

*Some Probable Mycorrhizal Associations  
in the Pacific Northwest. II*

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OCCURRENCE OF sporocarps of mycorrhizal fungi may be used to indicate specific fungus-host associations if proper precautions are taken during field observation. This approach has been used in the Pacific Northwest to increase the very limited knowledge of the region's mycorrhizal associations. Information from continuing field observation has suggested several probable associations in addition to those listed in an earlier paper (Trappe, 1957).

The following criteria are used to determine if a fungus-host association is likely to be mycorrhizal:

1. The fungus must belong to a genus (or, for genera containing both mycorrhizal and purely saprophytic species, a subgenus) considered to be consistently mycorrhiza forming. Or, if the mycorrhizal status of the genus is not known, the fungus must be a species already proved to be mycorrhiza forming.

2. Sporocarps must occur near roots of a higher plant known to form ectotrophic mycorrhizae, with no possibility of roots of another host species being present. This circumstance is most readily found in pure stands; but even there, extreme caution is needed to avoid understory hosts that form ectotrophic mycorrhizae, e.g., *Alnus*, *Corylus*, and *Salix*.

In addition, obligate occurrence of some fungi with particular tree genera and tracing of hyphae from sporocarps to roots are used as supplementary evidence where possible.

These associations, observed in the areas cited, are probably mycorrhizal: *Amanita aspera* (Fries) Quél.: *Pseudotsuga menziesii* var. *menziesii* and *Tsuga heterophylla*—Puget Sound region of Washington at elevations of 100 to 1,200 feet.

*Amanita chlorinosma* (Peck) Sacc.: *Pseudotsuga menziesii* var. *menziesii*—Puget Sound region of Washington at elevations of 600 to 800 feet.

- Amanita junquillea* Quél.: *Pseudotsuga menziesii* var. *menziesii*—Mount Rainier National Park in Washington at an elevation of 2,000 feet; above the Columbia River in southwestern Washington at an elevation of 1,000 feet; and in the Willamette Valley of Oregon at an elevation of 400 feet.
- Amanita muscaria* (L. ex Fries) Pers. ex S. F. Gray: *Tsuga heterophylla*—west slope of the Cascade Range in Washington at elevations of 1,500 to 3,000 feet.
- Amanita pantherina* (D.C. ex Fries) Secr.: *Cedrus deodara*—campus of the University of Washington, Seattle, elevation 200 feet; *Pinus ponderosa*—Blue Mountains in northeastern Oregon, elevation 3,000 feet (specimen deposited in University of Washington herbarium); *Pseudotsuga menziesii* var. *glauca*—Blue Mountains in northeastern Oregon at elevations of 3,000 to 5,000 feet; *Pseudotsuga menziesii* var. *menziesii*—Puget Sound region of Washington and Willamette Valley of Oregon from sea level to an elevation of 3,000 feet.
- Amanita silvicola* Kauffm.: *Pseudotsuga menziesii* var. *menziesii*—west slope of the Cascade Range in Washington at elevations of 2,000 to 2,500 feet.
- Amanita vaginata* (Bull. ex Fries) Quél. var. *plumbea* (Schaeff. ex Quél.): *Pinus contorta*—Blue Mountains in northeastern Oregon at an elevation of 4,000 feet; *Pinus ponderosa*—Blue Mountains in northeastern Oregon at an elevation of 3,000 feet (specimens deposited in University of Washington herbarium).
- Boletus edulis* Bull. ex Fries: *Abies amabilis* and *Tsuga heterophylla*—east slope of the Cascade Range in Washington at an elevation of 3,000 feet.
- Boletus frustosus* Snell and Dick: *Tsuga mertensiana*—Crater Lake National Park in Oregon at elevations of 5,500 to 7,400 feet (specimen deposited in Crater Lake National Park herbarium).
- Cantharellus floccosus* Schweinitz f. *floccosus*: *Pseudotsuga menziesii* var. *menziesii* and *Tsuga heterophylla*—west slope of the Cascade Range in Washington at elevations of 2,000 to 3,000 feet.
- Cortinarius croceofolius* Peck: *Pinus ponderosa*—east slope of the Cascade Range in Washington at elevations of 2,000 to 3,000 feet (specimen deposited in University of Washington herbarium).
- Gomphidius oregonensis* Peck: *Pseudotsuga menziesii* var. *menziesii*—Willamette Valley of Oregon at elevations of 100 to 500 feet (previously reported by Singer, 1949b).

- Gomphidius smithii* Sing.: *Pseudotsuga menziesii* var. *menziesii*—Willamette Valley of Oregon at elevations of 100 to 500 feet, and on west slope of the Cascade Range in Washington at an elevation of 2,000 feet (previously reported by Singer, 1949b).
- Gomphidius subroseus* Kauffm.: *Pseudotsuga menziesii* var. *menziesii*—Willamette Valley of Oregon at elevations of 100 to 500 feet (previously reported by Singer, 1949a).
- Hebeloma crustuliniforme* (Bull. ex Fries) Quél.: *Pseudotsuga menziesii* var. *menziesii*—Puget Sound region of Washington at elevations of 2,000 to 3,000 feet (specimen deposited in University of Washington herbarium); *Sorbus americana*—east slope of the Cascade Range in Washington at an elevation of 5,000 feet.
- Hygrophorus gliocyclus* Fries: *Pinus contorta* and *Pinus ponderosa*—Blue Mountains in northeastern Oregon at elevations of 3,000 to 5,000 feet (specimen deposited in University of Washington herbarium).
- Hygrophorus karstenii* Sacc. and Cub. f. *karstenii*: *Pinus ponderosa*—Blue Mountains in northeastern Oregon at elevations of 3,000 to 4,500 feet (specimen deposited in University of Washington herbarium).
- Lactarius deliciosus* (L. ex Fries) S. F. Gray: *Pinus contorta*—Blue Mountains in northeastern Oregon at an elevation of 3,000 feet and on west slope of the Cascade Range in Oregon at an elevation of 3,000 feet.
- Leccinum aurantiacum* (Bull. ex Pers.) S. F. Gray: *Pinus contorta* and *Populus tremuloides*—Blue Mountains in northeastern Oregon at an elevation of 4,000 feet.
- Rhizopogon rubescens* Tul. var. *vittadini* Tul.: *Pseudotsuga menziesii* var. *menziesii* and *Tsuga heterophylla*—Puget Sound region of Washington at elevations of 500 to 1,500 feet (specimens deposited in University of Washington herbarium).
- Suillus granulatus* (L. ex Fries) O. Kuntze: *Pinus monticola*—west slope of the Cascade Range in Washington at an elevation of 2,000 feet (previously reported by Singer, 1945 and 1949a).
- Suillus luteus* (L. ex Fries) S. F. Gray: *Pseudotsuga menziesii* var. *menziesii*—Willamette Valley of Oregon at an elevation of 300 feet.
- Xerocomus chrysenteron* (Bull. ex Fries) Quél.: *Salix scouleriana*—Puget Sound region of Washington at an elevation of 500 feet.

*Laccaria laccata* (Scop. ex Fries) Berk. & Br. may be a mycorrhiza former. Rawlings (1951) suggested that it forms mycorrhizae with *Pinus* and *Pseudotsuga*. Other *Laccariae* are also reported in mycorrhizal association: *L. amethystina* (Bolt. ex Fries) Berk. & Br. with *Quercus* (Sobotka, 1956); *L. ochropurpurea* (Berk.) Peck with *Carya* (McDougall, 1917); and *L. trullisata* (Ell.) Peck with *Salix* (Andersson, 1950). In Oregon and Washington, *L. laccata* mushrooms frequently arise directly from mycorrhizal clusters of *Pseudotsuga menziesii* and *Pinus contorta*. Often, however, the mushrooms appear where symbiosis with tree roots is precluded, as on rotten logs not touching the soil. Therefore, *L. laccata* cannot be considered a mycorrhizal fungus until proved so by pure-culture synthesis.

*Hebeloma crustuliniforme* was first suggested as a mycorrhizal fungus by Horn (1933). No similar mention of it was made until Kalmár (1950) reported it to form mycorrhizae with *Quercus* in Hungary, an assertion substantiated in the U.S.S.R. (Klyushnik, 1952, and Shemakhanova, 1956). Its reported associations and its occurrence in a variety of forests in other parts of the world indicate that *H. crustuliniforme* is able to form mycorrhizae with many tree species. It is similar in this way to *Amanita muscaria* and *A. pantherina*.

*Boletus frustosus* is one of the high-elevation mycorrhizal fungi of the Northwest. In California, Snell and Dick (1941) found it as high as 8,000 feet with *Abies magnifica* var. *shastensis*. The specimens reported in the list above were all found above 6,000 feet in pure stands of *Tsuga mertensiana* in Crater Lake National Park, Oregon. At 7,400 feet—about 600 feet above timberline—one specimen was arising from a mycorrhiza cluster of a shrubby *T. mertensiana*, growing in a soil pocket on an exposed talus.

The observation of association between *Leccinum aurantiacum* and *Pinus contorta* is interesting in view of the tendency of most *Leccina* to form mycorrhizae with angiosperms. Singer (1949a), however, notes that it does associate with other pines in North America.

#### *Acknowledgment*

The Foundation for American Resource Management supplied equipment for microtechnique through the auspices of the University of Washington.

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