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GLOMUS MICROAGGREGATUM, A NEW SPECIES IN THE ENDOGONACEAE

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Examination of soil samples from maritime and lacustrine sand dunes of North America and Hawaii for vesicular-arbuscular mycorrhizal (VAM) fungi revealed an undescribed species of Glomus of common occurrence that routinely sporulated inside dead spores of other VAM fungi.

Spores were extracted from soil samples by wet-sieving and filtration (Koske and Walker, 1984) or by sucrose centrifugation (Walker, Mize and McNabb, 1982). Spore wall terminology follows that of Walker (1983), and descriptions are based upon the appearance of spores mounted in a polyvinyl alcohol/glycerol/latic acid solution (PVLG) (Koske and Tessier, 1983). Collections have been deposited in the herbarium of Oregon State University (OSC: holotype), the Farlow herbarium (FH: isotype) and at Kew (K: isotype).

SPECIES DESCRIPTION

GLOMUS MICROAGGREGATUM Koske, Gemma & Olexia sp. nov. Figs. 1-9

Sporae in solo efformatae. Hyalinae vel pallide luteolae vel fulvae, globosae vel irregulares; (15-)30(-50) µm x (15-)30(-40)µm. Sporae tunica e strato uno vel duobus (1-2) in uno turmo; exteriori levi et fragili, hyalinae vel pallide luteolo vel fulvo, 0.5-1.2(-2) µm crasso; interno membranaceo, concolori cum exteriori, <0.5-1.2(-2) µm crasso. Hypha concolor cum exteriori, levis vel infundibuliforma, 1.8-3(-4.5) µm lata prope sporam, stratum ad 1.5(-12) µm crassum.

Sporocarps unknown. Spores formed singly in the soil, in roots, or in clusters inside dead spores of other Endogonaceae; hyaline to pale yellow to brownish-yellow in transmitted light; globose or subglose to irregular (15-)30(-50) x (15-)30(-40) µm diam. Spore wall structure (see murograph, Fig. 8) of one or two walls (1-2) in one group. Wall 1 a smooth, brittle unit wall, hyaline to pale yellow to brownish-yellow, 0.5-1.2(-2) µm thick. Wall 2,

if present, a membranous or unit wall, concolorous with wall 1, <0.5-1.2(-2) µm thick. Attachment hypha concolorous with wall 1, straight or infundibuliform, 1.8-3(-4.5) µm wide at spore base, wall up to 1.5(-2) µm thick. Pore usually open, sometimes closed by a septum formed by wall 2 distending into the attachment hypha.

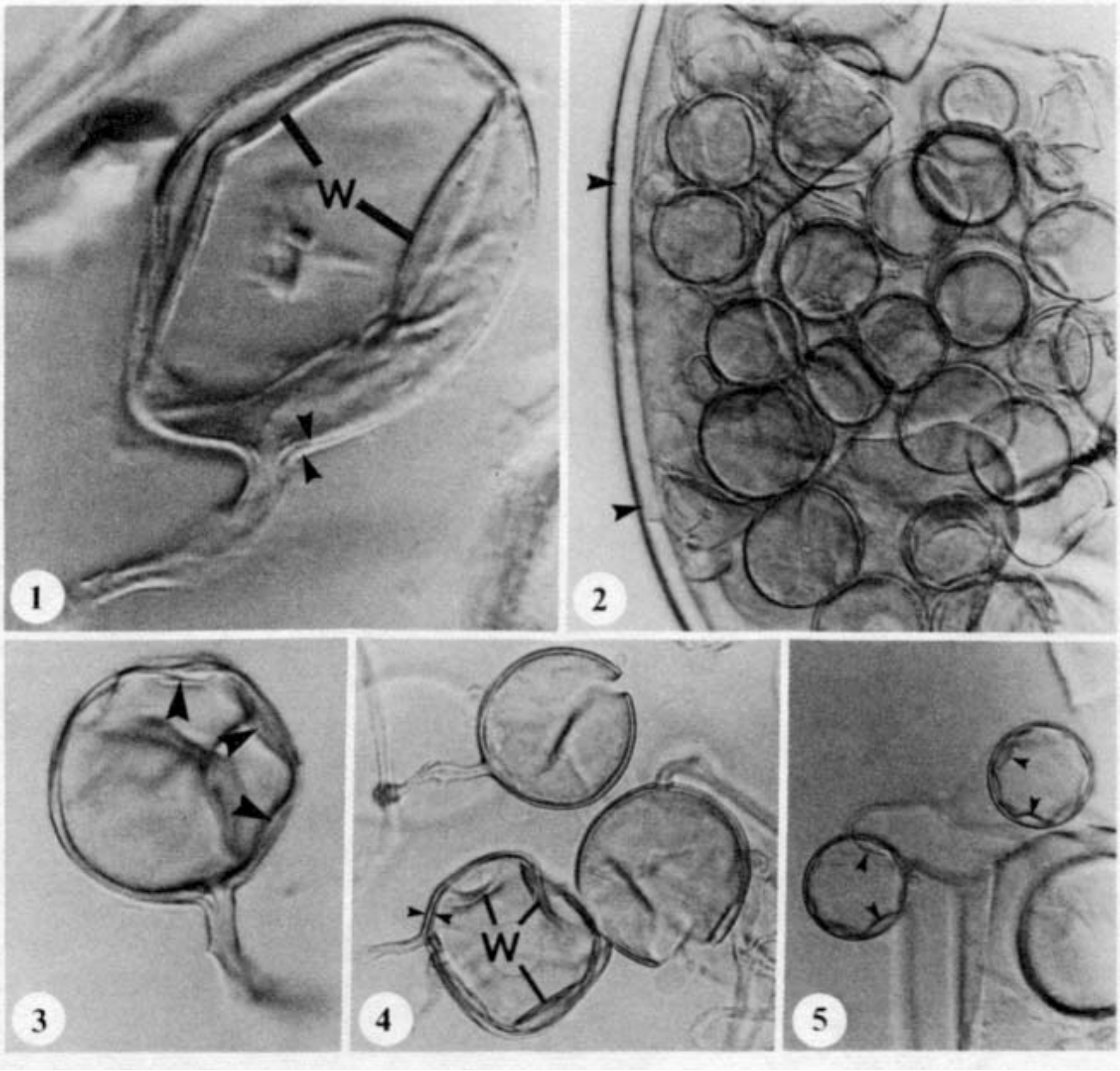
MYCORRHIZAL ASSOCIATIONS: Associated in the field with roots of Abronia maritima Nett. ex Wats., Ambrosia chamissonnis Less., Ammophila breviligulata Fern., Calamovilfa longifolia (Hook.) Scribn., Ipomoea brasiliensis (L.) Sweet, Malacothrix incana (Nutt.) T. & G. Pennisetum setaceum (Forsk.) Chiov., Sporobolus sp., Prunus pumila L., and Uniola paniculata L. Pot cultures were not attempted.

ETYMOLOGY: named for the resemblance of the spores to those of the larger-spored Glomus aggregatum Schenck & Smith.

DISTRIBUTION AND HABITAT: Known from sand dune soils in California, Hawaii, Michigan, and the Atlantic coast of the United States. Spores are seldom found freely in the soil. They routinely are found by crushing dead spores of other species of VAM fungi, where they occur in groups of 100 or more.

COLLECTIONS EXAMINED: HOLOTYPE: MICHIGAN - Benzie Co., Sleeping Bear Dunes State Park, among roots of Calamovilfa longifolia (Olexia 62, 16 Oct. 1984). OTHER COLLECTIONS: CALIFORNIA - Santa Barbara Co., San Miguel Island (Koske 575, 576, 581, 5 July 1984); HAWAII - Hawaii Co., Kailua (Koske 804, 806-810, 17 July 1984), Hapuna Beach State Recreation Area (Koske 816, 18 July 1984); MARYLAND - Worcester Co., Assateague Island (Koske 432, 14 Mar. 1982); MICHIGAN - Allegan Co., Saugatuck Dunes State Park (Olexia 109 25 Oct. 1984); RHODE ISLAND - Washington Co., Moonstone Beach (Koske 440, 15 Mar. 1982), Virginia Beach Township, Seashore State Park (Koske 518, 524, 526, 23 April 1983); WISCONSIN - Bayfield Co., Cornucopia Beach (Tews 049, 050, 3 July, 1985).

Figs. 1-5. Glomus microaggregatum. 1. Spore with two unit walls well separated at spore base (arrows). Note wrinkling (W) of walls 1 and 2 that occurred when the spore was mounted, X1090. 2 Spores inside dead spore of Gigaspora sp. Wall of Gigaspora is indicated (arrows), X335. 3. Spore with wrinkles in walls (arrows), X710. 4. Spores with two equal unit walls. Note separation near base of the lowermost spore (arrows) and wrinkling (W) of walls 1 and 2, X615. 5. Spores with a membranous wall 2 which has folded and wrinkled (arrows), X360.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DISCUSSION

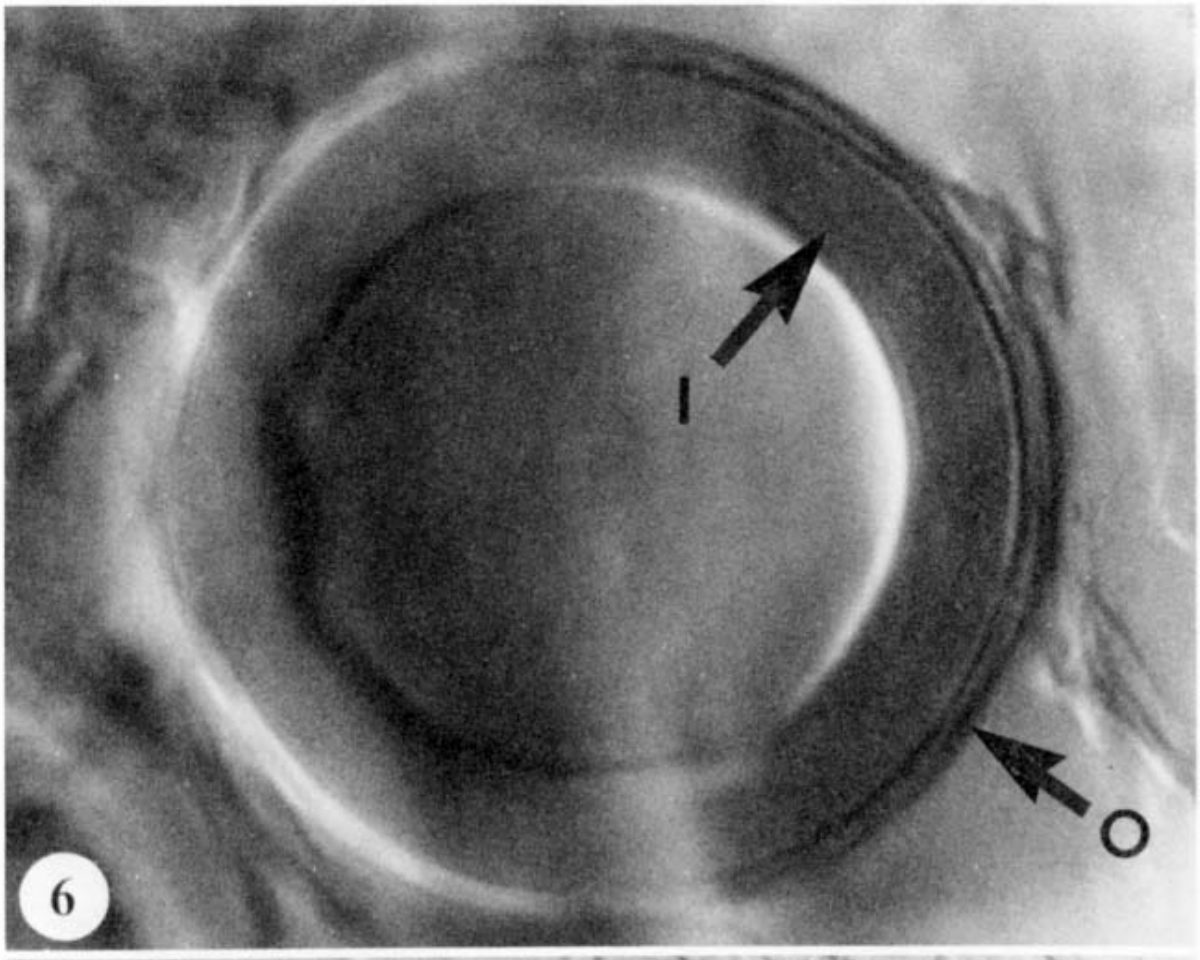
Glomus microaggregatum is distinguished from other species by the small size of its spores, the spore wall structure, the hyaline to very pale yellow or brownish-yellow color of the spores, and the narrow attachment hypha. In most spores, the wall structure consists of two unit walls with the innermost one equal in thickness to the outermost (usually 0.8-1.0 µm each) (Fig. 4) or slightly thinner (ca. 0.5 µm) than the outermost wall (Figs. 1,5). Included in a single spore cluster were spores with two equal unit walls, two sub-equal unit walls, an outer unit and an inner membranous wall (Fig. 5), and spores with apparently a single unit wall (Fig 4). It appears that the innermost wall forms after the outermost wall and progresses from a wrinkling, membranous type wall (Walker, 1983) to a thicker, more rigid, unit wall. Such a sequence of development has been suggested for the spore wall structure of G. aggregatum (Koske, 1985).

The double nature of the spore walls of G. microaggregatum often is most apparent at the base of the spore where it joins the attachment hypha, (Figs. 1, 4), and the two walls may continue down the subtending hypha for a distance of 15 µm.

Glomus microaggregatum most resembles G. aggregatum in the variation in spore wall structure that is apparent in spores in different stages of development, the range of spore shapes produced, and the propensity to sporulate inside of its own spores and inside of dead spores of other VAM fungi (Koske, 1985) (Fig. 2). It can be distinguished from G. aggregatum (average spore diam. 60-85 µm) by its smaller spores (typically 30-40 µm diam.) (Fig. 9) and their lighter color. The two species occasionally occur together and are easily separated by these two criteria.

Four species of Glomus, G. occultum Walker, G. diaphanum Morton & Walker, G. microcarpum Tul. & Tul., and G. pubescens (Sacc. & Ellis) Trappe & Gerd. produce small, hyaline or sub-hyaline spores that could be confused with those of G. microaggregatum. Glomus occultum resembles G. microaggregatum in the variation in spore shape, and spore sizes of the two species overlap (15-100 x 20-100 µm for G. occultum and 15-50 x 15-40 µm for G. microaggregatum). However, spores of G. occultum possess three walls of equal thickness, and no inner wrinkling wall is present during development (Morton, 1983). Furthermore, spores of G. occultum often appear roughened, while those of G. microaggre-

Figs. 6,7. Spores of similar Glomus species. 6. Glomus microcarpum (from Type material). Spores mounted in PVLG. Note apparent outermost wall (O) and thick inner wall (I), X2000. 7. Glomus pubescens. Spores mounted in water. Note thick outer wall (O) and membranous, wrinkling inner wall (I), X425.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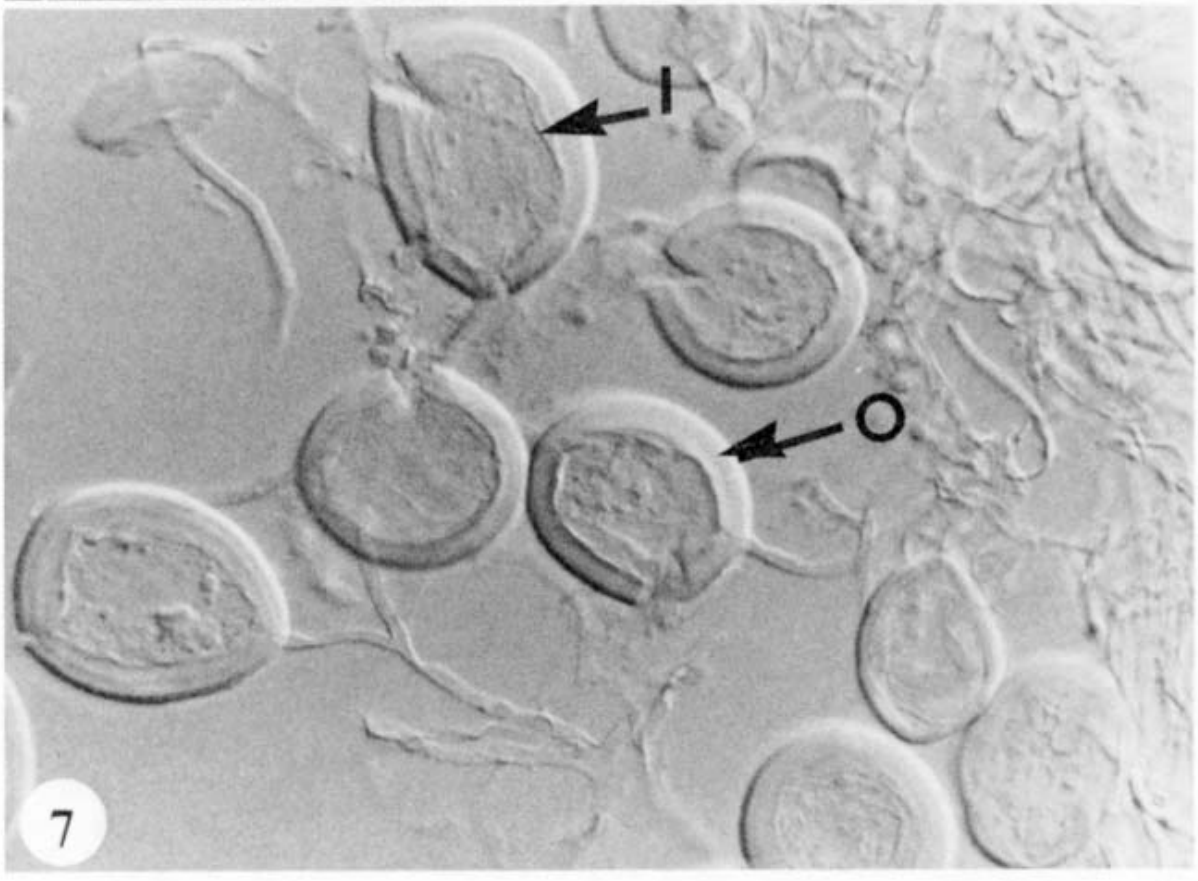
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gatum usually are smooth and, although sometimes hyaline when fresh, are pale yellow to yellow-brown after a few days in the PVLG mounting solution. The subtending hypha of spores of G. microaggregatum is very narrow, averaging about 3 µm wide compared to an average of about 4.3-6.5 µm for G. occultum (Morton, 1985). In addition, the walls of the subtending hypha of G. occultum are usually very thin (0.5 µm), while those of G. microaggregatum are usually 1 µm or more thick.

Spores of G. diaphanum possess an inner membranous wall that resembles wall 2 in some spores of G. microaggregatum. The outer wall of G. diaphanum is much thicker (2-6.5 µm) than that of the latter species. Also, spores of G. diaphanum typically are larger (39-121 µm diam) than those of G. microaggregatum. After a few weeks in PVLG, the hyaline spores of G. diaphanum and G. occultum turn a pale yellow color similar to that of spores of G. microaggregatum.

Glomus microcarpum produces spores similar in size and color to those of G. microaggregatum, but those of the former possess a laminated wall that is thicker (4-6 µm) than either of the two walls of G. microaggregatum. Berch and Fortin (1984) interpreted the spore wall structure of G. microcarpum as consisting of a single wall of the laminated type (Walker, 1983). Examination of Berch and Fortin's material by one of us (REK) led to a different interpretation: an outer unit wall (wall 1) surrounds a thick, laminated wall (wall 2) (Fig. 6). Berch (pers. comm.) believes that the apparent outermost wall is an artefact resulting from the lactic acid causing the outermost lamination of the laminated wall to separate, giving the appearance of a distinct unit wall. Regardless, the thick-walled spores with their wide subtending hyphae (4-8.5 µm) clearly are distinguishable from those of G. microaggregatum.

Glomus pubescens resembles G. microaggregatum in the size and color of its spores and in the narrowness of the attached hypha. However, spores of the former possess a robust laminated wall 2-7 µm thick (av. 3-4 µm) and are known to be produced only in well-organized sporocarps with distinctive peridial hyphae that form tufts on the surface of the sporocarp (Gerdemann and Trappe, 1974). Spores of G. pubescens, as seen in Thaxter's collections in the Farlow Herbarium, are more similar to those of G. microcarpum than to G. microaggregatum. In water mounts, spores of G. pubescens possess a thick outermost laminated wall to which is appressed an inner wrinkling, membranous wall 0.5 µm thick (Fig. 7). Spores mounted in PVLG appear to have an additional wall, a thin, outermost unit wall 1-2 µm thick appressed to the laminated wall.

Spores of G. microaggregatum were seldom found occurring freely in the soil. Unless the contents of dead spores of other VAM fungi were examined or roots were crushed open, spores of this species would have been overlooked.

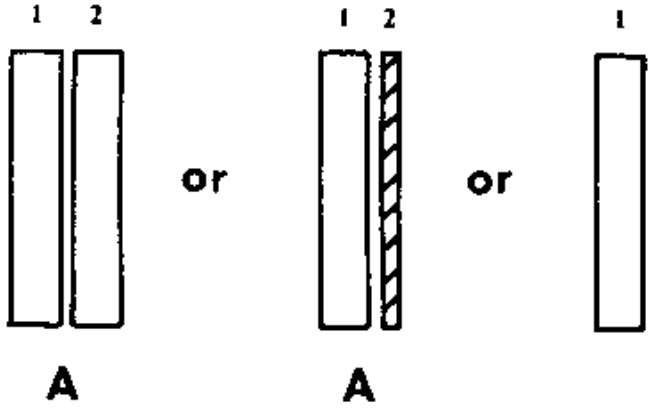

Fig. 8. Murographs of spore wall structure of Glomus microaggregatum. Spores with two walls predominate in most collections. See Text for explanation.

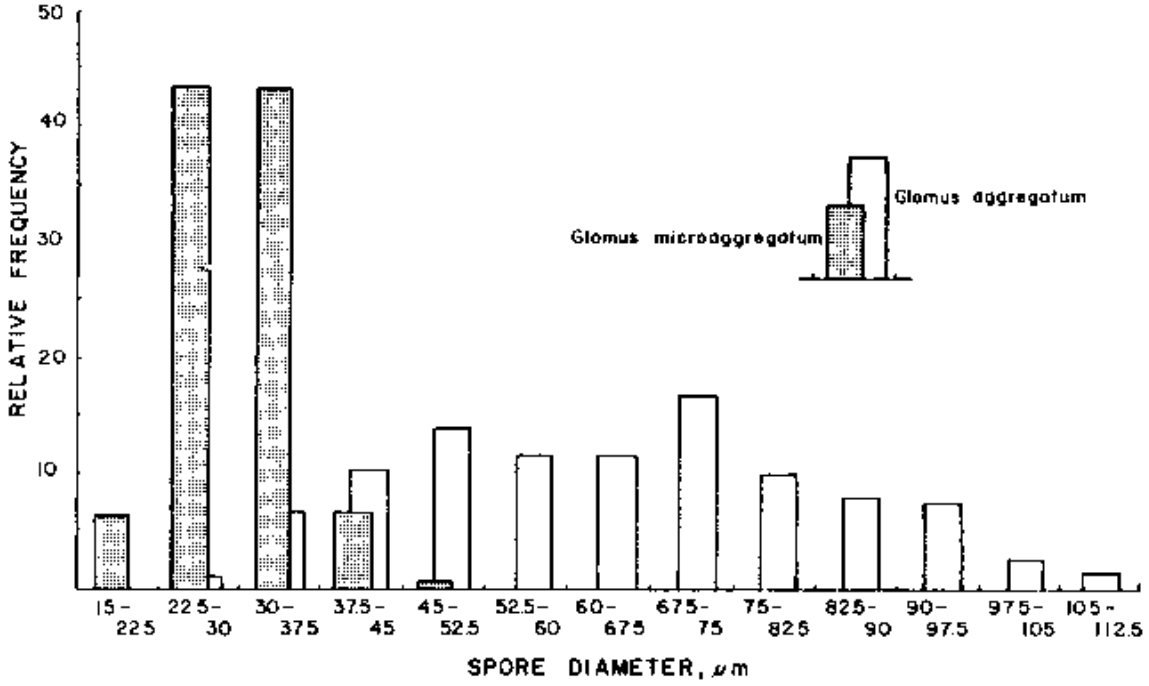

Fig. 9. Spore diameter frequency diagram. For non-globose spores, only the largest diameter was measured. Data for Glomus microaggregatum are from 5 collections representing 210 spores. For Glomus aggregatum, data are from 7 collections representing 189 spores.

ACKNOWLEDGEMENTS

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