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GIGASPORA RETICULATA: A NEWLY DESCRIBED ENDOMYCORRHIZAL FUNGUS FROM NEW ENGLAND*

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Collections of endogonaceous spores from sand dunes in Rhode Island and an orchard in Massachusetts yielded a previously unknown species of Gigaspora with unusually ornate spores. The species, here named Gigaspora reticulata sp. nov. forms arbuscular endomycorrhizae.

GIGASPORA RETICULATA Koske, Miller et Walker sp. nov. (Figs. 1-10)

Sporae cinnamomeae vel obscure castaneae, globosae vel subglobosae, 188 - 340 x 208 - 470 um, in solo singillatim genitae, lateraliter ad cellulam instar suspensoris efformatae. Sporarum tunica turmis duobus separatis strata reticulo alveolato inductis. Turma externa stratis tribus. Stratum exterius 0.5-1 um crassum, cinnamomeum vel castaneum, reticulo 0.5-1 um alto, pagina sporae inter cristas reticuli spinis gradatim decrescentibus vel cristis angustis 0.5-2 um altis. Stratum medium 5-11 um crassum,

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hyalinum vel luteolum, strato interiore 0.3-0.7 um crasso adhaerens. Turma interna stratis tribus. Stratum exterius et interius utrumque 1 um crassum, stratum medium 2 um crassum, amorphum. Cellula instar suspensoris 45-87 x 85-140 um, cinnamomea vel castanea. Vesiculae in solo 25-30 x 30-40 um, in fasciculis 10-40 numero, atrobrunneae vel castaneae, projecturis obtusis nodosis. Endomycorrhizae arbusculis formans.

Spores (azygospores?) orange-brown to dark red-brown, globose to subglobose, 208-470 x 188-340 um, borne singly in the soil, laterally on bulbous suspensor-like cells formed at the tips of thick-walled, sparsely septate or coenocytic pale-brown hyphae. Wall structure complex, consisting of two separate groups of wall layers overlain by an alveolate reticulum. Outer wall group three-layered. Outer layer 0.5-1 um thick, orange-brown to red-brown, supporting raised, straight to sinuous interconnecting ridges that form a reticulum 0.5-1 um high, with 4- to 8-sided meshes 2-24 x 2-30 um across. Spore surface between ridges covered with polyhedral, conical or subcylindrical spines, or narrow straight, curved, or angular ridges 0.5-2 um high and 0.25-0.5(-1) um apart; the spines 0.3-1.5 um diam at base, tapering to a point or a rounded tip less

FIGURES 1-9. *Gigaspora reticulata* spores by brightfield (B), differential interference contrast (DIC), or scanning electron (SEM) microscopy.

1. An intact spore showing the reticulate outer covering and the laterally attached bulbous suspensor-like cell (B).

2. The vesicles formed in the soil by *G. reticulata*.

3. A crushed spore that has lost or failed to develop fully the reticulate outer covering, the vestiges of which (ret) can be seen near the spore base. The flexible inner wall-group (iw) and the germination shield (gs) can clearly be seen (DIC).

4. A crushed spore showing the reticulate covering and the flexible inner wall group (iw) (B).

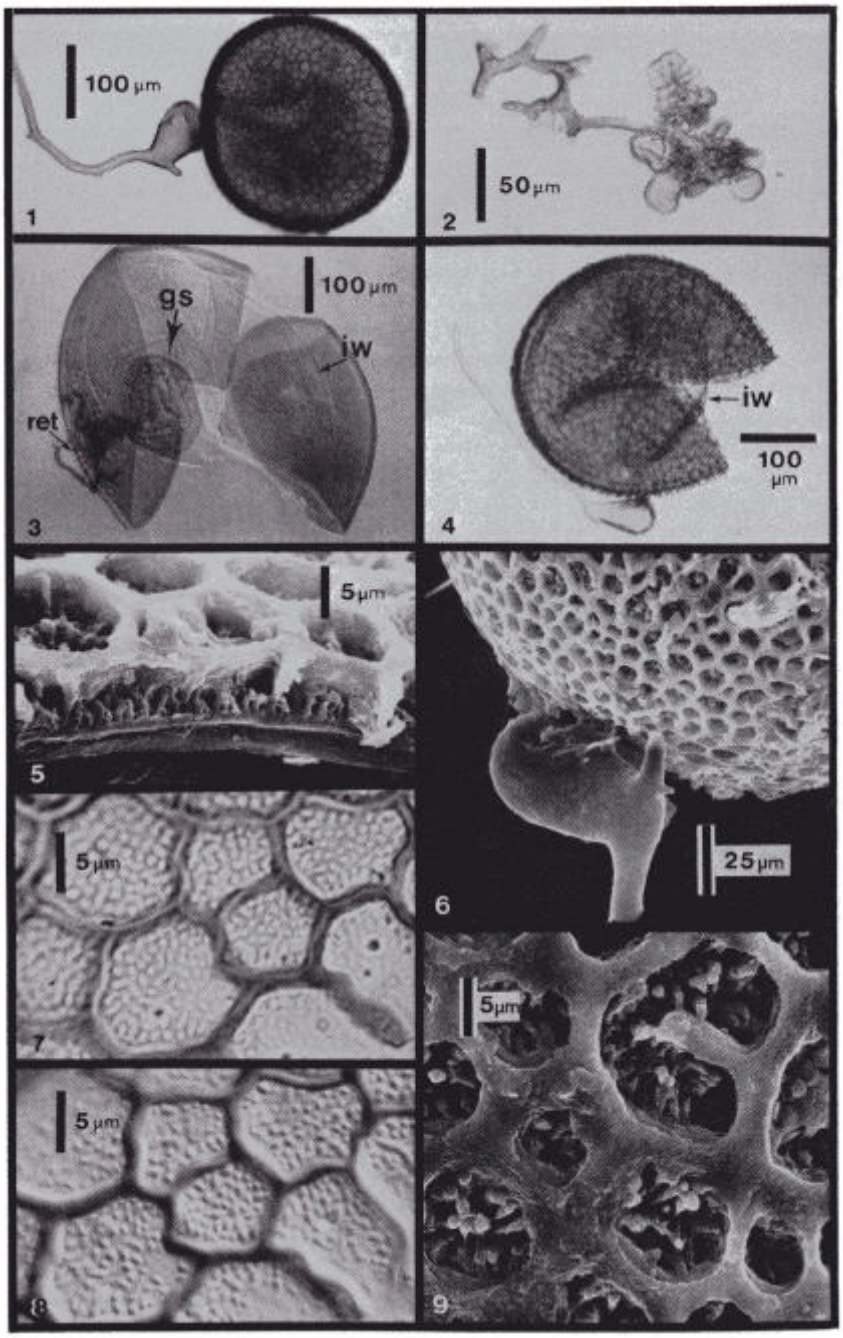
5. Detail of the outer wall-group. The alveolate reticulum, spiny layer, and thick, colored middle layer are evident. The thin, hyaline basal layer is not evident (SEM).

6. Base of a spore showing the bulbous suspensor-like cell with a peg-like hyphal protrusion (SEM).

7. Spore surface detail by brightfield microscopy.

8. Same part of spore surface as in Figure 7, but by differential interference microscopy.

9. Detail of reticulum showing alveoli filled with spines.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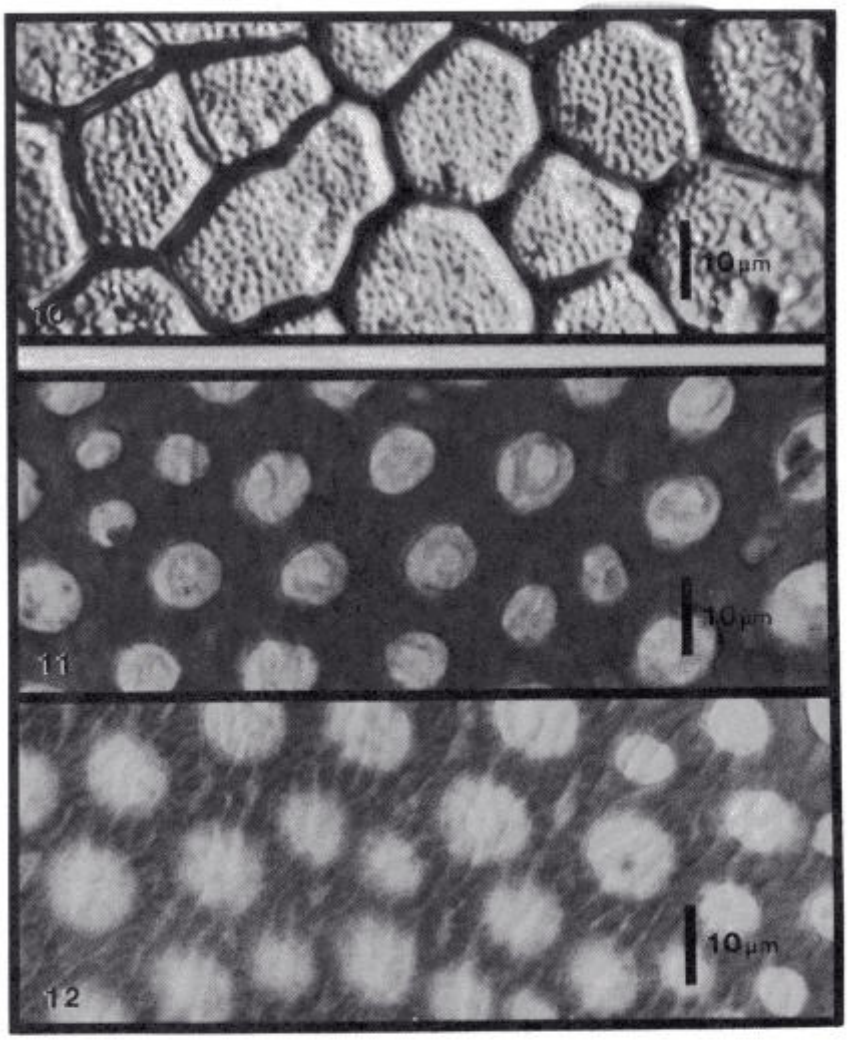

FIGURES 10-12. Light microscopy of outer wall-layers of *Gigaspora reticulata* (Figure 10) and *G. nigra* (Figures 11 and 12). Figures 11 and 12 show the even, rounded holes in the outer wall of the latter. Figure 10 shows the difference between the reticulate outer covering of the former and the apparently sinuous nature of the wall of *G. nigra* beneath the outer wall. This can be compared with the spines and ridges evident on *G. reticulata* in Figure 10.

than 0.5 um diam; the ridges 0.5-1 x 1-7 um at the base, tapering to a rounded edge less than 0.5 um wide. Middle layer hyaline to pale yellow, 5-11 um thick, tightly adherent to the thin, hyaline inner layer that is 0.3-0.7 um thick. Reticulate ridges on outer wall supporting a detachable alveolate reticulum 0.5-2 um wide and 2-6 um high. Inner wall group three-layered, consisting of membranous inner and outer hyaline layers each 1 um thick, connected by a hyaline amorphous middle layer 2 um thick. Outer and inner layers separating before germination to form a complex, circular to reniform germination shield, 94-156 x 156-208 um, from which germ tubes arise near the spore base.

Suspensor-like cell 45-87 x 84-140 um, with a peg-like protrusion extending 10-20 um towards the spore wall. Wall of suspensor-like cell laminated, orange-brown to red-brown, 3-5 um thick except near the spore-base where it thickens to 7-10 um; in some specimens, consisting of two distinct laminated layers, the inner layer 1.5-3 um thick, orange-brown to red-brown, the outer layer 2-7 um thick, hyaline to pale yellow.

Vesicles in the soil forming in clusters of 10-40 on somatic hyphae or around the suspensor-like cell, dark brown to red-brown, 25-30 x 30-40 um, with blunt, knobby projections 4-8 x 2-6 um.

Forming endomycorrhizae with arbuscules.

DISTRIBUTION AND HABITAT: Known from coastal sand dunes at the boundary with a saltmarsh, Sand Hill Cove, Rhode Island, and from a barrier sand dune at Moonstone Beach, Rhode Island. Also found in a Montauk soil (coarse-loamy, mixed mesic Typic Fragiochrepts (Soil Survey Staff, 1975)) in an orchard at Belchertown, Massachusetts. Associated, but not proved mycorrhizal, with roots of Phragmites communis Trinx, Ammophila breviligulata Fern., Myrica pensylvanic Loisel., Malus domestica Borkh., Prunus persica (L.) Batsch., Dactylis glomerata L., and Agropyron repens (L.) Beauv.

MYCORRHIZAL ASSOCIATIONS: Forming arbuscular mycorrhizae in greenhouse pot cultures with Sorghum sudanese (Piper) Staph. and Coleus x hybridus. Attempts to induce mycorrhizal formation with Allium sativa L. cv Agway sweet spanish, Zea mays L. cv seneca chief, and Malus domestica were not successful.

ETYMOLOGY: Latin, reticulata, referring to the prominent reticulate outer wallcovering of the spores.

COLLECTIONS EXAMINED: HOLOTYPE: RHODE ISLAND - Washington County, Sand Hill Cove, in rhizosphere of Phragmites communis on a sand dune. Collected 23 iii 1981 (Koske Collection # 286, Walker Accession # 379) (OSC; isotypes FH, K). PARATYPE: MASSACHUSETTS - Hampshire County, Belchertown, University of Massachusetts Horticulture Research Farm. Collected 13 viii 1980 (Miller accession # 56, Walker # 321) (OSC, ISC). OTHER COLLECTIONS: RHODE ISLAND, Washington County, Sand Hill Cove sand dunes, 4 iv 1979 collected by E. Ovsenik (Koske # 239): RHODE ISLAND - Washington County, Moonstone Beach sand dune, 9 ix 1978 (Koske # 201). In addition, specimens from pot cultures established with sorghum and coleus have been examined. Besides the specimens lodged in herbaria, samples have been retained in the collections of each suthor.

Gigaspora reticulata is readily distinguishable from other species in the genus by the prominent dark reticulum covering the spore surface. Only G. nigra J. F. Redhead in Nicolson & Schenck could be confused with G. reticulata, but these two differ distinctly. G. reticulata has globose to subglobose spores 188-340 x 208-470 (mean 264 x 281) um, considerably smaller than spores of G. nigra, which are globose and 297-1050 (mean 402) um in diameter. In addition, spores are much darker than those of G. reticulata , being dark brown to black compared with orange-brown to dark red-brown. The main difference between the species, however, is in the wall structure. G. reticulata has an outer wall covered by rounded spines and ridges that are contained, but not overlain, by a polygonal reticulum with ridges 0.5-2 um wide and meshes varying from 2 x 2 to 24 x 30 um across (Figure 10). The inner wall-group of G. reticulata consists of two membranous walls apparently fastened together by an amorphous middle layer. G. nigra, in contrast, has a distinct outer wall pitted by rounded pores 7-10 um diam, overlaying a second wall made up of coiled elements (Nicolson & Schenck, 1979; Old et al., 1973) that appear as densely packed, sinuous rods by light microscopy (Figures 11 and 12). The inner wall-group in this species consists of a continuous, laminated wall surrounding two thin, membranous walls.

G. reticulata spores tend to lose their suspensor-like cells during sieving from the soil and can then be confused with spores of fungi in the genus Acaulospora. The resemblance of this species to A. bireticulata Rothwell & Trappe is particularly striking, and the plates in Rothwell and Trappe (1979) and Walker and Trappe (1981) (Figure 2 amd Figure 12, respectively) are almost indistinguishable from Figures 7, 8, and 10 in this paper. Care should therefore be taken when identifying spores in this group to verify the nature of the attached hyphae.

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