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A sporocarpic species of Glomeromycotina, *Glomus radiatum* new to Japan

胞子果性グロムス亜門の日本新産種 *Glomus radiatum*

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Abstract

Glomus radiatum, a large sporocarp-forming species of Glomeromycotina, was collected from Gunma Prefecture. Over all the characteristics of sporocarp and spore are identical to description of the North American specimens including holotype. This is the first record of *G. radiatum* from Asia.

要旨

大型の胞子果を形成するグロムス亜門の一種、*Glomus radiatum* が群馬県内で採集された。日本産標本の胞子果構造および胞子の特徴はホロタイプを含むアメリカ産標本およびカナダ産標本の記載と合致した。本報告はアジアにおける *G. radiatum* の初記録である。

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Introduction

Glomeromycotina belongs to Mucoromycota that is the sister clade of Dikarya including Basidiomycota and Ascomycota (Spatafora et al., 2016). All the species in this subphylum but *Geosiphon pyriforme* (Kütz.) F. Wettst., which forms endosymbiosis with cyanobacteria, are considered to be a mycobiont of various land plants forming arbuscular mycorrhizae within plant roots (Smith & Read, 2008). Most species in Glomeromycotina form putative asexual spores (i.e., conventionally named chlamydospore or azygospore), individually in rhizosphere without sporocarp formation (Błaszkowski, 2012; Schüßler & Walker, 2010; Yao et al., 1996). However, this subphylum also includes sporocarpic species whose sporocarps are several millimeters to tens of millimeters in diameter (Gerdemann & Trappe, 1974; McGee, 1986). These sporocarpic species are traditionally regarded as truffle-like fungi

(Pegler et al., 1993; Tulasne & Tulasne, 1851).

Until now, the truffle-like sporocarp formation has been reported from several genera, e.g., *Glomus* (e.g., *G. macrocarpum* Tul. & C. Tul.), *Rhizophagus* (e.g., *R. fasciculatus* (Thaxt.) C. Walker & A. Schüßler), and *Sclerocystis* (e.g., *S. coremioides* Berk. & Broome) in Glomerales (Gerdemann & Trappe, 1974; Thaxter, 1922), and *Acaulospora* (e.g., *A. sporocarpia* S.M. Berch), *Diversispora* (e.g., *D. epigaea* (B.A. Daniels & Trappe) C. Walker & A. Schüßler), and *Redeckera* (e.g., *R. fulvum* (Berk. & Broome) C. Walker & A. Schüßler) in Diversisporales (Berch, 1985; Daniels & Trappe, 1979; Redecker et al., 2007; Schüßler & Walker, 2010). Some of the sporocarpic species are suggested to be cosmopolitan (e.g., *G. macrocarpum* and *G. microcarpum* Tul. & C. Tul., from Europe, North America, and Australia [Berch & Fortin, 1984b; Gerdemann & Trappe, 1974; McGee & Trappe, 2002; Tulasne & Tulasne, 1851]). On the other hand, diversity and distribution of sporocarpic species of Glomeromycotina are still under investigation in Japan; only *S. coremioides* has been reported from the Kanto District (Degawa, 2001).

Since 2017, zygomycetous flora of Gunma Prefecture has been investigated (Degawa, 2018). During the course of a field survey of myxomycetes (2018 summer field excursion of the Japanese Society of Myxomycetology), a sporocarp of *G. radiatum* (Thaxt.) Trappe & Gerd. was collected from Numata-shi, Gunma Prefecture in July 2018. Brief description of its morphology is given bellow.

Materials and methods

Hand-cut sections of dried specimen were mounted in 3% KOH and observed under light microscope (OPTIPHOTO, Nikon, Tokyo, Japan). All measurements were performed with PhotoRuler 1.1.3 (http://inocybe.info/). The terminology of Yao et al. (1996) was adopted for the description. Dried specimen was deposited in the Kanagawa Prefectural Museum of Natural History (KPM) in Japan.

Taxonomy

***Glomus radiatum* (Thaxt.) Trappe & Gerd.**, Mycologia Memoirs 5: 46, 1974.

≡ *Endogone radiata* Thaxt., Proceedings of the American Academy of Arts and Sciences 57: 316, 1922.

Fig. 1.

Sporocarp epigeous on litter surface, reniform, ca. 3 mm in width, ca. 2 mm in height, not containing the foreign matter, without exuding latex, surface white or greyish-white, slightly cottony (Fig. 1A, B). Peridium undeveloped but a thin layer composed of interwoven, aseptate, thin-walled, filamentous hyphae present. Gleba developed on peripheral region of basal sterile region of sporocarp, darker toward the sterile base (Fig. 1B). Hyphae of sporocarp hyaline, thin-walled, aseptate, 1.5–5.3 µm in width (Fig. 1D, E), sometimes forming terminal swelling up to 20 µm in diam in outermost part of sporocarp, (Fig. 1D). Spore radially distributed, thin-walled younger ones embedded in exterior and thick-walled ones in interior (Fig. 1C), surface smooth, light yellow-brown, ellipsoidal to broadly ellipsoidal, 55–87 µm in length, 44–55 µm in width, mean 68 × 50 µm (n = 20), Q = 1.2–1.6, mean 1.4 (n = 20), often containing pale yellow single large droplet up to 22 µm in diam and many small droplets (Fig. 1F). Spore wall composed of single layer, 4.6–8.1 µm in thickness. Subtending hyphae single; boundary between spore and subtending hyphae occluded by wall thickening (Fig. 1F).

Specimens examined: JAPAN, Gunma Prefecture, Numata-shi, Tanbara kogen, N 36.787027, E 139.061407, alt. 1183 m, on litter surface in a moor, 29 Jul. 2018, Y. Degawa, KPM-NC 26800.

Notes: Morphological characteristics of the Japanese specimen are almost identical to those in the original description from the Northeast (Thaxter, 1922) as well as the descriptions from the Pacific Northwest (Gerdemann & Trappe, 1974) in USA and from Quebec in Canada (Berch & Fortin, 1984a). This is the first report of *G. radiatum* from Asia. *Glomus radiatum* is also reported from Austria (Palmer, 1997); however, the morphological description of this specimen is too brief to conclude the identity to the Japanese specimen.

The most distinctive character of this species among sporocarpic species is a radial arrangement of spores in sporocarp. The spores start to mature at the base of the sporocarp (Fig. 1C). This centrifugal development pattern of the sporocarp was consistent with the previous report mentioned by Berch & Fortin (1984a). Hyphal swellings observed around the surface zone of sporocarp were putatively an initial stage of spore development that was also described in previous studies (Berch & Fortin, 1984a; Thaxter, 1922). However, those swellings were not described in Gerdemann & Trappe (1974). In addition, a hyphal intrusion to spore observed on several specimens in North America (Berch & Fortin, 1984a; Gerdemann & Trappe, 1974) was not found in the Japanese specimen and type specimen (Gerdemann & Trappe, 1974; Thaxter, 1922). Both morphological comparison and phylogenetic study based on a number of Japanese and North American specimens are necessary to determine whether those specimens are conspecific.

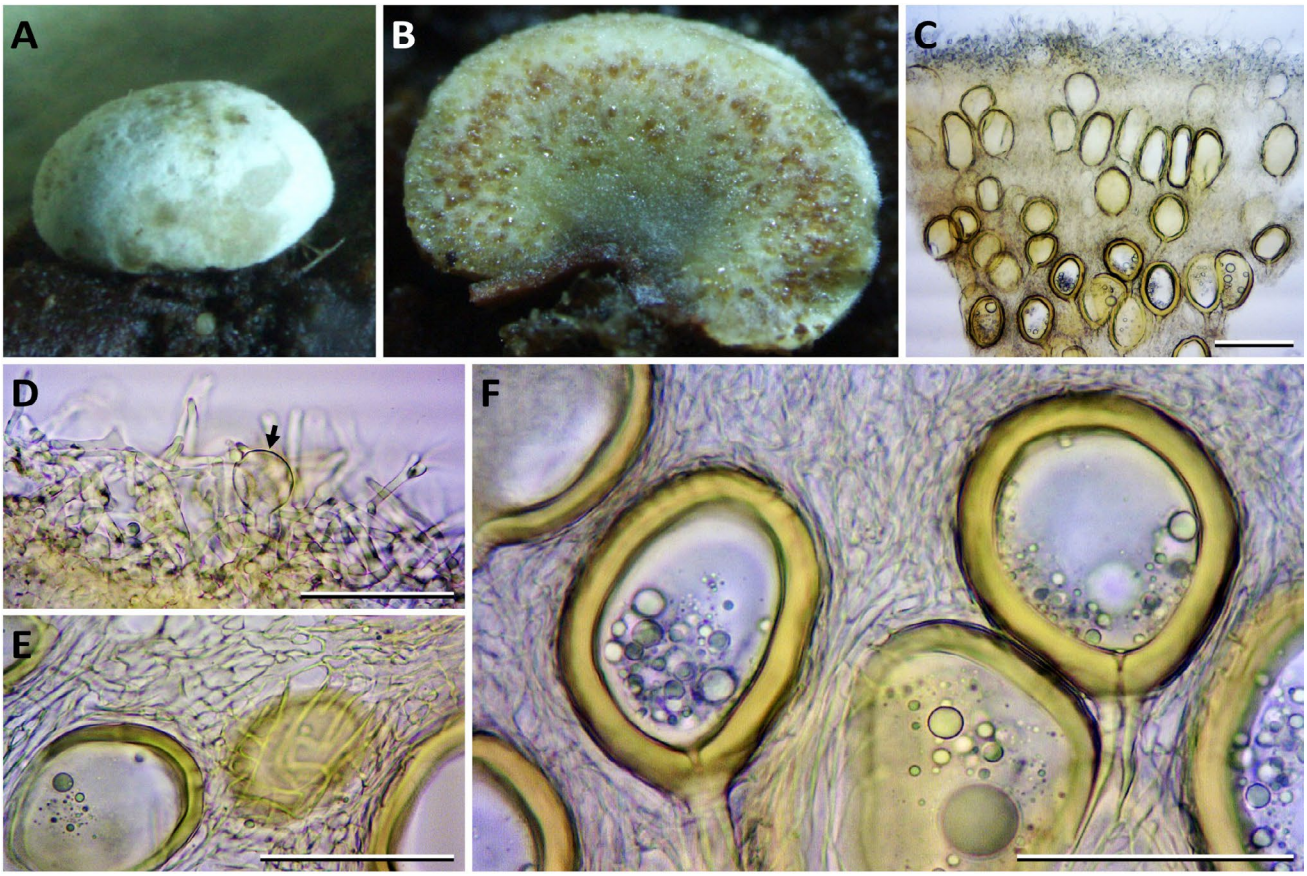

Fig. 1. *Glomus radiatum* collected from Gunma Prefecture, Japan. A: Sporocarp. B: Sectioned sporocarp. Radially embedded brown spores and a sterile base are shown. C: Magnified image of cross section of sporocarp. Thin-walled younger spores embedded in exterior (above) and thick-walled ones in interior (below) are shown. D: Hyphae of surface zone of sporocarp. Arrow indicates swollen hyphal tip. E: Hyphae of inner zone of sporocarp. F: Spores. Bars: C = 100 µm; D–F = 50 µm.

図 1. 群馬県産 *Glomus radiatum*. A：胞子果．B：胞子果断面．放射状に配列する褐色を帯びた胞子と無性基部を示す．C：胞子果断面（拡大）．基部（下部）に成熟した厚壁の胞子が，縁部（上部）に未熟な薄壁の胞子が存在する様子を示す．D：胞子果表面の菌糸とその先端の肥大部（矢印）．E：胞子果内部の菌糸．F：胞子．スケール：C 100 µm; D–F 50 µm.

According to Gerdemann & Trappe (1974), *G. radiatum* was proved as an arbuscular mycorrhizal fungus associated with *Cupressus nootkatensis* D. Don (Cupressaceae) by the observation of a direct attachment of sporocarps to the plant root. *Thujopsis dolabrata* (L. f.) Siebold & Zucc. (Cupressaceae) grown near the habitat is one of the candidates of the host plant, although the direct attachment of the Japanese specimen to any roots was not observed. The sporocarp collected in this study (KPM-NC 26800) grew on moist litter surface in a moor dominated by *Phragmites australis* (Cav.) Trin. ex Steud. and other herbaceous plants. Similarly, specimens from USA, Canada and Austria have been collected in wetlands, i.e., stream banks, hummocks in a boggy (Gerdemann & Trappe, 1974), and *Sphagnum* (Thaxter, 1922) or *Juncus articulatus* L. (Palmer, 1997) growing sites. Therefore, *G. radiatum* seems to prefer wet environment.

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