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Polyporus phyllostachydis sp. nov. with notes on other rhizophilic species of *Polyporus* (Basidiomycota, Polyporaceae)

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Abstract *Polyporus phyllostachydis* is described and illustrated as a new species. This species is characterized by its occurrence on bamboo roots, the small and centrally stipitate basidiocarps, the white pileus, usually becoming darker from the center at maturity, and the cylindrical stipe with a distinct crust. Morphological characters of the present species were compared with those of *P. cryptopus* and *P. rhizophilus*, other rhizophilic species of the genus. *Polyporus cryptopus* and *P. rhizophilus* are morphologically distinct by contextual texture, basidiospores, and hyphae, and possibly represent two distinct species.

Key words Bamboo roots · Cultural characters · *Polyporus cryptopus* · *Polyporus phyllostachydis* · *Polyporus rhizophilus*

Introduction

Polyporus Fr. is the type genus of the family Polyporaceae and is characterized by the stipitate basidiocarps, the dimittic hyphal system with arboriform skeletal-binding hyphae, the cylindrical and smooth basidiospores, and by causing white rots (Gilbertson and Ryvarden 1987; Núñez and Ryvarden 1995a). Núñez and Ryvarden (1995b) listed 18 species of *Polyporus* from Japan including 6 species newly reported.

Recently, we collected a *Polyporus* species on bamboo roots in a warm temperate area of Japan. This species is

very similar to *Polyporus cryptopus* Ellis & Barthol. and *P. rhizophilus* (Pat.) Sacc. in its ecology and basidiocarp morphology.

Polyporus cryptopus is hitherto reported only from the Great Plains region in the North America (Overholts 1953; Gilbertson and Ryvarden 1987). Weir (1917) recorded this fungus attached to the bark of *Pinus* from Montana, but it usually grows on the ground in sandy pastures or prairie (Overholts 1953).

Polyporus rhizophilus grows on steppe grass such as *Stipa*, more rarely on *Agropyron*, *Rudbeckia*, or *Elymus*, *Cynodon*, etc. (Bondartsev 1953). It is reported from Central and Southern Europe, Central Asia (Kazakhstan), and North Africa (Bondartsev 1953; Domański et al. 1967). Recently, Silveira and Wright (2005) reported *P. rhizophilus* from Argentina. However, this and other rhizophilic species of *Polyporus* are hitherto unknown from East Asia.

In this study, we describe the *Polyporus* fungus collected on bamboo roots as a new species and compare it with *P. cryptopus* and *P. rhizophilus* with their detailed descriptions.

Materials and methods

Macroscopic characters of the new species were described based on fresh and dried specimens. Color descriptions are given according to the Munsell System. Microscopic characters were mainly based on dried specimens, examining free-hand sections mounted in 3% (w/v) KOH solution after staining with 1% (w/v) phloxine solution and in Melzer's reagent. Dried specimens of *P. cryptopus* and *P. rhizophilus* were also examined.

Basidiospore measurements were made from material mounted in Melzer's reagent. The following abbreviations are used in the text: L, mean spore length (arithmetic mean of all basidiospores); W, mean spore width (arithmetic mean of all basidiospores); R, the ratio of length/width of a basidiospore; r, arithmetic mean of R. The term ($n = x/y$) means x measurements of basidiospores from y specimens.

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Cultural characters of the new species were studied on malt agar (Difco) plates at 25°C and described according to Nobles (1965). Mycelial growth rate K_r at 25°C was calculated as follows: $R_1 = R_0 + K_r(t_1 - t_0)$, where R_1 = colony radius at time t_1 , and R_0 = colony radius at time t_0 . Extracellular oxidase reactions were tested according to Käärik (1965).

Herbaria holding specimens were abbreviated according to Holmgren et al. (1990). Cultures examined were deposited in the culture bank of the Microbial Ecology Laboratory, Forestry and Forest Products Research Institute, Tsukuba, Japan.

Taxonomy

Polyporus phyllostachydis Sotome, T. Hatt. & Kakish., sp. nov. Fig. 1

Basidiocarpia stipitata, annua. Pilei orbiculati vel irregulares, usque ad 2 cm diametro, primo cremei, mox fusci, glaberi, crustosi. Stipites cylindrici, sinuosi, usque ad 3.5 cm longi, cum crusta. Tubi cremei, usque ad 2.5 mm longi. Pori cremei, 3–4/mm. Contextus carnosus, albus vel cremeus, usque ad 2 mm crassus. Sporae cylindricae vel subcylindricae, hyalinae, $5-7 \times 2.5-4 \mu\text{m}$. Ad radices *Phyllostachydis*.

Holotypus: TFM, F-21341 (see below.)

Etymology: Greek, referring to the host of the present fungus, *Phyllostachys*.

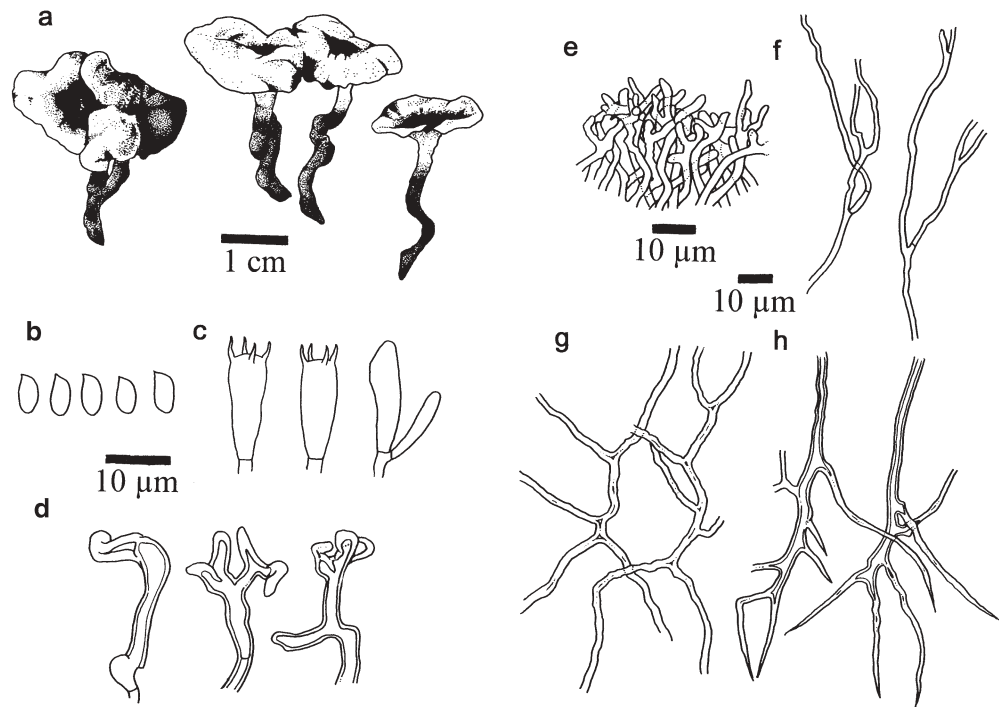
Basidiocarps annual, centrally stipitate, solitary or caespitose. Pileus circular to irregular in outline, flat to depressed in the center, 0.8–2 cm in diameter, up to 4 mm thick; surface smooth, glabrous, white when young, with age

usually becoming umber to black (10YR3-4/4-4, 5Y3/4) from the center, azonate; margin round to obtuse, entire, flat to irregularly wavy. Stipe cylindrical, sinuous, up to 3.5 cm long, 1.8–4 mm in diameter, smooth, white at the top, other portions usually covered with a black to cigar brown (10YR3-4/1-4) crust, often caespitose and fused. Context fleshy to tough fleshy in fresh condition, drying leathery, 0.3–2 mm thick, white to pale orange (10YR9/4), with or without a thin and dark crust at maturity. Pore surface white, pores round to angular, 3–4/mm, occasionally irregular and elongated, then up to 0.5 mm in diameter, dissepiments mostly entire. Tubes concolorous with the pore surface, 0.3–2.5 mm deep.

Hyphal system dimitic with generative hyphae and skeletal-binding hyphae. Contextual generative hyphae in dried specimens 1–3.5 μm in diameter, thin-walled, hyaline, without clamp connections, often difficult to find. Contextual skeletal-binding hyphae mostly solid, frequently branched, highly interwoven, hyaline, 1.5–4 μm in diameter. Tramal skeletal-binding hyphae arboriform, frequently branched, hyphal tips abundantly seen, thick-walled with a distinct lumen, highly interwoven, hyaline, dextrinoid, 3–4 μm in diameter at the basal stalk. Tramal generative hyphae same as in context. Crust on the pileus and stipe composed of coralloid-binding hyphae with clavate tips, hyphae thick-walled, highly agglutinated, light brown to brown, 2.5–5 μm in diameter. Cystidia and other sterile elements absent in hymenium. Basidia clavate, $12.5-25 \times 2.5-6 \mu\text{m}$, 4-sterigmate. Basidiospores cylindrical to subcylindrical, hyaline, nondextrinoid, $5-7 \times 2.5-4 \mu\text{m}$, $L = 6.25 \mu\text{m}$, $W = 3.05 \mu\text{m}$, $R = 1.5-2.4$, $r = 2.04$ ($n = 68/3$).

Habitat: terrestrial, on living or dead roots of *Phyllostachys heterocyclus* (Carr.) Mitf.

Fig. 1. Structures of *Polyporus phyllostachydis* from basidiocarps (from TFM, F-21341). **a** Basidiocarps. **b** Basidiospores. **c** Basidia and unripe basidium. **d** Coralloid binding hyphal tips in crust. **e** Section of crust. **f** Generative hyphae from trama. **g** Skeletal-binding hyphae from context. **h** Skeletal-binding hyphae from trama



Specimens examined: Japan: Ibaraki Pref., Tsuchiura, Shishitsuka, on *Phyllostachys heterocykla* root, Sept. 4, 2004, K. Sotome & T. Hattori (holotype, TFM, F-21341); the same host and place, Aug. 7, 2004, K. Sotome & T. Hattori (TFM, F-21340); the same host and place, Sept. 11, 2005, K. Sotome & T. Hattori (TFM, F-21342).

Cultural characters

Fig. 2

Growth slow, 2.1–2.8 mm/day, plates covered in 4 weeks. Advancing zone even, appressed, some mycelia submerged in the agar, white. Mat white, aerial mycelium woolly to flat, becoming light brown to dark brown with crustose areas from the center. Reverse unchanged. Odor none. Hymenophore development not seen within 6 weeks. Generative hyphae from the advancing zone thin-walled, moderately branched, hyaline, 1.5–3 µm in diameter, without clamp connections.

Generative hyphae from aerial mycelium and submerged mycelium thin-walled, hyaline, 2.5–5 µm in diameter, without clamp connections. Fiber hyphae present, branched, hyaline, thick-walled to solid, up to 3 µm in diameter. Interlocking hyphae present in the crustose areas. Polyhedral crystals formed on the hyphae and in the agar. Conidia absent.

Extracellular peroxidase activities: 1-naphthol, +; tyrosine, –.

Species code: 2, 6, 8, 11, 32, 36, 38, 44, 56.

Cultures examined: WD-2321, isolated from tissue of the basidiocarp of TFM, F-21341; WD-2322, isolated from tissue of the basidiocarp of TFM, F-21342.

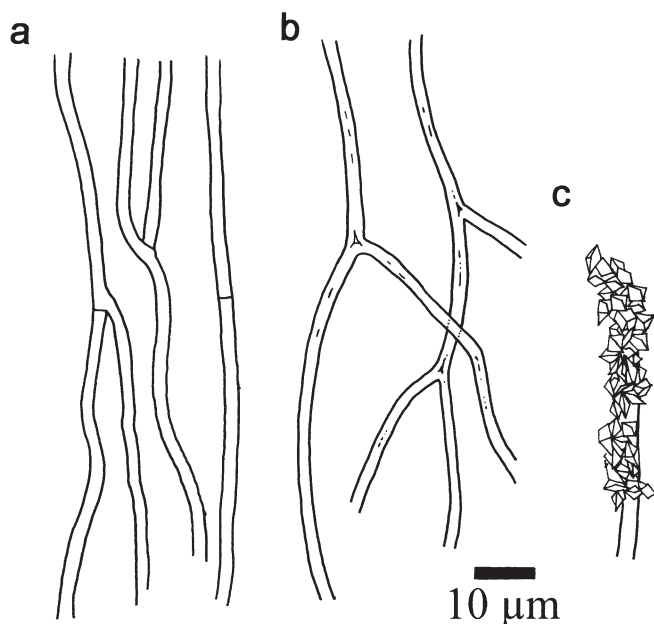


Fig. 2. Structures of *Polyporus phyllostachydis* from culture (from WD-2322). **a** Generative hyphae from aerial mycelium. **b** Fiber hyphae from aerial mycelium. **c** Hyphal tip encrusted with crystals

Species related to *P. phyllostachydis* examined

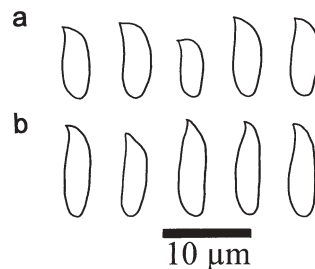
Polyporus cryptopus Ellis & Barthol., *Erythea* 4:79 (1896). Fig. 3a

Basidiocarps centrally stipitate. Pileus circular, plane or depressed in the center, 1.9–5 cm in diameter, up to 3 mm thick; pileus surface wrinkled, light brown to grayish-brown (10YR5-7/4), margin round with inconspicuous lobes. Stipe cylindrical, up to 1.5 cm long, up to 5 mm in diameter, wrinkled, pale orange (10YR8-9/4) at the top, otherwise covered with a grayish-brown to dark brown (10YR3-5/2) crust or without a crust. Context soft corky, brittle, 0.2–1.2 mm thick, pale orange (10YR9/4), without a crust. Pore surface light brown (10YR6-7/4-8), pores angular, 2–3/mm, dissepiments thin, slightly dentate. Tubes pale orange (10YR7-9/4), up to 2 mm deep.

Hyphal system dimitic with generative hyphae and skeletal-binding hyphae. Contextual generative hyphae 2–5 µm in diameter, thin-walled, hyaline, with clamp connections. Contextual skeletal-binding hyphae thick-walled to solid, frequently branched, interwoven, hyaline, 2.5–5 µm in diameter. Tramal generative hyphae 2–5 µm in diameter, thin-walled, hyaline, with clamp connections. Tramal skeletal-binding hyphae 2–5 µm in diameter, otherwise as in context. Crust on stipe composed of coralloid-binding hyphae with clavate tips, hyphae thick-walled, highly agglutinated. Basidia clavate, 17.5–37.5 × 4–8 µm, with a basal clamp, 4-sterigmate. Basidiospores subcylindrical to subfusiform, hyaline, nondextrinoid, 6–10 × 2.5–4 µm, L = 7.50 µm, W = 3.01 µm, R = 2.0–3.2, r = 2.51 ($n = 127/5$).

Specimens examined: USA: Rooks, Kansas, on Gramineae, July 24, 1895, E. Bartholmew (BPI, US0206745, holotype); Rockport, Kansas, 1898, E. Bartholmew (BPI, US0302651); Rooks, Kansas, on Gramineae, July 24, 1895, E. Bartholmew (BPI, US2026747); Rooks, Kansas, on Gramineae, July 25, 1895, E. Bartholmew (BPI, US2026748); Rockport, Kansas, on Gramineae, July 1895, E. Bartholmew (BPI, US2026749); Rockport, Kansas, on Gramineae, July 1895, E. Bartholmew (BPI, US2026746); Stockton, Kansas, on Gramineae, July 24, 1896, E. Bartholmew (BPI, US2026744, as *Scutigera cryptopus*); Bozeman, Montana, on *Pinus contorta*, 1917, J.R. Weir (BPI, US0206750); Kulm, North Dakota, July 1909, J.F. Brenckle (BPI, US0303050); Kulm, North Dakota, July 20, 1909, J.F. Brenckle (BPI, US0207090); Louisiana, July 19, 1894, A.B. Langlois (BPI, US2027091).

Fig. 3. Basidiospores of *Polyporus cryptopus* and *P. rhizophillus*. **a** *Polyporus cryptopus* (from BPI, US0206750). **b** *Polyporus rhizophillus* (from PRM, 709523)



Polyporus rhizophilus (Pat.) Sacc., Syll. Fung. 11:82 (1895). Fig. 3b

Basidiocarps centrally stipitate. Pileus circular to semi-circular, plane to convex, 0.5–2.2 cm in diameter; pileus surface wrinkled, grayish-orange to grayish-brown (10YR7-8/2-4), margin acute, entire. Stipe cylindrical, up to 1.5 cm long, up to 4 mm in diameter, wrinkled, grayish-orange to pale orange (10YR7-9/2-4), rarely with a cuticle near the base. Context soft corky, brittle, white to pale orange (10YR9/4), without a crust. Pore surface concolorous with the stipe, pores angular, (1–)2–3/mm, dissepiments thin, mostly entire. Tubes concolorous with pore surface.

Hyphal system dimitic with generative hyphae and skeletal-binding hyphae in the trama, monomitic to dimitic in the context. Contextual generative hyphae 2.5–6 µm in diam., thin-walled, hyaline, with clamp connections. Contextual skeletal-binding hyphae mostly solid, branched, interwoven, hyaline, 2–5 µm in diameter, often sparse, lacking in the marginal areas. Tramal generative hyphae 2–4 µm in diameter, thin-walled, hyaline, with clamp connections. Tramal skeletal-binding hyphae thick-walled to solid, frequently branched, interwoven, hyaline, 1–3 µm wide, dextrinoid or nondextrinoid. Cuticle on stipe composed of coralloid-binding hyphae with clavate tips, hyphae nonagglutinated, easy to loosen. Basidia clavate, 25–32.5 × 5–7 µm, with a basal clamp, 4-sterigmate. Basidiospores cylindrical to fusiform, hyaline, nondextrinoid, 7–11 × 2.5–4 µm, L = 9.14 µm, W = 3.2 µm, R = 2.25–4, r = 2.86 (n = 77/3).

Specimens examined: Czech Republic: Distr. Litoměřice, Pr. Vel. Žernoseky, Vendula, on *Festuca valesiaca*, Apr. 21, 1970, K. Kubát (PRM, 709523); Pr. Louny, Rana, on *Stipa capillata* (as '*Stipam capillatam*'), July 13, 1971, Z. Pouzar (PRM, 741776); Distr. Louny, Charvatce, on base of Gramineae, July 24, 1995, E. Skála (PRM, 890770).

Discussion

Núñez and Ryvar den (1995a) divided the genus *Polyporus* into six groups based on morphological characters. *Polyporus phyllostachydis* belongs to the group *Melanopus*, which is characterized by tough and thin contexts and stipes covered by the black cuticles. Among the group *Melanopus*, *P. phyllostachydis* is remarkable by the small and centrally stipitate basidiocarps, the whitish pileus with or without an umber to black cuticle, the dimitic hyphal system with highly interwoven and dextrinoid skeletal-binding hyphae, the small basidiospores, and occurrence on bamboo roots.

Polyporus phyllostachydis, *P. cryptopus*, and *P. rhizophilus* share small and centrally stipitate basidiocarps and occurrence on roots of Gramineae. However, *P. phyllostachydis* differs from the other two species by the pileus usually becoming covered with a dark crust from the center at maturity and the leathery context in dried condition.

Their hyphal characters are also distinct. Generative hyphae are simple-septate in *P. phyllostachydis* but consistently clamped in *P. cryptopus* and *P. rhizophilus*. Tramal

skeletal-binding hyphae are dominant in *P. phyllostachydis*, whereas both generative and skeletal-binding hyphae are abundant in the trama of *P. cryptopus* and *P. rhizophilus*. *Polyporus phyllostachydis* has more interwoven tramal skeletal-binding hyphae than the other two species. Basidia (12.5–25 × 2.5–6 µm) and basidiospores (5–7.5 × 2.5–4 µm) in *P. phyllostachydis* are smaller than those in *P. cryptopus* and *P. rhizophilus*. *Polyporus phyllostachydis* is hitherto known on bamboo roots in a wet and warm temperate locality while the other two species are found on grass roots in dried steppes. Thus, *P. phyllostachydis* is apparently distinct from *P. cryptopus* and *P. rhizophilus*.

Lloyd (1912) discriminated *P. cryptopus* from *P. rhizophilus* by smaller pores and basidiospores. Gilbertson and Ryvar den (1987) also treated the former as a distinct species. On the other hand, Núñez and Ryvar den (1995a) took *P. cryptopus* as a synonym of *P. rhizophilus* without further comment.

Among the specimens we examined, one specimen of *P. rhizophilus* had clearly larger pores (1–2/mm), but the pore size of other specimens was almost identical with that of *P. cryptopus*. Most specimens of *P. cryptopus* have a stipe that has an agglutinated crust on the lower half or is almost entirely crustose, whereas all specimens of *P. rhizophilus* examined in this study have a stipe without crust or with a slightly agglutinated cuticle only at the base. However, Bondartsev (1953) and Domański et al. (1967) reported that *P. rhizophilus* has a stipe with a blackish crust. Therefore, we conclude that these species cannot be differentiated by pore size and occurrence of a crust on the stipe. On the other hand, these species are distinct in characters of the contextual texture, basidiospores, and hyphae. *Polyporus cryptopus* is distinguished from *P. rhizophilus* by the less-brittle context and the shorter and more-elliptical basidiospores. For hyphal characters, both generative hyphae and skeletal-binding hyphae are abundantly seen in the context of *P. cryptopus* whereas generative hyphae are dominant in the context of *P. rhizophilus*.

Morphologically *P. cryptopus* and *P. rhizophilus* seem to represent two distinct species, but their critical identity at the species level should be consulted after further studies such as detailed observation of fresh specimens and ecological characteristics, mating tests, and phylogenetic studies.

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