

## BRIEF ARTICLES

### *GLOMUS PANSIHALOS*, A NEW SPECIES IN THE ENDOGENACEAE, ZYGOMYCETES

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Collections of soil from the root zone of ferns in Ontario, Canada, and dune plants in California, New Jersey, and Michigan, contained spores of an undescribed *Glomus* species. The spores were identical to those in a collection that had previously been sent to J. W. Gerdemann, but for which no collection data were available. Collections are deposited in the herbarium of Oregon State University (OSC), Farlow Herbarium (FH), and Kew (K). Spore wall terminology follows that of Walker (1983). Polyvinyl alcohol (PVL) is used as a semi-permanent mounting medium (Walker, 1983; Koske and Tessier, 1983).

*Glomus pansihalos* Berch et Koske, *sp. nov.*

FIGS. 1–4

Sporocarpia irregularia, usque ad  $15 \times 12 \times 7$  mm, brunneola vel brunnea, hyphis abundantibus, radicibus et materiis alienis diversis. Peridium destitutum. Gleba pallide vel obscure brunnea, sporis, hyphis, radicibus, at arena immixta. Sporae globosae, subglobosae, ellipsoideae, vel irregulares,  $(108\text{--})155\text{--}(200) \times (110\text{--})130\text{--}(180)$   $\mu\text{m}$ , avellaneae vel obscure croceis. Tunicae sporae tres, inseparabilis: exterior hyalina,  $3\text{--}5\text{--}(15)$   $\mu\text{m}$  crassa, granularis, in acid lactico vel alcoholi polyvinilo in columnis scabris, hyalinis vel luteolis, radiatis tumescens; media gilva vel ferruginea,  $3\text{--}8$

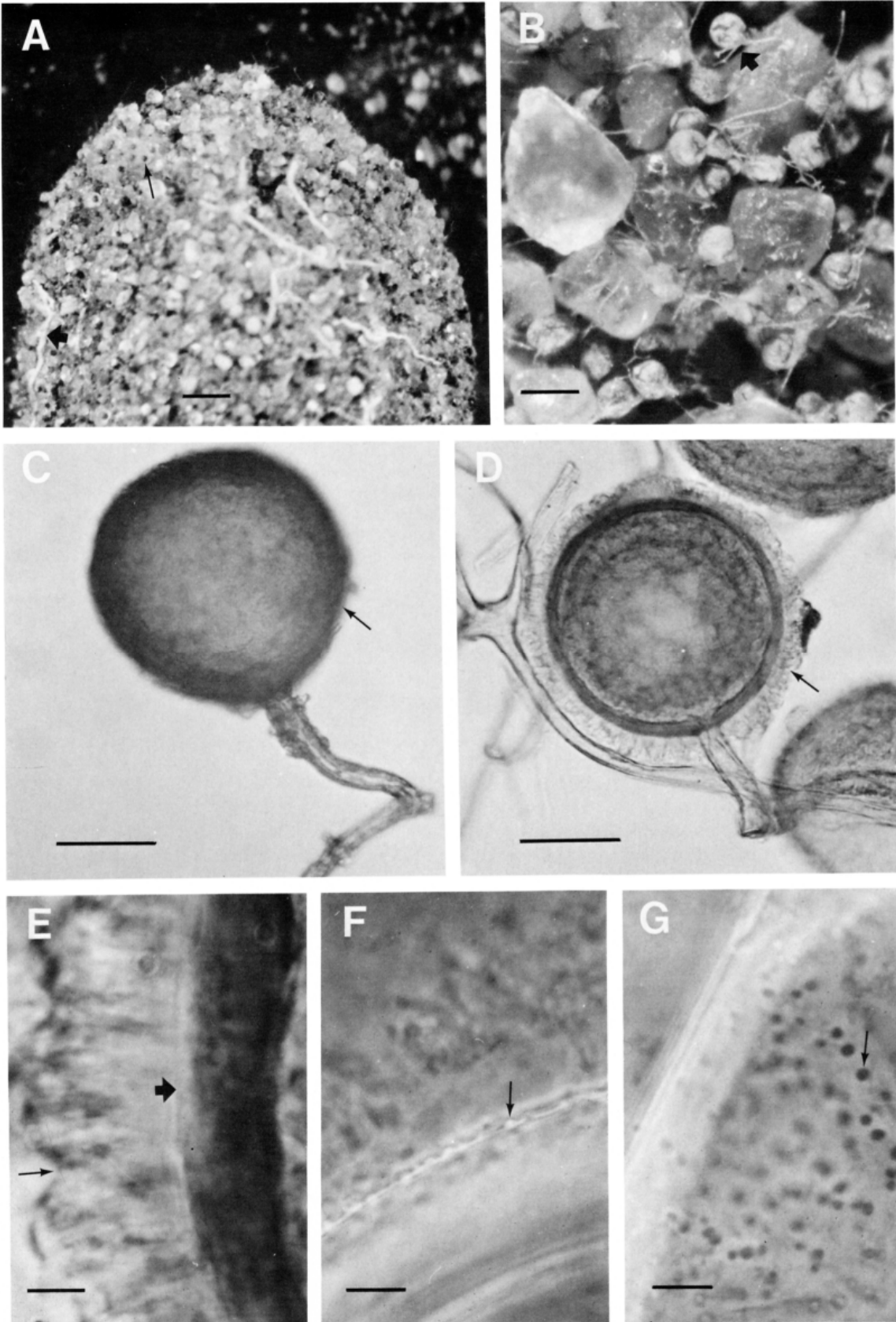
$(\text{--}38)$   $\mu\text{m}$  crassa, laminata, in pagina externa verruculis ornata; interior gilva,  $1\text{--}2$   $\mu\text{m}$  crassa. Hypha sustinens ad sporae basim  $10\text{--}20$   $\mu\text{m}$  diam, glandacea, tunica tribus. Holotypus Koske 558 (OSC), Insula San Mi-gueli, California.

*Sporocarps*: irregularly ellipsoid, up to  $15 \times 12 \times 7$  mm, light or dark brown, containing abundant hyphae, roots, and foreign material. *Peridium*: absent. *Gleba*: light or dark brown, composed of intermixed spores and hyphae, also containing roots and sand.

*Spores*: globose, subglobose, ellipsoid, or irregular,  $(108\text{--})130\text{--}155\text{--}(200) \times (110\text{--})120\text{--}130\text{--}(180)$   $\mu\text{m}$ , yellowish-brown to dark brownish-orange in transmitted light, in incident light surface of dried spores off-white, opaque and flaky, cracking to expose darker inner spore walls, borne on a single subtending hypha, singly in soil or in plant roots, in small numbers in loose clusters, or in multi-spored loose sporocarps. *Wall of spore* (see micrograph, FIG. 2): composed of a single group: *group A* consists of three inseparable walls: *wall 1* in water mount hyaline,  $3\text{--}5\text{--}(15)$   $\mu\text{m}$ , expanding, granular, swelling in lactic acid or PVL into roughened, hyaline or light yellow columns that radiate up to  $100$   $\mu\text{m}$  from

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FIG. 1. *Glomus pansihalos* Berch and Koske. A. Part of sporocarp consisting of sand, spores (small arrow), and roots (large arrow), bar = 1 mm. B. Surface of sporocarp illustrating spores borne on hyphae (large arrow) intermingled with sand and debris, bar =  $200$   $\mu\text{m}$ . C. Spore mounted in water, wall 1 (arrow) unexpanded, bar =  $50$   $\mu\text{m}$ . D. Spore mounted in lactic acid, wall 1 expanded (small arrow), bar =  $50$   $\mu\text{m}$ . E. Structure of walls in lactic acid, expanded wall 1 (small arrow), wall 2 (large arrow), bar =  $5$   $\mu\text{m}$ . F. Optical section of wall 2 in lactic acid illustrating warts (small arrow), bar =  $5$   $\mu\text{m}$ . G. Surface view of wall 2 illustrating hemispherical warts (small arrow), bar =  $5$   $\mu\text{m}$ .



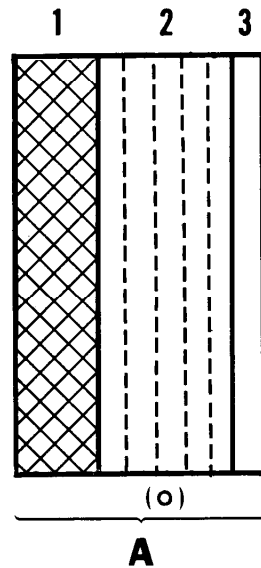


FIG. 2. Murograph of spore wall of *Glomus pansihalos*. Wall structure is composed of an outermost wall (1) that swells in lactic acid; a colored, laminated wall (2); and a colored unit wall (3). Terminology, symbols, and graphics follow Walker (1983).

outer surface of wall 2 or may dissolve completely; wall 2 yellow-orange to brownish-orange, 3–8(–38)  $\mu\text{m}$ , laminate, unchanged in lactic acid or PVL, outer surface covered with hemispherical warts smaller than  $1 \times 1 \times 1 \mu\text{m}$  and spaced 1–5  $\mu\text{m}$  apart; wall 3 yellow-orange, 1–2  $\mu\text{m}$ , unit, unchanged in lactic acid or PVL.

*Subtending hypha*: flared, straight, or constricted, 10–20  $\mu\text{m}$  at point of attachment, widening to 17–20  $\mu\text{m}$  below point of attachment, yellow-brown, paler than spore wall, typically single, infrequently double, perpendicular to spore or recurved. *Wall of subtending hypha*: composed of 1–3 walls continuous with those of spore, totalling 5  $\mu\text{m}$  thick at point of attachment, thinner distally: wall 1 may extend along subtending and vegetative hyphae, becoming thin and patchy. *Pore in subtending hypha*: occluded by wall 3 or open.

*Reaction to Melzer's reagent*: wall 1 turns light yellow, but remains contracted and granular; wall 2 turns red-brown starting at the broken edges, and wall 3 is unaffected. *Reaction to cotton blue*: not distinctive. *Reaction to KOH*: not distinctive. *Reaction to lactic acid*: wall 1 swells into roughened, hyaline or light yellow columns that radiate up to 100  $\mu\text{m}$  from the outer surface of wall 2, and may dissolve completely. *Reaction*

*to polyvinyl alcohol (PVL)*: similar to reaction to lactic acid.

*Type of mycorrhiza*: unknown.

**DISTRIBUTION AND HABITAT**: Associated with sand dune soils in California, New Jersey, and Michigan, and from forest soils in southern Ontario, Canada. Gerdemann's specimen, for which no collection data exist, appears to be from a dune site.

**MYCORRHIZAL ASSOCIATIONS**: In the field with *Abronia maritima* Nett. ex Wats., *Ambrosia chamissonis* Less., *Andropogon* sp., *Artemisia* sp., *Distichlis spicata* (L.) Greene, *Malacothrix* sp., *Mesembryanthemum* sp., *Solidago sempervirens* L., *Athyrium thelypteroides* Desvaux, and *Thelypteris palustris* Schott.

**ETYMOLOGY**: From Latin, "pandere"—to spread out, and "halos"—halo, referring to the swelling of spore wall 1 in lactic acid and PVL.

**COLLECTIONS EXAMINED**: HOLOTYPE: UNITED STATES, California, Santa Barbara Co., San Miguel Island, in soil under *Abronia maritima*/*Ambrosia chamissonis*, 5/VII/1984, Koske 558 (OSC; isotypes FH, K). PARATYPE: Collection information unknown, in sand, received by J. W. Gerdemann (OSC). OTHERS: CANADA, Ontario, Waterloo Co., near Waterloo, mixed deciduous forest, soil beneath *Athyrium thelypteroides* Desvaux, VII/1978, Berch 97C; Ontario, near Paris, from soil beneath *Thelypteris palustris* Schott, VI/1978, Berch 35A. 5-12. UNITED STATES, California, San Miguel Island, in soil under various dune plants (see "Mycorrhizal Associations," above), 5 and 6/VII/1984, Koske 552, 555, 570, 579, 586, 587, 588, 589; New Jersey, Cape May Co., Cape May Pt., in soil under *Solidago sempervirens*, 13/IV/1982, Koske 402; Michigan, Benzie Co., Sleeping Bear Dunes National Seashore, in soil beneath *Andropogon* sp., 16/X/1984, Olexia 73.

Spore diameter frequency over the range 100–199  $\mu\text{m}$  is diagrammed in FIG. 3. Most of the spores observed fit within the range 130–150  $\mu\text{m}$ .

*Glomus pansihalos* is easily distinguished from other specimens by the striking reaction of the outer spore wall to lactic acid or PVL solution (which contains lactic acid). Upon treatment with lactic acid, granular wall 1 immediately expands markedly, forming radiating columns (FIG. 1D, E) that give the appearance of a corona. The swelling of wall 1 in lactic acid is greatest with fresh spores, typically expanding 20–50(–100)  $\mu\text{m}$  outward from wall 2. The wall of previously dried spores expands up to 15  $\mu\text{m}$ . Spores that have been preserved on PVL slides for 1–2 years sometimes appear to have lost the outermost, expanded wall. The wall has either dissolved or its refractive index has become the same as the PVL. Wall 1 of some spores that had been fixed in FAA for a few months did not swell in PVL. Even if the outer wall has been lost or does not swell, spores can be identified by the character-

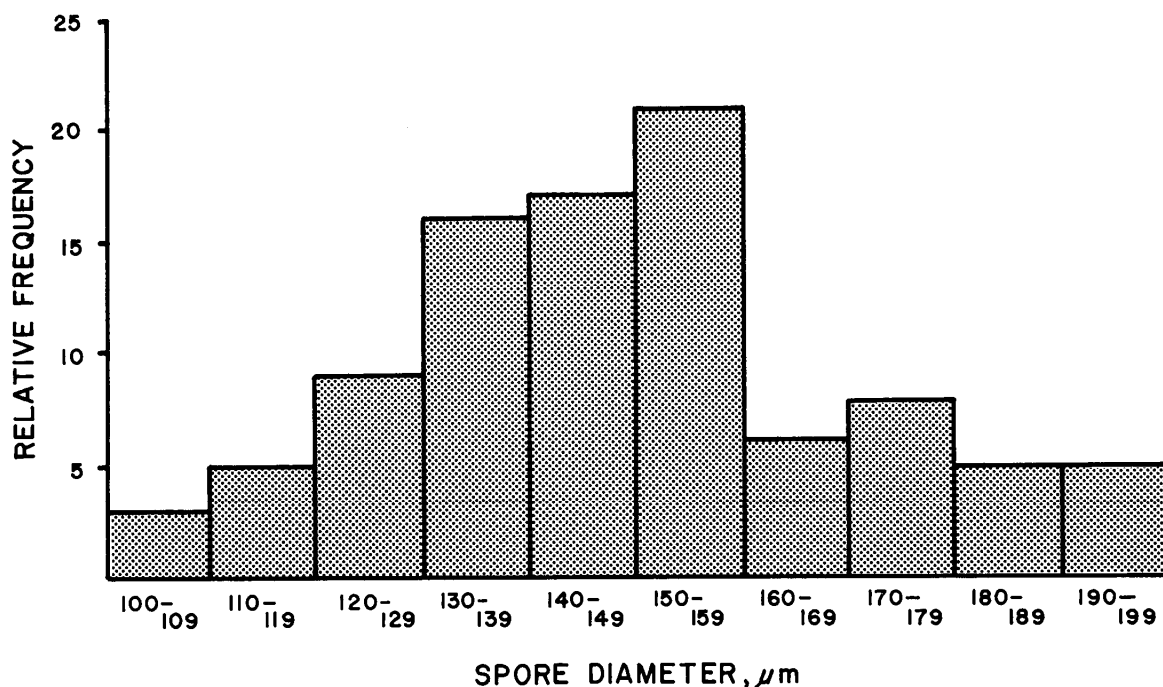


FIG. 3. *Glomus pansihalos* spore diameter frequency diagram. For non-globose spores, only the largest diameter was measured.

istic, uniformly sized warts on wall 2 (FIG. 1G). These warts may be obscured by the granular wall 1 (if present), particularly in water mounts. Their presence is revealed by viewing the edge of the spore (FIG. 1F).

We refer to wall 1 as "expanding," a term we propose to add to the terminology for spore wall structure introduced by Walker (1983). Although wall 1 of *G. pansihalos* may disappear after treatment with lactic acid or PVL, we have never observed this disappearance on spores collected directly from soil. Wall 1 seems to persist under natural conditions and only occasionally evanesces when subjected to certain chemicals. We think the new term "expanding" is necessary to categorize this previously undescribed type of wall. We define the term as: "Expanding"—expands markedly when treated with certain chemicals such as lactic acid or polyvinyl alcohol. Designated in the murograph with crosshatching (FIG. 2) and in the muronym (Walker, 1983) by the letter "X."

Typically, wall 2 is markedly laminated. In spores with very thick walls, the laminations of wall 2 may separate, and the wall appears to be composed of two subequal walls. Of the three walls, wall 2 varies most in thickness (FIG. 4). In

nearly 50 of the spores examined, it measured 3–5 μm. In some spores in plant roots, however, it was up to 38 μm thick.

The subtending hypha of *G. pansihalos* is variable in its attachment to the spore, ranging from flared to constricted. A few spores in the collections from San Miguel Island had two subtending hyphae, one at each end of an ellipsoidal spore. Subtending and vegetative hyphae frequently contain thin-walled intra-hyphal hyphae, such as seen in *G. fasciculatum* (Thaxter *sensu* Gerde-mann) Gerd. and Trappe (Lim *et al.*, 1983) and *G. aggregatum* Schenck and Smith (Koske, 1985).

Spore wall composition of *G. pansihalos* is similar to that of *G. macrocarpum* Tul. and Tul., *G. australe* (Berk.) Berch, and *G. caledonium* (Nicol. and Gerd.) Gerd. and Trappe. Only in *G. pansihalos*, however, does the outer wall react to lactic acid by swelling into a distinct halo composed of columnar elements. In addition, among these four species, only *G. pansihalos* has distinct, hemispherical warts on the outer surface of wall 2.

Wall 2 of spores of *Glomus monosporum* Gerd. and Trappe is colored and ornamented, but the ornamentation consists of closely packed, angular projections rather than the more widely

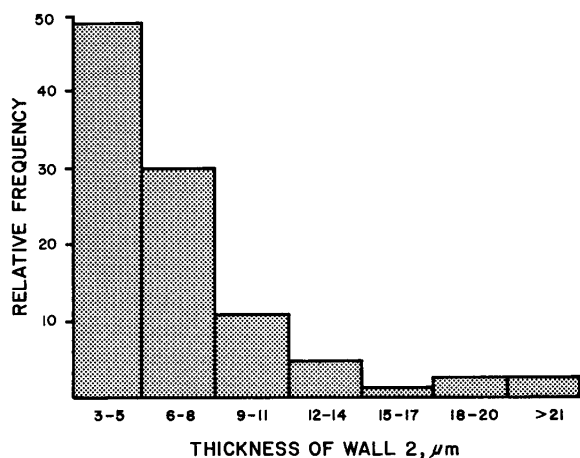


FIG. 4. *Glomus pansihalos* wall thickness frequency diagram. Data are shown only for wall 2, which varied most in thickness.

spaced, round warts of *G. pansihalos*. The outer surface of wall 2 of *G. caledonium* may appear roughened but lacks distinct warts.

*Glomus pansihalos* has previously been reported as *Glomus* sp. (halo) by Berch (1979), who found it in the root zone of the ferns *Athyrium thelypteroides* and *Thelypteris palustris* growing in mixed hardwood forests in southern Ontario, Canada.

We thank Dr. J. Trappe for reviewing the manuscript and for preparing the Latin diagno-

sis, P. Olexia for samples from Michigan, Chris Nerone for preparing Figs. 3 and 4, R. Shesath for suggesting the frequency diagrams, Dr. W. L. Halvorson, National Park Service, for making possible the sampling of San Miguel Island, and F. Ugolini for assistance in collecting samples. The senior author is grateful to the USDA Forest Service and the Natural Sciences and Engineering Research Council of Canada for partial support.

Key Words: *Glomus pansihalos*, Endogonaceae, taxonomy, spore wall structure.

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