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ON *PILODERMA BICOLOR* AND THE CLOSELY RELATED *P. BYSSINUM*, *P. CROCEUM*, AND *P. FALLAX*

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ABSTRACT

We confirm an earlier conclusion that two species of mycorrhizal fungi, *Piloderma bicolor* and *P. byssinum*, are distinct and that the name *P. bicolor* has been correctly applied in North America. We also conclude that *P. fallax* is the most appropriate name for what has been called *P. bicolor* and *P. croceum*. Descriptions of the two species are supplemented with line drawings and photomicrographs.

INTRODUCTION

The genus *Piloderma* was introduced by Jülich (1968) to accommodate species originally included in *Corticium* sect. *Byssina* Bourd. & Galz. (Bourdot and Galzin, 1928) and typified by *Corticium bicolor* Peck. Species of *Piloderma* are reportedly ectomycorrhizal, particularly *P. bicolor* (Peck) Jülich [*Corticium bicolor* Peck (Peck, 1873)] (Eriksson *et al.*, 1981) and *P. byssinum* (Karst.) Jülich [*Lyomyces byssinus* Karst. (Karsten, 1884)] (Melin, 1936; Mikola, 1962; Vozzo, 1971; Froidevaux, 1975; Froidevaux and Jaquenoud-Steinlin, 1978; Harley and Smith, 1983).

The precise application of *P. byssinum* and *P. bicolor* was questioned earlier (Eriksson *et al.*, 1981; Larsen, 1983). Larsen (1983) objected to the new name, *P. croceum* Erikss. et Hjörts., proposed by Eriksson *et al.* (1981) to replace *P. bicolor*. Eriksson *et al.* (1981) concluded that *P. bicolor* had been applied consistently to a different species in Europe and was, therefore, a *nomen rejiciendum*. Furthermore, Eriksson *et al.* (1981) and Rogers and Jackson (1943) concluded that *P. bicolor* was synonymous with *P. byssinum*, and noted that *P. bicolor* had nomenclatural priority. Larsen (1983) concluded that the application of the name *P. bicolor* in North America was correct and that the species was distinguishable from *P. byssinum*. These views are also held by Jülich (1972), Gilbertson (1974), and Jülich and Stalpers (1980).

Stalpers (1984), after studying species of *Sporotrichum* Link., concluded that *P. (Sporotrichum) fallax* (Lib.) Stalp. is an earlier name for *P. croceum*. He (Stalpers) goes on to state that Libert's (1832) description of basidioma color ["primo aureis, tum sulphureis, demum albis" (at first golden yellow, then sulfur yellow, finally dull white - mjl)] excludes a possible synonymy with *P. byssinum*. Thus, the dispute over the identity of *P. byssinum* and its relationship to *P. bicolor* remains.

Our purpose here is to present results and conclusions based on the examination of nomenclatural types of the names in question and other specimens with regard to synonymy and criteria for separation of species. *Piloderma fallax* (syns. *P. bicolor*, *P. croceum*) is separated from *P. byssinum* by shape and size of spores and basidia, presence/absence of cystidioles, and color of cordons and subicula.

MATERIALS AND METHODS

Data on microscopical characteristics were obtained from small portions of basidiocarps squash-mounted in 5 percent KOH and stained with 1 percent Phloxine B or cotton blue (Johansen, 1940). Melzer's reagent (Melzer, 1924) was used to detect amyloid or dextrinoid structures. Capital letters used to designate herbaria are those of Holmgren *et al.* (1990). Color designations are those of Munsell (1929-1942). Photomicrographs were prepared with the aid of an Olympus Vanox-T photomicroscope utilizing Kodak T max 35 mm film. The contrast of Phloxine-B (spectral absorbance ca. 5100-5500 Å) stained structures was enhanced by a green filter (wave length emission ca. 5200 Å).

SPECIES DESCRIPTIONS

Piloderma fallax (Lib.) Stalp., Stud. Mycol. 24:53. 1984

- ≡ *Sporotrichum fallax* Lib., Plantae Cryptog. Ardenae; no. 187. 1832.
- = *Corticium bicolor* Peck, Bull. Buffalo Soc. Nat. Sci. 1:62. 1873
- ≡ *Athelia bicolor* (Peck) Parm., Easti NSV Tead. Akad. Toim., Biol. 16:379. 1967.
- ≡ *Piloderma bicolor* (Peck) Jülich, Bericht. Deutsch. Bot. Ges. 81:417. 1969.
- = *Piloderma croceum* Erikss. et Hjörts., Cort. N. Europe 6:1201. 1981.
- = *Corticium croceum* Bres., Atti Accad. Sci. Lett. Art. Agiati Rov. 3:112. 1897, non *Corticium croceum* (Pat.) Sacc., Syll Fung. 11:124 1895 (= *Aleurodiscus croceus* Pat., Bull. Soc. Mycol. France 9:133. 1893).

Basidiomata effuse, up to 0.5 mm thick, occurring in small discontinuous patches or continuous, arachnoid to byssoid; **hymenial surface** smooth, usually distinctly pellicose, dull white to pale cream (near 7.5Y 8/4 TO 2.5Y 8/4); **cordons** saffron yellow (near 2.5Y 8/10) at first ["....under surface greenish yellow, upper surface white." (Peck, 1873 and see Libert's (1832) comments on color mentioned earlier)], eventually mostly dull cream but with some yellow to pale orange tints; **subiculum** saffron yellow (near 2.5Y 8/10) at first, fading to dull white with some parts pale dull yellow; **margin** concolorous with the subiculum, farinaceous to fimbriate.

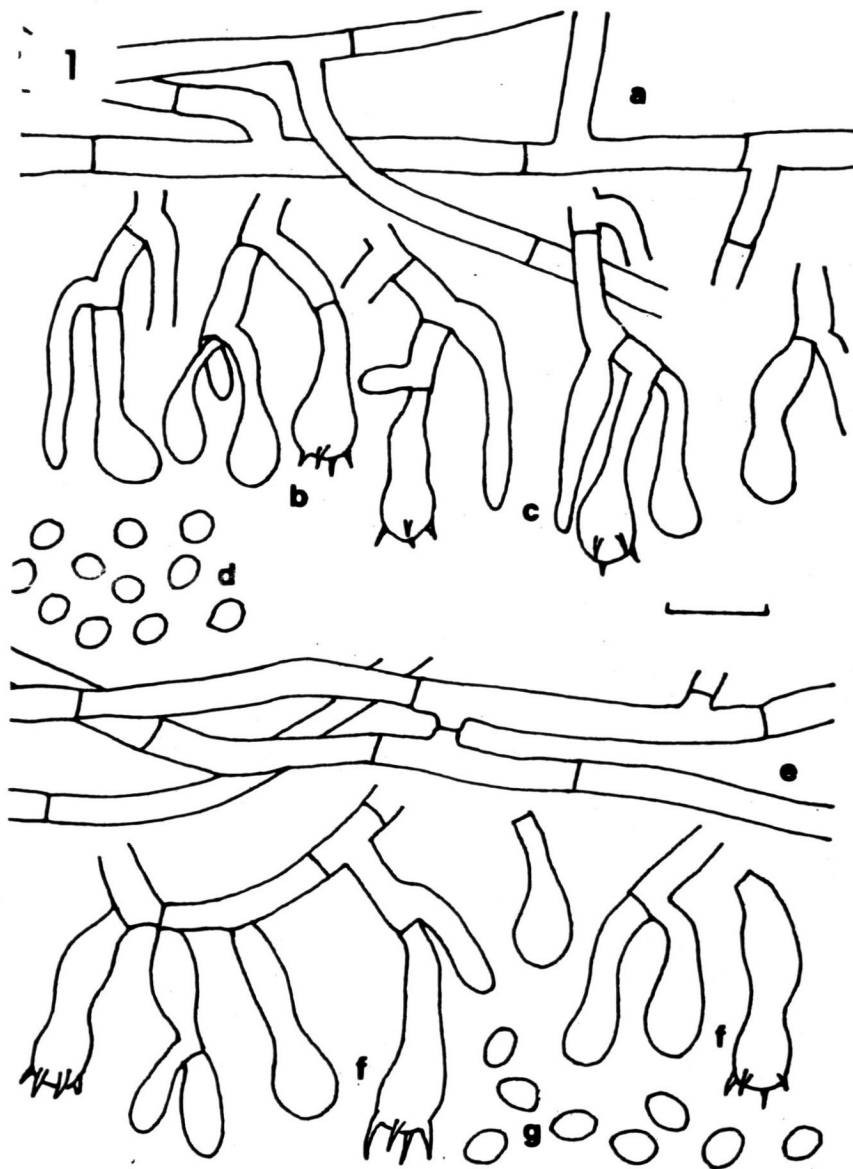


Fig. 1. Microscopical characteristics of *Piloderma fallax*. a: subicular hyphae; b: mature and immature basidia; c: cystidioles; d: basidiospores. *Piloderma byssinum*. e: subicular hyphae; f: mature and immature basidia; g: basidiospores (scale bar equal 10 μ m).

Hyphal system monomitic. **Subicular hyphae** 2-2.5 (-3) μm diam., septate without clamp connections, hyaline, thin-to somewhat thick-walled, often encrusted with variably shaped crystalline material; **cordons** 15-75 μm diam., individual hyphae as in subicular hyphae; **subhymenial hyphae** 2.5-3.5 μm diam., septate without clamp connections, hyaline, thin-walled; **sterigmate basidia** 12-15 x 3.5-4.5 μm , shape variable, sometimes appearing urniform or clavate, usually swollen apically and narrowed abruptly toward the base, septate without clamp connections at the base, hyaline, thin-walled, (2-) 4 (-6) -sterigmate; **cystidioles** frequent in most specimens, 10-13 x 2.5-3.5 μm , hyphoid to subulate, thin-walled, hyaline; **basidiospores** 2.5-3 (-3.5) x 2.5-3 μm , globose to subglobose, hyaline to pale yellow, usually thin-walled but some with thickened walls, faintly to intensely dextrinoid in Melzer's reagent, infrequently cyanophilous.

Specimens examined. ALASKA: Kenai Peninsula, south of Moose Pass, Trail Lakes campground, on *Betula papyrifera* Marsh., H. Burdsall, Jr. 12408, 13 Sept. 1988 (CFMR); Fairbanks, Steese Hwy. near Chaitaika River, under moss and *Picea mariana* (Mill.) B. S. P., B. Caldwell, 29 July 1995 (OSC). ARIZONA: Pima Co., Santa Catalina Mts., Coronado National Forest on *Pinus ponderosa* Laws., R.L. Gilbertson 9323, 31 Oct. 1969 (ARIZ; AN 003813). CALIFORNIA: 4 mi. east of Mendocino, on *Pseudotsuga menziesii* (Mirb.) Franco, R.L. Gilbertson 13807, 16 Dec. 1984 (ARIZ; AN 003815). COLORADO: 4th of July Camp, Boulder Canyon, R.L. Gilbertson 4998, 21 Aug. 1964 (ARIZ; AN 003804). IDAHO: Kootenai Co., Kaniksu National Forest, north end of Priest Lake, M. Larsen 135931 and 135932, 23 Sept. 1995 (OSC), and J. Smith and D. McKay, T17355, 23 Sept. 1995 (OSC). MICHIGAN: Marquette Co., Huron Mountain Club, on *Tsuga canadensis* (L.) Carr., H. Burdsall, Jr. 9272, 28 Aug. 1976 (CFMR). MONTANA: Crane Mt., Mission Range, Flathead National Forest, on conifer wood, R.L. Gilbertson 4517, 29 June 1964 (ARIZ; AN 003799). North Fork Flathead River, on *P. ponderosa*, R.L. Gilbertson 4886 (ARIZ; AN 003801). NEW MEXICO: Los Alamos Co., Los Alamos, on *Populus tremuloides* Micht., R.L. Gilbertson 7383, 9 Aug. 1967 (ARIZ; AN 003809). NEW YORK: Karner (Center), on rotten wood, C.H. Peck no. 135 (Type of *Corticium bicolor*; NY); Warrensburg, on *Tsuga canadensis* (L.) Carr., C.H. Peck, Oct. 19 (NY; BPI, US0280466) [listed as *P. byssinum* in Jülich (1972)]; Minerva, Essex Co., on conifer wood, H.D. House, 6 Oct. 1931 (NY); Oneida, Madison Co., on fallen pine limbs, H.D. House, 25 Nov. 1918 (NY; BPI, US0280456) [listed as *P. byssinum* in Jülich (1972)]; Ringwood Preserve, Thompsons Co., hypogeous under *Fagus grandifolia* Ehrh., J. Trappe 5965, 30 Sept. 1980 (OSC). OREGON: Tillamook Co., Otis, Cascade Head Experimental Forest, among roots of *Picea sitchensis* (Bong.) Carr., J. Trappe 5667, 4 Dec. 1979 (OSC). WASHINGTON: Thurstan Co., Fort Lewis, on decayed *P. menziesii*, W. Colgan III T17278, 3 Nov. 1993 (OSC); Olympia, Fort Lewis, on decayed *P. menziesii*, W. Colgan III T17806, Jan. 1995 (OSC); Olympia, Fort Lewis, W. Colgan III T13246, 3 Nov. 1993 (OSC). BELGIUM: In *Fagetis* ad folia dejecta, truncos et radices herbarum muscorumque, autumnno, Plantae Cryptog. Ardennae no. 187 (Type of *Sporotrichum fallax*; BR). NORWAY: Doure National Park, Sør-Trøndelag, on *Betula* sp., K. Hjörtstam 13605, 16/17 Aug. 1983 (OSC). SWEDEN: Småland, Almesåkra parish, on litter and decorticated wood of *Betula* sp., S. Lundell (3026) and G. Haglund, Fungi Exsiccati Suecici 1842 (Type of

Piloderma croceum; UPS, BPI); Småland, Värnamo, Björs, on *Pinus sylvestris* L., 2 Nov. 1959, Fungi Suecici 180 (ARIZ; AN 003789).

- Piloderma byssinum*** (Karst.) Jülich, Ber. Deutsch. Bot. Ges. 81:418. 1968.
 = *Lyomyces byssinus* Karst., Medded. Soc. Fauna Fl. Fenn. 11:137. 1884.
 = *Tomentella byssina* (Karst.) Karst., Bidrag Kaenn. Finl. Nat. Folk 48:420. 1889.
 = *Corticium byssinum* (Karst.) Mass., Linn. Soc. Bot. J. 27:133. 1890.
 = *Athelia byssina* (Karst.) Parm., Easti NSV Tead. Akad. Toim. 16:380. 1967.

Basidiomata effuse, up to 0.4 mm thick, occurring in small patches, loosely attached, arachnoid to byssoid; **hymenial surface** smooth, arachnoid to pelliculose; fertile area dull white to pale cream (near 2.5Y 8/4); **subiculum and cordons** white (near 2.5Y 8/4); **margin** concolorous with the subiculum, farinaceous to fimbriate.

Hyphal system monomitic. **Subicular hyphae** 2.5-3 (-3.5) μm diam., septate without clamp connections, hyaline, usually encrusted with crystalline material of various shapes; **cordons** 15-30 μm diam., individual hyphae as in subicular hyphae; **subhymenial hyphae** 3.5-4 μm diam., hyaline, thin-walled, branching frequently; **cystidioles** not seen; **sterigmate basidia** 18-25 (-30) \times 4-6 μm , mostly clavate but often with a narrow stem-like basal part and abruptly expanded apex, some appearing urniform, hyaline, staining in cotton blue, some dextrinoid in Melzer's reagent, 4-sterigmate; **basidiospores** 3.5-4.5 \times (2.5-) 3-3.5 μm , ellipsoid to subglobose, thin-walled but some with thickened walls in KOH, usually cyanophilous, faintly dextrinoid in mass in Melzer's reagent after 2-3 hr exposure.

Specimens examined. ARIZONA: Mt. Bigelow, Santa Catalina Mts., Coronado Nat'l. Forest, on *Pinus ponderosa*, R.L. Gilbertson 9179, 16 Sept. 1969 (BPI; US0280535). COLORADO: Buckhorn area, Roosevelt Nat'l. Forest, on *Pinus murrayana* Grev. et Balf. in A. Murr. [= *Pinus contorta* var. *murrayana* (Grev. et Balf.) Engelm.] R. Davidson, 3 Oct. (BPI; US0279893). IDAHO: Priest River Experimental Forest, Priest River, M. Larsen 134612, 23 July 1981 (CFMR). MINNESOTA: Lake Itasca State Park, Clearwater Co., on *Picea glauca* (Moench) Voss, R.L. Gilbertson 9738, 18 Aug. 1970 (BPI; US0299931). OREGON: Benton Co., Woods Creek near Mary's Peak watershed gate, under *P. menziesii*, J. Trappe and L. Froideveaux, Trappe no. 3599, 17 Jan. 1973 (OSC). FINLAND: Nylandia, Mjölö (=Isosaari), E. Wainio, Karsten 681, Oct. 1883 (Type of *Lyomyces byssinus* (H); *Tarastia australis*, Tammela, Mustiala, in ligno *Pinus sylvestris* L., P.A. Karsten 680, 29 Oct. 1888 (H), and Syrjä, (Mustiala W), ad *Abietem*, P.A. Karsten, Nov. 1883. SWEDEN: Småland, Femsjö, very rotten coniferous wood, S. Lundell 1580, 13 Sept. 1939, Fungi Exsiccati Suecici 1033a (BPI); Småland, Femsjö, Stenekullarna, J. Johnsson and S. Lundell, 6 Oct. 1939, Fungi Exsiccati Suecici 1033b (BPI).

DISCUSSION AND CONCLUSIONS

Our observations indicate that *Piloderma fallax*, *P. croceum*, and *P. bicolor* represent the same species and is distinguishable from *P. byssinum*. The principle criteria for the separation of species is provided in Table 1.

Table 1. Summary of criteria for separation of *Piloderma fallax* and *P. byssinum*

	<i>P. fallax</i>	<i>P. byssinum</i>
Basidiospore size	2.5-3 (-3.5) x 2.5-3 μm	3.5-4.5 x (2.5-) 3-3.5 μm
Basidiospore shape	Globose to subglobose	Ellipsoid to subglobose
Basidial size	12-15 (-18) x 3.5-4.5 μm	(13-) 15-21 (-25) x 4-6 μm
Cystidioles	Usually present, subulate to hyphoid	Absent
Color of rhizomorphs and subiculum	Saffron yellow when fresh, frequently fading upon drying	Dull white when fresh and remaining so upon drying

The pigmentation, or lack thereof, of cordons and subicula appears to be a reliable field character for species recognition, especially for *P. fallax*. Microscopical characters also appear to be useful, particularly dimensions of basidia which are somewhat larger in *P. byssinum*. The frequent occurrence of cystidioles in *P. bicolor* may also be helpful. Basidiospores of both species are similar in shape and dimension and may not be a useful diagnostic aid for most observers.

Staining responses of basidiomata to chemotaxonomic reagents (Melzer's reagent or cotton blue) have proven to be unreliable criteria. In both *P. fallax* (= *P. croceum*, *P. bicolor*) and *P. byssinum*, our observations showed that cyanophilly and responses to Melzer's reagent were inconsistent in the same basidioma or between basidiomata. Our observations are in conflict with some reports in the literature. Eriksson *et al.* (1981) note that spores are non-cyanophilous and somewhat dextrinoid for *P. croceum*, while Gilbertson (1974, re *Athelia bicolor*) and Jülich (1972, re *P. bicolor*) report negative responses (non-amyloid and presumably non-dextrinoid) in Melzer's reagent.

LITERATURE CITED

- BOURDOT, H., AND A. GALZIN. 1928. Hyménomycètes de France. Paris. 761 pp.
- ERIKSSON, J., K. HJÖRTSTAM, AND L. RYVARDEN. 1981. The Corticiaeae of north Europe (*Phlebia-Sarcodontia*) 6:1048-1276.
- FROIDEVAUX, L. 1975. Identification of some Douglas fir mycorrhizae. Europ. J. Forest Path. 5:212-216.



Figs. 2-3. Immature and mature sterigmate basidia of *Piloderma fallax* (Fig. 2) and *P. byssinum* (Fig. 3).

- FROIDEVAUX, L., AND M. JAQUENOUD-STEINLIN. 1978. Les Hyménomycètes résupinés mycorrhiziques dans le bois pourri. Schweiz. Zeitschr. f. Pilzk. 56:9-14.
- HARLEY, J. L., AND S. E. SMITH. 1983. Mycorrhizal symbiosis. Academic Press, London. 483 pp.
- HOLMGREN, P. K., N. H. HOLMGREN, AND L. C. BARNETT. 1990. Index Herbariorum. Part I. The herbaria of the world. Reg. Veget. 120:1-693.
- JOHANSEN, D.A. 1940. Plant microtechnique. McGraw-Hill Book Co., New York, London. 523 pp.
- JÜLICH, W. 1972. Monographie der Atheliae (Corticaceae, Basidiomycetes). Wildenowia 7:1-283.
- JÜLICH, W., AND J. A. STALPERS. 1980. The resupinate non-poroid Aphyllophorales of the temperate northern hemisphere. Verhand. Konink. Nederl. Akad. Vetensch. Naturk. 74:1-335.
- KARSTEN, P. A. 1884. Fungi rariores Fennici atque non nulli Sibirici a Dire Edv. Vainio lecti. Meddel. Soc. Fauna Fl. Fenn. 11:136-147.
- LARSEN, M. J. 1983. On *Piloderma bicolor* in North America and its relationship to *Piloderma byssinum*. Mycologia 75:1092-1093.
- LIBERT, M. A. 1832. Plantae Cryptog. Ardennae, no. 187.
- MELIN, E. 1936. Methoden der experimentellen untersuchungen mykotropher Pflanzen. Handb. Biol. Arbeitsmeth. 11:1015-1108.
- MELZER, V. 1924. L'ornamentation des spores des *Russules*. Bull. Soc. Mycol. France 40:78-81.
- MIKOLA, P. 1962. The bright yellow mycorrhiza of raw humus. Proc. Int. Union Forest. Res. Organ., 13th Congress. No. 24-4. 14 pp.
- MUNSELL COLOR COMPANY. 1929-1942. Munsell Book of Color. Munsell Color Co., Inc., Baltimore, Md.
- PECK, C. H. 1873. V. Descriptions of new species of fungi. Hymenomycetes. Bull. Buffalo Soc. Nat. Sci. 1:41-72.
- ROGERS, D. P., AND H. S. JACKSON. 1943. Notes on the synonymy of some North American Thelephoraceae and other resupinates. Farlowia 1:263-328
- STALPERS, J. A. 1984. A revision of the genus *Sporotrichum*. Stud. Mycol. 24:1-105.
- VOZZO, J. A. 1971. Field inoculations with mycorrhizal fungi. Ed., E. Hacskeylo. In, Mycorrhizae: Proc. 1st. North Amer. Conf. Mycorrhizae, April 1969. USDA Forest Service Misc. Publ. 1189. pp. 187-196.