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ENTROPHOSPORA BALTICA SP. NOV. AND GLOMUS FUEGIANUM, TWO SPECIES IN THE GLOMALES FROM POLAND

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Abstract

Two fungal species, *Entrophospora baltica* sp. nov. and *Glomus fuegianum* (Glomales, Zygomycetes), are described and illustrated. *Entrophospora baltica* forms orange, (110–)177(–200) µm diam spores within the neck of sporiferous saccule. The spores and sporiferous saccules are enveloped in a sinuate hyphal mantle. Spore wall structure consists of five walls in two groups. Group A is composed of a hyaline, evanescent outermost wall, an orange, unit wall ornamented with warts, and a hyaline, laminated wall. A hyaline, membranous wall and a hyaline, coriaceous wall form group B. *Entrophospora baltica* occurred among roots of plants colonizing maritime sand dunes in northwestern Poland. *Glomus fuegianum* produces clusters of spores occurring singly in the soil or aggregated in sporocarps. Spore–groups are composed of radially arranged spores developed from a thick–walled, inflated hypha. The pale yellow to brown spores frequently are enveloped by branched and convoluted hyphae. Spores have one wall with two layers: a hyaline, sloughing outer layer adherent to a colored, laminated layer. *Glomus fuegianum* seems to be an extremely rarely occurring fungus in Poland. This fungus was recovered from three soil samples collected from the root zone of *Juniperus communis* growing in the inland sand dunes of the Kampinos National Park. This fungus is new to the mycota of Poland.

Key Words: *Entrophospora*, Glomales, *Glomus*, sand dunes, taxonomy, Zygomycetes

Introduction

During investigations of the occurrence of arbuscular mycorrhizal fungi in Poland, two earlier unrecorded fungi were recovered from beneath plants colonizing sand dunes. One of them is described here as *Entrophospora baltica*, sp. nov.

Materials and Methods

Collection of soil and root samples, as well as establishment of trap and single-species pot cultures were made as previously described (Błaszkowski, 1997a). The host plants used were *Plantago lanceolata* L., *Sorghum sudanense* (Staph.) Piper, and *S. vulgare* Pers. Plants were grown in a greenhouse at 18–30°C with supplemental 16-h lighting provided by one SON-T AGRO sodic lamp (Philips Lighting Poland S. A.) placed 1 m above pots. The maximum light intensity was 180 µE $m^{-2}s^{-1}$ at pot level. Plants were watered 2–3 times a week. Trap cultures were harvested at *ca* 1-mo intervals, beginning 5 months and ending 12 months after plant emergence. Spores were extracted by wet sieving and decanting (Gerdemann and Nicolson, 1963). Roots were stained in 0.05% trypan blue (Phillips and Hayman, 1970) and examined for the presence of mycorrhizae.

Because single-species cultures failed, morphological investigations of both fungi were performed on field-collected specimens and those coming from trap cultures. At least 100 sporocarps or spores of each species mounted in polyvinyl alcohol/lactic acid/glycerol (PVLG; Koske and Tessier, 1983) were examined. Additionally, *ca* 20 specimens of each fungus were investigated in a mixture of PVLG and Melzer's reagent (1:1, v/v). Specimens for scanning electron microscopy examination were fixed in 3% glutaraldehyde in a 0.02 M phosphate buffer (pH 6). They were then dehydrated in a graded ethanol series: 30, 50, 80 and 100%, critical point dried, mounted on aluminum stubs, and coated with gold. Wall characteristics of spores and terminology are those suggested by Franke and Morton (1994) and Spain *et al.* (1989) in respect to *Glomus fuegianum*, and Walker (1983, 1986) in respect to *E. baltica*. Although no ontogenetic investigations of *Glomus fuegianum* were conducted, results of Błaszkowski's (1997a), Błaszkowski and Tadych's (1997), Morton's (1996), Stürmer and Morton's (1997) studies suggest that subcellular structures of spores of all *Glomus* spp. are components of one spore wall, termed wall layers. Spore color was examined under a dissecting microscope on fresh specimens immersed in water. Color names are from Kornerup and Wanscher (1983). Specimens have been mounted on slides in PVLG and deposited in the Department of Plant Pathology (DPP), Academy of Agriculture, Szczecin, Poland. Specimens of the newly described species are also placed in the herbarium at Oregon State University (OSC), USA. Nomenclature of other fungi follows Almeida and Schenck (1990) and Walker and Trappe (1993). The classification is that of Morton and Benny (1990).

Descriptions and Discussions

Entrophospora baltica Błaszkowski, Madej & Tadych *sp. nov.*
Figs. 1–6

Sporocarpia ignota. Sporae singulae in solo efformatae, intra sacculum sporangiferum gestae. Sporae pallide aurantiacae vel aurantiacae; globosae vel subglobosae; (110–)177(–200) µm diam; aliquando ovoideae; 135–210 x 170–240 µm. Sporae at sacculi cum tunica e hyphis sinuosis, hyalinis vel pallide luteis, 2.5–10 µm latis, e tunicis 1–2 µm crassis; tunica rufa in solutione

Melzeri. Tunica sporae e stratis quinque (1–5) in turmis duabus (A, B). Turma externa e stratis tribus (strati 1–3); uno caduco, hyalino, (1.5–)2.0(–2.5) µm crasso; duobus rigido, pallide aurantiaco vel aurantiaco, (1.1–)1.3(–1.7) µm crasso, e verrucis, 0.6–0.8 µm altis; tribus laminato, hyalino, (1.5–)2.1(–2.7) µm crasso. Turma interna e stratis duabus (strati 4, 5); quarto membranaceo, hyalino, (0.5–)1.0(–1.3) µm crasso; quinque coriaceo, hyalino, (2.1–)2.7(–3.3) µm crasso. Sacculus sporangifer hyalinus vel pallide luteus; globosus vel subglobosus; (100–)170(–210) µm diam.

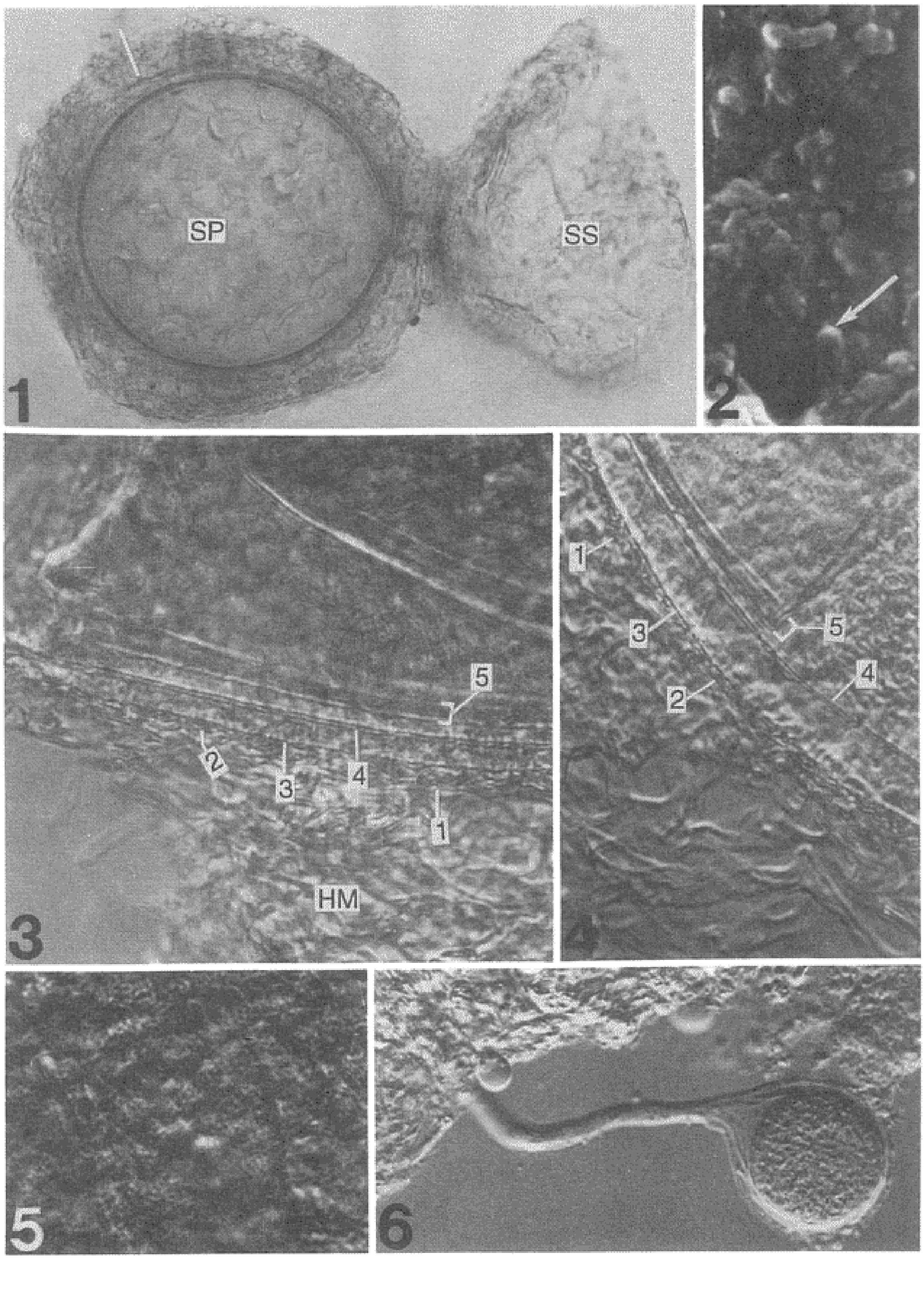
HOLOTYPUS. Poland. Świnoujście, infra *Ammophila arenaria* Link, 1 Oct. 91, *Błaszkowski, J., 2148* (DPP).

Sporocarps unknown. Spores formed singly in the soil, within the neck of a sporiferous saccule (Fig. 1).

Spores pale orange (6A3) to orange (6A8); globose to subglobose; (110–)177(–220) µm diam; sometimes ovoid, 135–210 x 170–240 µm. Spores and sometimes sporiferous saccules covered with a hyphal mantle (Figs. 1, 3, 4). Hyaline, globose to subglobose, 18–22.5 µm diam *Glomus*-like vesicles infrequently associated with a hyphal mantle (Fig. 6).

Mantle hyaline to pale yellow (3A3), 10–40 µm thick, composed of hyaline to pale yellow (3A3) interwoven, sinuous hyphae, 2.5–10 µm wide, with walls 1–2 µm thick (Figs. 1, 3, 4); staining lake red (9C8) in Melzer's reagent.

Figs. 1–6. *Entrophospora baltica*. **1.** Spore (SP) with sporiferous saccule (SS). Hyphal mantle (HM) and wall 1 are seen. Bright-field microscopy (BFM), x198. **2.** Some conical warts are arrowed. Scanning electron microscopy (SEM), x876. **3** and **4.** Spore walls 1–5 and hyphal mantle (HM). Differential interference contrast (DIC), x811. **5.** Spore surface in plan view (DIC), x986. **6.** *Glomus*-like vesicle associated with hyphal mantle (DIC), x986.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Spore wall structure (Figs. 1, 3–5) of five walls (1–5) in two groups (A, B). Group A consisting of three adherent walls (walls 1–3). Wall 1 evanescent, hyaline, (1.5–)2.0(–2.5) µm thick. Wall 2 unit, pale orange (3A3) to orange (6A8), (1.1–)1.3(–1.7) µm thick, ornamented with evenly distributed warts, 0.6–0.8 µm high (Figs. 2, 5). Wall 3 laminated, hyaline, (1.5–)2.1(–2.7) µm thick. Group B consisting of two separable hyaline walls (walls 4, 5). Wall 4 membranous, (0.5–)1.0(–1.3) µm thick. Wall 5 coriaceous, (2.1–)2.7(–3.3) µm thick.

Sporiferous saccule hyaline to pale yellow (3A3); globose to subglobose; (100–)170(–210) µm diam. *Saccule wall* of a granular, hyaline, 0.5–0.8 µm thick outer layer adherent to a smooth, hyaline inner layer, *ca.* 1 µm thick. Spores occasionally with a cylindric or funnel-shaped stalk projecting into the sporiferous saccule and with a short subtending hypha, usually present at the opposite the saccule. *Stalk* maize yellow (4A6) to deep yellow (4A8); 10–70 µm long, 15–35 µm wide at the spore base, broadened up to 112 µm when funnel-shaped, with laminated walls, 3.4–3.9 µm thick; stalk surrounding a hole, 15–32.5 µm diam. *Subtending hypha* pale yellow (4A3); 15–25 µm long, 13–16 µm wide at the spore base, with walls 2.8–3.7 µm thick at the spore base. Saccule collapsing at maturity. Spores and saccule not reacting in Melzer's reagent.

DISTRIBUTION AND HABITAT. *Entrophospora baltica* was recovered from six soil samples taken under three plant species growing in maritime sand dunes adjacent to Świnoujście in northwestern Poland (53°55'N, 14°14'E). Examination of over 600 other samples of dune soils and almost 600 soil samples from under non–dune uncultivated and cultivated plants did not reveal spores of this fungus. The plants associated with *E. baltica* were *A. arenaria, Artemisia campestris* L., and *Petasites spurius* (Retz.) Rchb. The spore abundance of *E. baltica* in the six soil samples in which this new fungus occurred ranged from 1 to 70 (mean 27.17) in 100 g dry soil. The proportion of *E. baltica* spores in the whole populations of recovered spores of arbuscular fungi ranged from 0.37 to 56.9% (mean 17.52%). The arbuscular mycorrhizal fungal species richness in samples containing *E. baltica* ranged from 2 to 5 (mean 3.0) in 100 g dry soil. Other species of arbuscular fungi isolated with *E. baltica* were an undescribed *Acaulospora* sp., *Glomus aggregatum* Schenck & Smith emend Koske, *G. constrictum* Trappe, *G. corymbiforme* Błaszk., *G. etunicatum* Becker & Gerd., *G. fasciculatum* (Thaxter) Gerd. & Trappe emend. Walker & Koske, *G. macrocarpum* Tul. & Tul., *G. mosseae* (Nicol. & Gerd.) Gerd. & Trappe, *G. pustulatum* Koske et al., *G. rubiforme* (Gerd. & Trappe) Almeida & Schenck, and an undescribed *Glomus* sp.

The soil chemical properties of the dunes adjacent to Świnoujście are: pH, 3.8–6.7; NO_3 (mg L^{-1}), 20–72; P, 5–12; K, 2–26; Mg, 10–41; Na, 4–23; Cl, 15–25; KCl, 0.1–0.6; organic C (%), 0.1–1.1 (Błaszkowski, 1995).

MYCORRHIZAL ASSOCIATIONS. *Entrophospora baltica* was associated with vesicular–arbuscular mycorrhizae of *A. arenaria* and *P. spurius*. The fungus failed to form mycorrhizae in pot cultures with *S. sudanense* and *P. lanceolata.*

ETYMOLOGY. Latin, *baltica*, referring to the Baltic Sea to which the dunes harboring this fungus adhere. We wish to dedicate this species to Prof. Dr. Hab. Janina Jasnowska, a prominent biologist and the former head of the Department of Botany, Academy of Agriculture, Szczecin.

COLLECTIONS EXAMINED. HOLOTYPE. POLAND. Świnoujście, under *A. arenaria*, 1 Oct. 1991, *Błaszkowski, J., 2148* (DPP); isotypes: *Błaszkowski, J., 2149–2170* (DPP) and two slides at OSC.

OTHER MATERIALS EXAMINED. POLAND. Świnoujście, under *P. spurius*, 1 Oct. 1991, *Błaszkowski, J., unnumbered collections* (DPP).

Spores of *E. baltica* are distinctive in being enveloped in a sinuate hyphal mantle and having a unique wall structure. The mantle consists of tightly interwoven thin–walled hyphae that evenly cover the spores and sometimes occur on the sporiferous saccule (Figs. 1, 3, 4). The presence of short hyphae on the surface of immature spores and the lack of the evanescent outermost wall 1 in crushed spores with a separated mantle suggest this mantle to be formed by hyphae developing from wall 1. Wall 1 is visible in most intact spores (Fig. 1). Wall 2 is always present and sometimes detaches from wall 3 in uncrushed spores mounted in lactic acid. Wall 3 consists of two to three laminae usually separating from each other in vigorously crushed spores. Wall 4 is a typical membranous wall. The coriaceous wall 5 is flexible and does not crack, although it is much thicker than the membranous wall 4.

Entrophospora baltica differs greatly from the four described species of the genus *Entrophospora* in appearance, morphology of the spore ornamentation, and in spore wall structure. None of the species of *Entrophospora* forms spores enveloped in a hyphal mantle. *Entrophospora infrequens* (Hall) Ames & Schneider and *E. kentinensis* Wu & Liu produce ornamented spores (Ames and Schneider, 1979; Wu *et al.*, 1995). However, the ornamentation of the former species consists of vacuolated projections developing from a laminated wall. The latter fungus produces spores with pits, also positioned in a laminated wall. In contrast, spores of *E. baltica* are ornamented with warts present on a unit wall adherent to a laminated wall (Figs. 2, 3–5). Spores of *E. baltica* and *E. infrequens* have an innermost coriaceous wall in group B, but those of the latter lack the penultimate membranous wall of the former. The only other arbuscular fungal species with spores having a membranous wall adherent to a coriaceous innermost wall is *Acaulospora gerdemannii* N. C. Schenck & T. H. Nicolson (Morton *et al.*, 1997). The other species of *Entrophospora, i.e.*, *E. colombiana* Spain & Schenck and *E. schenckii* Sieverding & Toro, may be separated readily from *E. baltica* by their smooth–walled spores and different wall structure. Additionally, spores of *E. schenckii* are hyaline (Morton and Benny, 1990; Sieverding and Toro, 1987; Schenck *et al.*, 1984).

Other arbuscular fungi having spores enveloped in a sinuate hyphal mantle include *Glomus globiferum* Koske & Walker, *G. mortonii* Bentivenga & Hetrick, *G. sinuosa* (Gerd. & Bakshi)

Almeida & Schenck, and *G. tortuosum* Schenck & Smith (Almeida and Schenck, 1990; Bentivenga and Hetrick, 1991; Koske and Walker, 1986; Schenck and Smith, 1982). However, the mantle of *G. globiferum* spores is composed of interwoven thin-walled hyphae bearing vesiculate swellings, structures not occurring in *E. baltica*. The mantle of *G. mortonii* and *G. sinuosa* consists of thick-walled hyphae, not reacting in Melzer's reagent. The mantle hyphae of *E. baltica* are thin-walled and stain lake red in this reagent. Although the mantle of *G. tortuosum* is composed of thin-walled hyphae, this fungus produces spores with only two walls: a laminated outer wall and a coriaceous inner wall (Morton and Benny, 1990). Spores of *Glomus* spp. originate terminally from subtending hyphae (Morton and Benny, 1990). Additionally, *G. mortonii* and *G. sinuosa* produce spores in sporocarps. In contrast, *E. baltica* spores develop within the neck of a sporiferous saccule and occur singly in the soil.

The small *Glomus*-like vesicles associated with mantle of *E. baltica* (Fig. 6) suggest that this fungus forms a synanamorph as does *A. gerdemannii* (Morton *et al.*, 1997). However, it is unclear whether they are only a young stage of this species or *E. baltica* is dimorphic. Ontogenetic studies with one-species cultures are needed to resolve the question. Unfortunately, this new fungus does not persist even in trap cultures, a similar behavior found for *E. infrequens* (Błaszkowski, pers. observ.).

Glomus fuegianum (Spegazzini) Trappe & Gerd.

Figs. 7–12

Spores occurring in the soil in groups (Figs. 7, 9) or sporocarps comprised of 2 to 28 spore-groups. A single spore-group mostly spherical, 100–140 µm diam, sometimes ovoid, 80–90 x 110–125 µm, consisting of 3 to 17 radially arranged and tightly adherent spores (Fig. 7) developed from a thick-walled, inflated hypha (Fig. 9). Sporocarps pale yellow (3A4) to brown (6E8), ovoid, 390–650 x 420–720 µm to prolate, 190–270 x 290–380 µm, with or without a peridium. Peridium hyaline to golden yellow (5B7), 10–70 µm thick, composed of thin–walled, interwoven hyphae, usually present only on a part of a sporocarp.

Spores (Figs. 9, 10) pale yellow (3A4) to yellowish brown (5B7), globose to subglobose; (20.0–)47.0(–60.0) µm diam or ovoid to prolate; 30–35 x 40–65 µm; with a single subtending hypha; spores frequently surrounded by branched and convoluted hyphae (Figs. 7, 8).

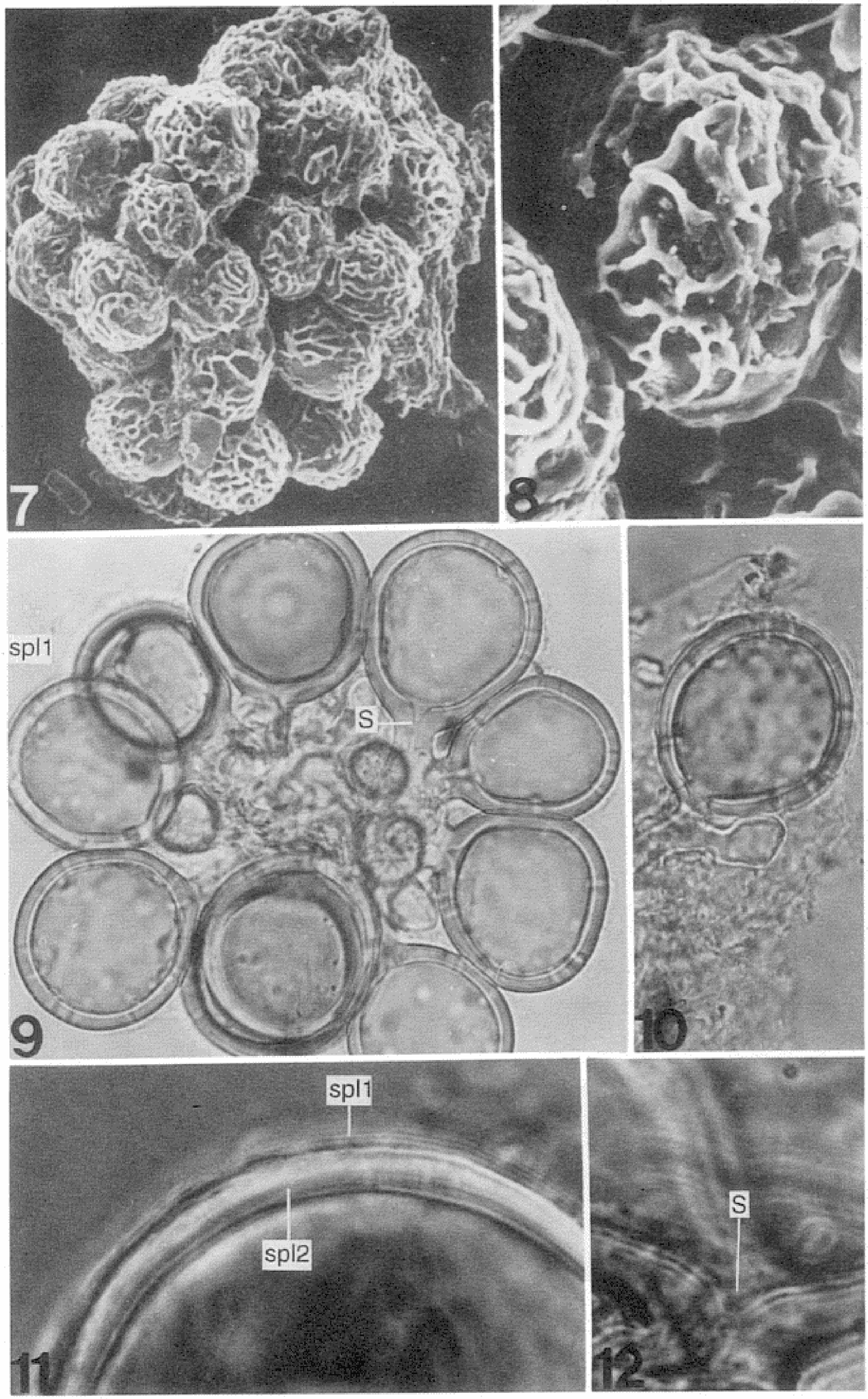
Subcellular structure of spores composed of one wall (Figs. 9–11) consisting of two layers (layers 1 and 2). Layer 1, forming the spore surface, sloughing, smooth, hyaline, (0.5–)0.8(–1.0) µm thick before disintegration, closely attached to layer 2 (Figs. 9, 11). Layer 2 laminated, pale yellow (3A4) to yellowish brown (5B7), (2.7–)3.9(–4.9) µm thick.

Subtending hypha pale yellow (3A4) to yellowish brown (5B7), straight to recurvate; funnel–shaped, sometimes cylindrical or constricted; (6.1–)7.9(–9.3)µm wide at the spore base. Wall of subtending hypha pale yellow (3A4) to yellowish brown (5B7), (2.2–)2.7(–3.4) µm thick, continuous with spore wall layers 1 and 2.

Pore (0.5–)0.9(–1.2) µm wide, occluded by a septum (Figs. 9, 12), *ca* 0.5–1.0 µm wide, continuous with the innermost lamina of wall layer 2, and occasionally by thickening of spore wall layer 2. Spore contents of oil droplets.

COLLECTION EXAMINED. Poland. Kampinos National Park (52°18'N, 20°46'E), all from among the roots of *Juniperus*

Figs. 7–12. *Glomus fuegianum*. **7.** Spore group (SEM), x296. **8.** Sinuous hyphal mantle (SEM), x1132. **9.** Spore group without hyphal mantle. Spore wall layer 1 (spl1) and a septum (s) enclosing the pore of subtending hypha are seen (BFM), x497. **10.** Young spore developing from the subtending hypha of a mature spore (BFM), x528. **11.** Spore wall layers 1 and 2 (spl1 and spl2) are visible. Phase contrast microscopy, x1497.**12.** Curved septum (S) continuous with the innermost lamina of spore wall layer 2 (BFM), x1872.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communis L., 26 July 191986, and 9 Aug. 1990, *Błaszkowski, J., 2171–2173* (DPP); *Błaszkowski, J., unnumbered collections* (DPP).

OTHER MATERIALS EXAMINED. United Kingdom. Yorks, Chew Valley, near Greenfield, on debris of *Nardus stricta* L., 5 Aug. 1962, *Palmer, J. I. 1835, 2031* (K); Debrys, Middle Moore, near Hayfield, on dead culms of *N. stricta* and *Sphagnum*, 26 Nov. 1961, *Palmer, J. I. 1790, 1808* (K); Middle Moore near Hayfield, on culms of *N. stricta* and on debris of *Polytrichum*, 17 Sept. 1961, *Palmer, J. I. 1592, 1766* (K); Chunal Moor, near Hayfield, on wet culms of *N. stricta* adjacent to *Sphagnetum*, 1 Oct. 1961, *Palmer, J. L. 1778, 1779* (K)

DISTRIBUTION AND HABITAT. In Poland *G. fuegianum* was found only in three soil samples collected from the root zone of *J. communis* growing in the inland dunes of the Kampinos National Park (Tab. 1). Examination of over 1000 other soil samples representing over 150 other sites with both cultivated and uncultivated plants did not reveal this fungus (Błaszkowski, 1993a, b; Błaszkowski, unpubl.).

The spore abundance of *G. fuegianum* in the three soil samples ranged from 14 to 1500 in 100 g dry soil. The proportions of spores of this species in spore populations of all arbuscular fungi recovered ranged from 7.44% to 47.2%. The species richness in these three soils harboring *G. fuegianum* ranged from 2 to 7 in 100 g dry soil. The fungal species occurring together with *G. fuegianum* were *Acaulospora lacunosa* Morton, *A. paulinae* Błaszk., an unknown *Acaulospora* sp., *G. constrictum, G. deserticola* Trappe, Bloss & Menge, *G. dominikii* Błaszk., *G. fasciculatum, G. ? geosporum* (Nicol. & Gerd.) Walker, *G. ? heterosporum* Smith & Schenck, *Scutellospora dipurpuresens* Morton & Koske, *S. pellucida* (Nicol. & Schenck) Walker & Sanders, and an unrecognized *Scutellospora* sp.

The chemical properties of a soil of a site closely neighboring that from which *G. fuegianum* was recovered were: pH 5.1; NO_3, 10; P, 14; and K, 9 mg L^{-1} (Błaszkowski, 1997b).

Table 1. Abundace[a] and proportional abundance[b] of *Glomus fuegianum* spores in spore populations of arbuscular fungi isolated, arbuscular taxa associated with this species

Host plant	Date of collection	Abundance	Proportional abundance (%)	Arbuscular taxa associated
Juniperus communis	26.07.1986	14	7.44	*Acaulospora lacunosa*, *A. paulinae*, *Glomus deserticola*, *G. dominikii*, *G. fasciculatum*, *G. ? geosporum*, unrecognized *Scutellospora sp.*
Juniperus communis	9.08.1990	308	75.3	*A. lacunosa*, *G. constrictum*, *G. dominikii*, *G. ? heterosporum*, *S. dipurpurescens*, *S. pellucida*
Juniperus communis	9.08.1990	1500	47.2	Unrecognized *Acaulospora sp.*, *G. ? heterosporum*

[a] No. of spores in 100 g dry soil.

[b] (no. of spores of a species/total Glomales spores) x 100.

MYCORRHIZAL ASSOCIATION. *Glomus fuegianum* was associated in the field with vesicular–arbuscular mycorrhizae of *J. communis*. This fungus formed spore–groups in trap cultures with *S. vulgare*. Attempts to obtain single–species cultures of this fungus failed.

The unique feature of *G. fuegianum* is the arrangement of its spores in groups (Figs. 7, 9). The spore–groups occur singly in the soil or are aggregated in small or large sporocarps interwoven with branched or convoluted hyphae. The spore–groups originate from swelling hyphae developing radially from thick–walled inflated hyphae. A single spore–group may include up to 17 tightly adherent spores. Due to the crowding, some of the spores may be ellipsoid to clavate. Spore–groups occurring singly in the soil usually lack a peridium which, however, almost always is present when spore–groups are aggregated in sporocarps. The peridium may be thick and, thereby, makes the spores difficult to see. In most of the sporocarps investigated, the peridium only partially encloses the spore–groups, possibly due to its damage by soil microorganisms.

Spores occurring in groups aggregated in sporocarps frequently are surrounded individually by thick–walled, branched, and convoluted hyphae (Figs. 7, 8) arising from the spore–producing region. This hyphal mantle rarely occurs in single spore–groups.

The spore wall of *G. fuegianum* consists of two layers, a hyaline, thin, sloughing outer layer and a colored, thick, laminated inner layer (Figs. 9, 11). The two layers are continuous with the wall layers of a subtending hypha. However, the outer layer frequently was absent in the specimens investigated, especially in those lacking a peridium (Fig. 9). This probably results from a degradative activity of parasitic soil microflora, as Morton (1995) suggested. Using electron microscopy, Yao *et al.* (1992) found in *G. fuegianum* a 3–layered spore wall: an outer electron grey to dense layer, a central electron grey laminated layer, and an inner electron dense layer abutting the lumen. Recent examinations (Błaszkowski, unpubl. observ.) of specimens coming from both

Poland and the United Kingdom suggests that the innermost layer seen by Yao *et al.* (1992) represents one of the inner sublayers of the laminated layer synthesized during spore ontogenesis. Similarly as in other *Glomus* spp. [e. g., *G. melanosporum* Gerd. & Trappe and *G. pustulatum* (Gerdemann and Trappe, 1974; Koske *et al.*, 1986)], the inner laminae of the laminated layer are lighter colored, and hence may appear an additional layer.

The distinctive property of *G. fuegianum* spores also is their wide and short subtending hypha. Because of this, the spores are almost sessile (Fig. 9). The pore of the subtending hypha of the specimens found in Poland is either open or occluded by a curved septum continuous with the innermost lamina of the laminated layer 2 of the spore wall (Figs. 9, 12). According to Yao *et al.* (1992), "the lumen of the spore is occluded by a plug near the junction with the pedicel. This plug lacks the true cross wall nature of a septum and appears to be derived from modified cytoplasm". However, examination of *G. fuegianum* spores from collections deposited in the herbarium of the Royal Botanic Gardens at Kew revealed spores with a subtending hypha occluded by a septum similar to that occurring in spores of this fungus collected in Poland. In *G. caledonium* (Nicol. & Gerd.) Trappe & Gerd., the subtending hypha of immature spores is open, but it becomes occluded by the innermost lamina near completion of the laminated layer differentiation (Morton, 1996). This suggests that Yao's *et al.* (1992) description was made based on immature spores.

The most closely related arbuscular mycorrhizal fungi producing spores similar in appearance and aggregated in structures resembling the spore groups of *G. fuegianum* are *G. rubiforme* (Gerd. & Trappe) Almeida & Schenck and *G. sinuosum* (Gerd. & Bakshi) Almeida & Schenck (Almeida and Schenck, 1990; Wu, 1993 a, b). Although both *G. fuegianum* and *G. rubiforme* form spores from a thick–walled, inflated hypha, the latter species lacks the hyphal mantle. *Glomus sinuosum* spores are mantled by sinuous hyphae reminiscent of those present in *G. fuegianum*, but the spores of *G. sinuosum* originate from a mass of interwoven hyphae, not from an inflated hypha as *G. fuegianum*.

Glomus fuegianum probably is a widely distributed but rarely occurring fungus in the world. This fungus has originally been found in Argentina (Pegler *et al.*, 1993). However, most records of *G. fuegianum* come from the United Kingdom (Godfrey, 1957; Pegler *et al.*, 1993) where it was considered to be rather widespread. Additionally, *G. fuegianum* has been found in New Zealand (Hall, 1977). The finding of this fungus in only three of over 1000 soil samples collected in different regions of Poland indicates *G. fuegianum* to be an extremely rarely occurring soil fungus in this country.

The ability of *G. fuegianum* to form mycorrhizae has not been experimentally confirmed so far. The type specimen of *G. fuegianum* was found under moss (Pegler *et al.*, 1993). Although Godfrey (1957) found this fungus under *Taxus baccata* L., the other reports from the United Kingdom describe the occurrence of *G. fuegianum* associated with above–ground plant parts, including living or dead culms of *Eriophorum angustifolium* Honck., *Molinia coerulea* (L.) Moench, *N. stricta*, *Polytrichum* and *Sphagnum*, as well as with rootstock of *Juncus effusus* L. and wet debris of a *Molinia sp.* Hall (1977) reported this fungus from a forest soil. In Poland *G. fuegianum* was found in the field among vesicular–arbuscular mycorrhizal roots of *J. communis*. Although *G. fuegianum* formed new spore–groups in trap cultures with *S. vulgare*, it failed to sporulate in one–species pot cultures with this plant. The inability of arbuscular mycorrhizal fungi living in trap cultures to sporulate in single–species pot cultures probably results from the especially high selective nature of the latter ones, as Koske *et al.* (1997) and Koske (pers. comm.) suggested. The factor most limiting establishment of mycorrhizae in single–species pot cultures seems to be the lack of microflora of the soil from which a given fungus originated. Soil microorganisms have been demonstrated to hasten mycorrhizal fungus spore germination (Azcon–Aguilar *et al.*, 1986) and root colonization (Azcon–Aguilar and Barea, 1985).

According to Morton and Benny (1990), fungi of the order Glomales form obligately arbuscular mycorrhizae in mutualistic associations with living plants. However, the marked saprophytic capability of *G. fuegianum* expressed by the formation of its spores on above-ground plant parts indicate that the fungus is a facultative symbiont. A similar conclusion may be drawn in respect to *G. fasciculatum* and *G. sinuosum* (Gerd. & Bakshi) Almeida & Schenck found to be associated with non-root habitats (Gerdemann and Trappe, 1974; Koske, pers. comm.).

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