subtending hypha of *G. clarum* spores may extend 400 µm below the spore, and is closed by a bulging septum in in the pore. The hypha subtending spores of *G. occultum* rarely is longer than 100 µm (often it is less than 25 µm), and when a septum exists, it normally is some distance distad of the spore base.

The size ranges of spores of *G. albidum* Walker & Rhodes and *G. occultum* overlap, but the wall structures are different, the latter having a thin, persistent outer wall covered by an amorphous outer coat, and a thicker inner wall. *Glomus albidum* spores have two subequal walls, the outer of which sloughs at maturity. Some *G. occultum* spores have only a single wall and thus might be mistaken for mature *G. albidum* spores. But the persistent subtending hypha of the former contrasts with that of the latter which breaks down and almost disappears at maturity. *Glomus scintillans* Rose & Trappe possesses hyaline chlamydospores, but these can be distinguished from those of *G. occultum* by their knobby surface and easily separable multiple walls. *Glomus lacteum* Rose & Trappe spores are white, but their thin, smooth, single walls, and multiple hyphal attachments render them easily distinguishable from those of *G. occultum*.

In some keys to the Endogonaceae (e.g., Gerdemann & Trappe, 1974; Hall & Fish, 1979), hyaline-spored *Glomus* spp., such as *G. occultum*, may key out to *G. fasciculatum* or *G. microcarpum*. However, neither of these species produces hyaline spores at maturity, and collections of such spores should be compared with the description of *G. occultum* and other hyaline-spores species such as *G. clarum*, *G. pallidum*, and *G. albidum*.

Spores of *G. occultum* could easily be overlooked in soil sievings. Their small size, lack of color, and often subangular form, make them difficult to distinguish from sand grains. I have found *G. occultum* spores to be more easily seen if only incident illumination is used when examining sievings under a dissecting microscope, rather than the combination of incident and transmitted light recommended by Mosse & Bowen (1968).

Sieves with openings no less than 100 µm often are used for wet-sieving and decanting endogonaceous spores, and since most *G. occultum* spores are smaller than this, they will be lost through such sieves. In view of the wide distribution of this species, it may be common, but might have been overlooked in the past.

THE NEW STATUS

Another *Glomus* sp. found in Iowa is *G. macrocarpum* var. *geosporum*. This species has been reported from various parts of the United States (Pfeiffer & Bloss, 1980; Gerdemann & Trappe, 1974; Nicolson & Schenck, 1979); from Great Britain (Nicolson & Gerdemann, 1968), from India (Thapar & Khan, 1973) and from the southern hemisphere (Hall, 1977; Hayman, 1978). I propose raising this variety to species rank. The differences between it and *G. macrocarpum* var. *macrocarpum* sensu Gerdemann & Trappe (1974) are at least as great as, for example, the differences between *G. fasciculatum* (Thaxter sensu Gerdemann) Gerdemann & Trappe and *G. macrocarpum* var. *macrocarpum*, or between *G. microcarpum* Tul. & Tul. and *G. fasciculatum*. Similarly, *G. constrictum* Trappe is as different from *G. macrocarpum* var. *macrocarpum* as is *G. macrocarpum* var. *geosporum*.

Nicolson & Gerdemann (1968) erected three varieties of *Endogone macrocarpa* (Tul. & Tul.) Tul. & Tul., based on resemblance to the specimens used by Thaxter (1922) in his classical contribution to the taxonomy of the group. Later, Gerdemann & Trappe (1974) raised *E. macrocarpa* var. *caledonia* Nicolson & Gerdemann to full species status and placed it in the genus *Glomus*. The absence of sporocarps, the septal occlusions of the subtending hypha, and the long extension of spore-wall thickening into the subtending hypha in *G. macrocarpum*

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