

## Four new species of the Endogonaceae (Zygomycotina) from Poland

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Four new species of vesicular-arbuscular mycorrhizal fungi from Poland, *Glomus dominikii* Błazsk., *Acaulospora polonica* Błazsk., *A. gedanensis* Błazsk., and *A. thomii* Błazsk. are described.

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### Introduction

The Endogonaceae are hardly known in Poland. Only one species, *Glomus macrocarpum* Tul. & Tul., has been reported there (Ławrynowicz 1979). During the last four years I have studied the occurrence of endomycorrhizal fungi. Among the isolated species there are many which have been described earlier (Błazkowski 1988). However, in 1985 and 1986 I collected specimens that differ from any known species. Their descriptions are presented below.

### Material and methods

Soil samples collected from the rhizosphere of various plants were investigated. Spores were extracted by a wet-sieving and filtration technique (Koske & Walker 1984). Spores were then mounted on microscope slides in polyvinyl alcohol lactophenol (Walker 1979), lactophenol, and Melzer's reagent. Wall descriptions and terminology are according to Walker (1983, 1985). A pot culture (Gilmore 1968) was used to indicate the type of mycorrhizae. Roots were stained after Phillips and Hayman (1970). All collections were made by the author. The holotype and other specimens are deposited in the Department of Plant Pathology (DPP), Academy of Agriculture, Szczecin, Poland.

### *Glomus dominikii* Błazkowski n. sp.

— Figs. 1, 9

*Chlamydosporae in solo efformatae, albae, luteolae*

*vel luteae, globosae vel subglobosae, (75–) 107 (–165) μm diam, raro ovoideae, 100 x 150 μm, cum ornamento. Sporae tunica e stratis tribus; exteriore hyalino, rigido, (1.7–) 3 (–3.7) μm crasso, cum verrucis exiguis, 1.7–5.7 x 0.7–1.9 μm; secundo hyalino, membranaceo, (0.2–) 0.7 (–1.2) μm crasso; interiore hyalino, membranaceo, (1.2–) 1.8 (–2.5) μm crasso. Hypha hyalina, 180–220 μm longa, (6.4–) 8.7 (–12.5) μm diam. — Holotype: Poland. Szczecin voiv., Kołbacz, under *Trifolium pratense* L., 10.VII.1985 J. Błazkowski 256 (DPP). I have named this species in honour of Prof. T. Dominik, a long-time student of mycorrhizae in Poland.*

*Chlamydosporae*. Borne singly in the soil, white, slightly pink when immersed in water, becoming light yellow to orange-yellow with age, ornamented, globose to subglobose, (75–) 107 (–165) μm in diam, rarely ovoid, 100 x 150 μm, with a single subtending hypha.

*Spore wall structure*. Of three layers (layers 1–3) in two groups (groups A, B). Group A, of a hyaline, unit, (1.7–) 3 (–3.7) μm thick outer layer (layer 1), ornamented with fine warts, 1.7–5.7 x 0.7–1.9 μm. Group B, of a hyaline, smooth, membranous, (0.2–) 0.7 (–1.2) μm thick layer (layer 2), tightly adhering to a hyaline, smooth, membranous, (1.2–) 1.8 (–2.5) μm thick innermost layer (layer 3).

*Subtending hypha*. Hyaline, straight or slightly

recurvate, 180–220  $\mu\text{m}$  long, (6.4–) 8.7 (–12.5)  $\mu\text{m}$  wide, with walls (1.2–) 1.5 (–1.9)  $\mu\text{m}$  thick at the spore base, without a septum; usually slightly constricted at the attachment.

The wall 1 turns yellow, wall 2 is not reacting, and wall 3 stains red or orange-red in Melzer's reagent. Differs from *G. scintillans* Rose & Trappe (Rose & Trappe 1980) in the colour and size of the spores, by having a thinner middle layer, and by staining in Melzer's reagent.

*Mycorrhizal associations.* Unknown.

*Material examined*

Poland. *Szczecin* voiv.: Kotbacz, under *Trifolium pratense*, 10.VII.1985 J. Błaszowski 256–260. Prusinowo, under *Fragaria vesca*, 5.VIII.1985 J. Błaszowski 266–268. Czuczad, under *T. pratense*, 27.VIII.1985 J. Błaszowski 271–280. Nowogard, under *Lupinus luteus*, 5.VIII.1985 J. Błaszowski 281–285. Kamień Pomorski, under *Pisum arvense*, 25.VII.1985 J. Błaszowski 286. Brzozowo, under *Triticum vulgare*, 25.VII.1985 J. Błaszowski 287. Przybierów, under *Secale cereale*, 25.VII.1985 J. Błaszowski 288. Trzebiatów, under *Allium porrum*, 5.VIII.1985 J. Błaszowski 289. Gdańsk voiv., Chynów, under *Avena sativa*, 20.VII.1985 J. Błaszowski 261–265. Zielona Góra voiv., Lasocin, under *Zea mays*, 27.VIII.1985 J. Błaszowski 269–270. Zamość voiv., Zwierzyniec, under *Festuca rubra*, 18.X.1986 J. Błaszowski 290–291.

***Acaulospora polonica* Błaszowski n. sp.**  
— Figs. 2, 9

*Azygosporae singulares in solo efformatae, sessiles; terminatione inflata globosa vel subglobosa, 60–90  $\mu\text{m}$  diam; hypha interjacens spora et terminationis 40–70  $\mu\text{m}$ . Sporae hyalinae, albiae, globosae vel subglobosae, (80–) 94 (–115)  $\mu\text{m}$  diam, raro ovoideae, 115 x 80  $\mu\text{m}$ . Sporae tunica e stratis quattuor; exteriore hyalino, rigido, (1.5–) 1.9 (–2.3)  $\mu\text{m}$  crasso; secundo hyalino, membranaceo, ad 0.5  $\mu\text{m}$  crassum; tertio et quarto hyalino, membranaceo, (0.5–) 0.8 (–1)  $\mu\text{m}$  crasso. — Holotype: Poland. Gdańsk voiv., Hel, about 200 m from the Baltic Sea, under *Thuja occidentalis* L., 21.VIII.1985 J. Błaszowski 95 (DPP). I have named this species referring to the country in which it was first noted.*

*Azygospores.* Borne singly in the soil, hyaline, whitish, smooth, globose to subglobose, (80–) 94 (–115)  $\mu\text{m}$  in diam, rarely ovoid, 115 x 80  $\mu\text{m}$ , sessile on a hypha tapering to a globose to subglobose swollen hyphal terminus, 60–90  $\mu\text{m}$  in diam; hyphal terminus contents hyaline; terminus wall 0.7–1  $\mu\text{m}$  thick; distance between the hyphal terminus and the spore 40–70  $\mu\text{m}$ ; hyphae at the point of the spore attachment 8–12.5  $\mu\text{m}$  in diam; in maturity the terminus empties and collapses.

*Spore wall structure.* Of four layers (layers 1–4) in three groups (groups A, B, C). Group A, of a hyaline, unit, (1.5–) 1.9 (–2.3)  $\mu\text{m}$  thick outer layer (layer 1). Group B, of a hyaline, membranous, up to 0.5  $\mu\text{m}$  thick layer (layer 2). Group C, of two hyaline, membranous, (0.5–) 0.8 (–1)  $\mu\text{m}$  thick, adhering layers (layers 3, 4).

Spores filled with hyaline droplets, and not reacting in Melzer's reagent. Four species of *Acaulospora*, *A. trappei* Ames & Lind. (Ames & Linderman 1976), *A. delicata* Walker, Pfeiffer & Bloss (Walker et al. 1986), *A. nicolsonii* Walker, Reed & Sanders (Walker et al. 1984), and *A. longula* Spain & Schenck (Schenck et al. 1984) produce hyaline or subhyaline spores that could be confused with those of *A. polonica*. *A. trappei* forms slightly smaller (42–99 x 42–70  $\mu\text{m}$ ) and 1-layered spores. The spore wall of *A. delicata* is also 4-layered but the layers are of different types of which the innermost one stains orange-red in Melzer's reagent. Spores of *A. nicolsonii* are considerably larger (99–198 x 109–218  $\mu\text{m}$ ) and have a different wall structure (4-layered with evanescent, laminate, unit, and membranous layers). *A. longula* has 5-layered spore wall, stains light purple in Melzer's reagent, and forms spores at greater distance (100–200  $\mu\text{m}$ ) from its hyphal terminus.

*Mycorrhizal associations.* Unknown.

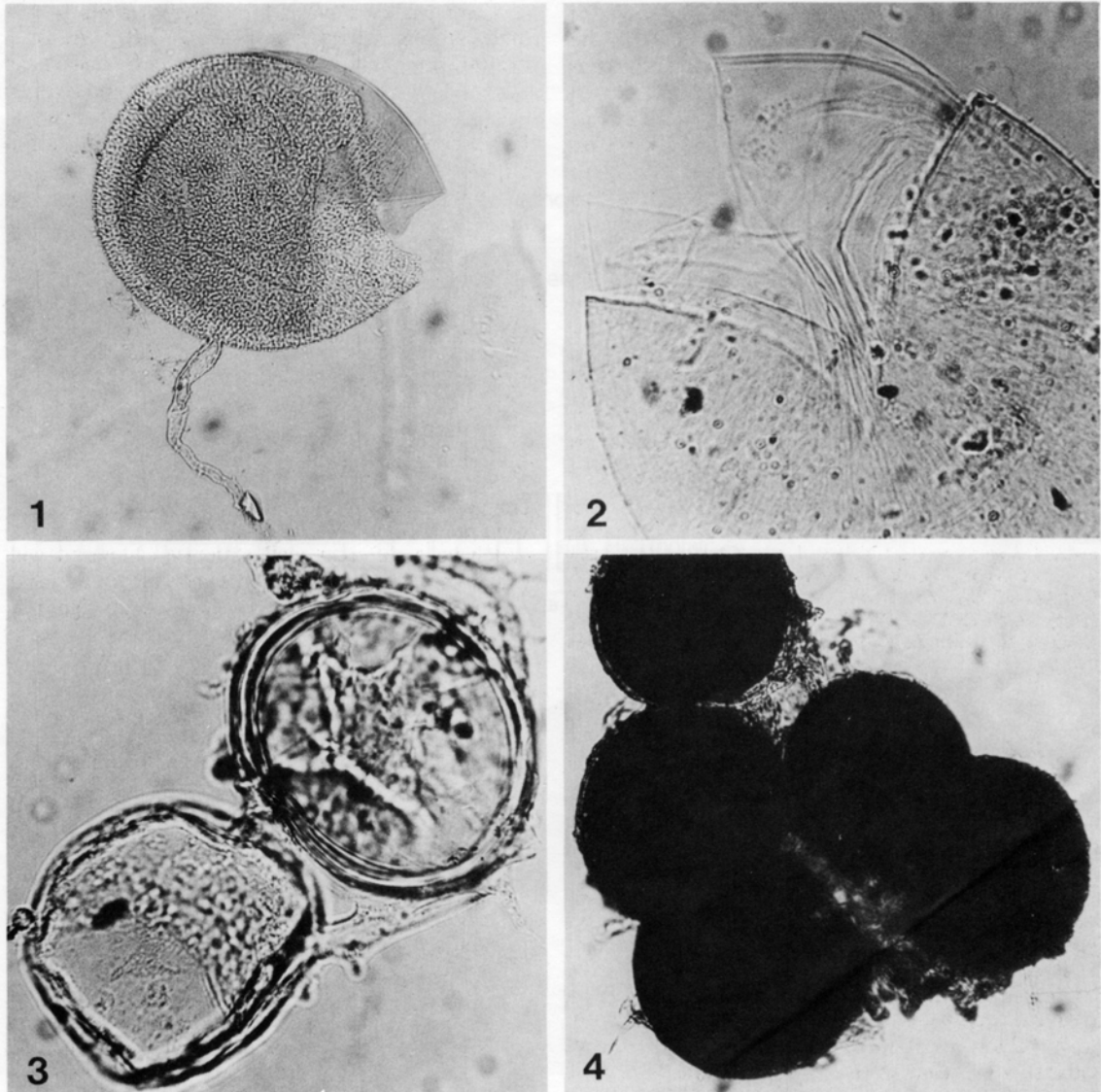
*Material examined*

See the type, and J. Błaszowski 96–136 (isotypes, DPP).

***Acaulospora gedanensis* Błaszowski n. sp.**  
— Figs. 3, 9

*Azygosporae singulares in solo efformatae, sessiles; terminatione inflata globosa vel subglobosa, 60–70  $\mu\text{m}$  diam; hypha interjacens spora et terminationis 50–60  $\mu\text{m}$ . Sporae pallide luteae vel luteobrunneae, globosae vel subglobosae, (55–) 65 (–75)  $\mu\text{m}$  diam. Sporae tunica e stratis quinque; exteriore hyalino, ad 0.5  $\mu\text{m}$  crassum; secundo luteo vel pallido brunneo, laminato, (2.5–) 3.6 (–4.3)  $\mu\text{m}$  crasso; tertio ad quinque hyalina, membranacea, ad 0.5  $\mu\text{m}$  crassum. — Holotype: Poland. Gdańsk voiv., Chałupy, about 500 m from the Baltic Sea, under *Festuca ovina* L., 23.VIII.1985 J. Błaszowski 137 (DPP). I have named this species referring to the voivodeship in which it was noted.*

*Azygospores.* Single in the soil, pale yellow to yellow-brown, globose to subglobose, (55–) 65 (–75)  $\mu\text{m}$  in diam, sessile on a hypha tapering to a globose to subglobose swollen hyphal terminus, 60–70  $\mu\text{m}$  in diam; hyphal terminus contents hyaline, terminus wall 0.5  $\mu\text{m}$  thick; distance between the

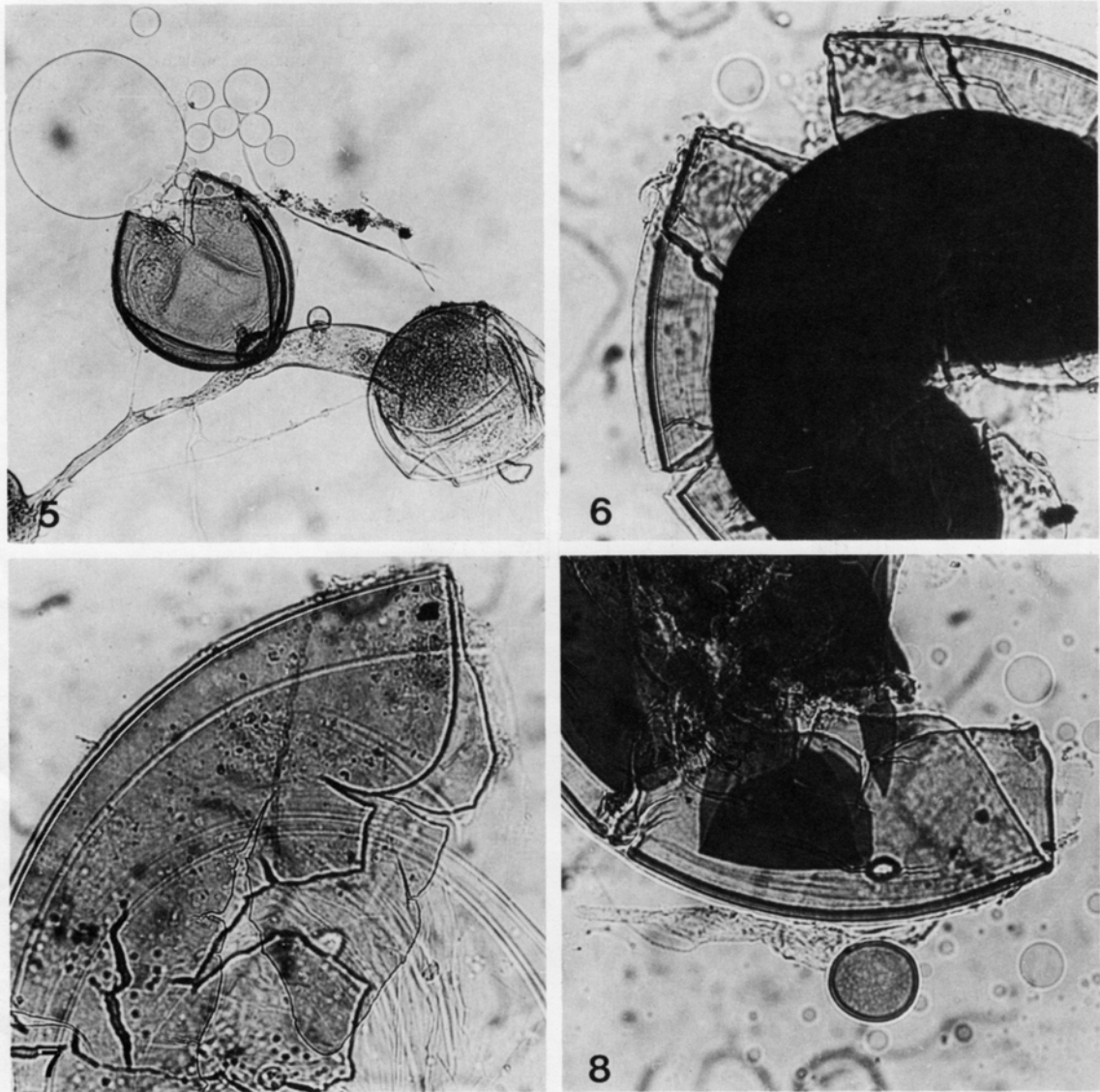


Figs. 1-4. Micrographs of the Endogonaceae. — 1: *Glomus dominikii*, a crushed spore in Melzer's reagent; the innermost layer is stained dark (x 236). — 2: *Acaulospora polonica*, a crushed spore in lactophenol showing the wall structure (x 559). — 3: *A. gedanensis*, a spore with empty hyphal terminus (x 568). — 4: *A. thomii*, a sporocarp in water (x 109).

hyphal terminus and the spore 50–60  $\mu\text{m}$ ; in maturity the terminus empties and collapses.

**Spore wall structure.** Of five layers (layers 1–5) in two groups (groups A, B). Group A, of a hyaline, sloughing, up to 0.5  $\mu\text{m}$  thick outer layer (layer 1), adhering to a yellow to pale brown, laminate, (2.5–) 3.6 (–4.3)  $\mu\text{m}$  thick layer (layer 2). Group B, of three hyaline, separating membranous layers (layers 3–5), each up to 0.5  $\mu\text{m}$  thick.

*A. gedanensis* is very similar to *A. rugosa* Morton, *A. dilatata* Morton, and *A. lacunosa* Morton (Morton 1986). *A. rugosa* forms brighter (subhyaline to straw-coloured) and slightly larger (49–92–118  $\mu\text{m}$  in diam) spores, their wall contains 5 layers of different types the innermost of which stains dark purple in Melzer's reagent. Spores of *A. dilatata* are larger (78–106–130  $\mu\text{m}$  in diam) and covered with minute pits, have a different wall structure (5-layered



Figs. 5-8. Crushed spores of *Acaulospora thomii*. — 5: With empty hyphal terminus, in polyvinyl alcohol lactophenol (x 132). — 6: In Melzer's reagent, showing the thick hyaline layer 1 adhering to layer 2 and dark-stained innermost layer (x 631). — 7: In polyvinyl alcohol lactophenol, showing the wall structure (x 344). — 8: In Melzer's reagent, with dark-stained vesicular structure (x 652).

in 3 groups) and stain in Melzer's reagent. *A. lacunosa* also produces larger spores (98-131-186  $\mu\text{m}$  in diam) which have a different wall structure (5-layered in 3 groups, the outermost layer is pitted) and stain dark purple in Melzer's reagent.

*Mycorrhizal associations.* Unknown.

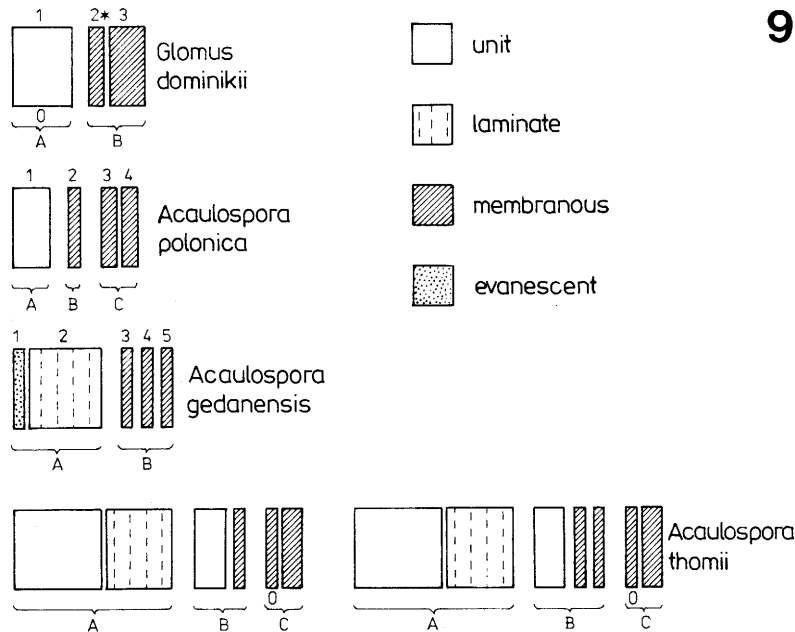
*Material examined*

See the type, and Błaszowski 138-154 (isotypes, DPP).

*Acaulospora thomii* Błaszowski n. sp.

— Figs. 4-9

*Azygosporae singulares in solo efformatae vel in sporocarpis, 160-520 x 300-700  $\mu\text{m}$ , sine peridio, e sporis duobus ad quinque. Sporae sessiles; terminatione inflata globosa vel subglobosa, (170-) 186 (-210)  $\mu\text{m}$  diam; hypha interjacens spora et terminationis (70-) 136 (-250)  $\mu\text{m}$ . Sporae fuscae*



9 Fig. 9. Murographs of four new species of the Endogonaceae. The numbers indicate each wall in order from outer to inner wall; the letters indicate wall groups. \* = walls very difficult to discern; 0 = wall surface ornamented.

*vel nigrae, globosae vel subglobosae, (150–) 185 (–240) μm diam, raro ovoideae, 200 x 240 μm. Sporae tunica e stratis sex vel septem; exteriore hyalino, rigido, (2.5–) 4.4 (–6.5) μm crasso; secundo luteo-brunneo vel brunneo, laminato, (2.5–) 3.3 (–4) μm crasso; tertio hyalino, rigido, 1.3–1.8 μm crasso; quarto ad quinque hyalinum, membranaceum, ad 0.5 μm crassum; sex hyalino, membranaceo, granulato, ad 0.5 μm crassum; septem hyalino, membranaceo, (0.5–) 0.9 (–1.3) μm crasso. — Holotype: Poland. Zielona Góra voiv., Bolesławiec, under *Triticum aestivum*, 17.VIII.1985 J. Błaszowski 352 (DPP). I have named this species in honour of my son, as a present for his first birthday.*

**Azygospores.** Formed singly in the soil or occasionally in regular or irregular-shaped, small, 160–520 x 300–700 μm sporocarps, without a peridium, with 2–5 spores. Spores dark brown to black in water, olive-brown to brown in lactophenol, globose to subglobose, (150–) 185 (–240) μm in diam, borne laterally on a hypha, 22.5–45 μm wide at the attachment, tapering to a globose to subglobose swollen hyphal terminus, 170–210 μm in diam; hyphal terminus contents hyaline to light yellow; terminus wall 2.5–4.5 μm thick; distance between the hyphal terminus and the spore 70–250 μm; in maturity the terminus empties and collapses.

**Spore wall structure.** Of six or seven layers (layers 1–7) in three groups (groups A, B, C). Group A, of a hyaline, unit, (2.5–) 4.4 (–6.5) μm

thick outer layer (layer 1), adhering to a yellow-brown to brown, laminate, (2.5–) 3.3 (–4) μm thick layer (layer 2). Group B, of a hyaline, unit, (1.3–) 1.5 (–1.8) μm thick layer (layer 3), and one or two hyaline, up to 0.5 μm thick membranous layers (layers 4, 5). Group C, of a hyaline, membranous, up to 0.5 μm thick layer (layer 6), with 'beaded' appearance, adhering to a hyaline, membranous, (0.5–) 0.9 (–1) μm thick innermost layer (layer 7).

*A. thomii* closely resembles *A. sporocarpia* Berch (Berch 1985) and *A. laevis* Gerd. & Trappe (Gerdmann & Trappe 1974). *A. sporocarpia* forms larger sporocarps (2.5 x 1.5 x 1.5 cm) and the spores have a two-layered wall, the outer of which is thinner (2.5–5 μm) than the inner one (7–15 μm). *A. laevis* produces spores singly in the soil and has a three-layered spore wall of which the outer sloughs.

In the sporocarps of *A. thomii* one can sometimes find thin-walled 'vesicle-like' structures (Fig. 8). They stain rapidly in Melzer's reagent, changing from hyaline to orange-pink. Similar structures occur in sporocarps of *A. appendicula* Schenck et al. and *A. sporocarpia*. As discussed by Schenck et al. (1984), these structures seem to be a feature that links species of *Acaulospora* and *Glomus*.

**Mycorrhizal associations.** Forming vesicular-arbuscular mycorrhizal infections with *Triticum aestivum* and *Zea mays* in the pot culture.

**Material examined**

See the type, and J. Błaszowski 353–383 (isotypes, DPP).

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