A PRELIMINARY SURVEY OF THE GENUS *BUCHWALDOBOLETUS* (BOLETALES: BOLETACEAE)

Beatriz Ortiz-Santana
Center for Forest Mycology Research, US-Forest Service Northern Research Station
One Gifford Pinchot Drive, Madison, Wisconsin 53726
bortizsantana@fs.fed.us

and

Ernst E. Both
Buffalo Museum of Science, 1020 Humboldt Parkway, Buffalo, New York 14211
eboth@sciencebuff.org

ABSTRACT – *Buchwaldoboletus* is a small genus of about a dozen species with a world-wide distribution. The boletes of this genus are non-mycorrhizal, saprophytic and lignicolous. A preliminary survey is provided and seven new combinations are proposed.

INTRODUCTION

Fries (1838) published *Boletus sulfureus* [sic!] on the basis of a single collection in a woodshed in Uppsala, where it grew in great abundance on wood chips. He compared its luxurious, caespitose habit to that of *Pholiota spectabilis* and placed it in tribe *Subtomentosi*.

Berkeley and Curtis (1853) reported *Boletus hemichrysus* from South Carolina "attached to the roots of *Pinus palustris*" based on a collection by Ravenel. They stated that "it resembles *B. variegatus*" (= *Suillus variegatus*), which Fries also placed in *Subtomentosi*.

Six years later Barla (1859) published *Boletus sphaerocephalus* also found growing caespitosely on woodchips, but in the forest rather than in an enclosed room. Barla's taxon differed from *B. sulphureus* mainly in a considerable extension of the margin of the pileus, which Barla considered to be a veil. Fries listed Barla's species in his "Hymenomycetes europaei" (1874) some distance away from his own (now spelled "*sulphureus*"), calling it "Princeps Boletorum" without recognizing their similarities.

In his "Boleti of the United States" Peck (1889) followed the classification of Fries but he erected a new tribe, "Pulverulenti" to accommodate the North American *Boletus hemichrysus, B. auriflammeus,* and *B. ravenelii*. Murrill (1910) created the genus *Pulveroboletus* with *P. ravenelii* as the only species.

In 1924 Kallenbach proposed "*Boletus sulphureus forma silvestris*" as a reddish-rust color form, theorizing that *B. sulphureus* was merely a paler color form since it grew in an enclosed place. By 1929 Kallenbach was convinced that the two taxa were different and he published his *forma* as *Boletus lignicola*. He believed that *B. sphaerocephalus* was not the same as *B. sulphureus* because of its "veil."

Singer (1947) transferred *B. sulphureus* to *Phlebopus* and created the sections *Sulphurei* in that genus to accommodate it. He listed *B. hemichrysus*, *B. hemichrysus* var. *mutabilis* and *B. sphaerocephalus* as synonyms and *B. lignicola* as a questionable synonym. He based his description on Fries' diagnosis and the descriptions of Neuhoff and Corbière in Kallenbach (1929).

Singer (1947) placed section *Sulphurei* in his emended version of Murrill's *Pulveroboletus,* and in 1961 he transferred *Boletus hemichrysus* to *Pulveroboletus.* In his description of *Pulveroboletus hemichrysus* (Singer 1967, merely a German version of his 1947 description as "*Phlebopus sulphureus*") he listed *Boletus sulphureus* and *B. sphaerocephalus* as synonyms.

Pilát (1965) transferred *Boletus lignicola* to *Pulveroboletus* and in 1969 he proposed the genus *Buchwaldoboletus* to accommodate *Boletus lignicola* (type species) and *B. hemichrysus*. Pilát characterized the two members of the genus by their lignicolous habit, lack of veil, decurrent and arcuate hymenophore, the stipes with yellow mycelium, the bluing yellow flesh and the absence of hyphal clamps.

Singer's synonymy was followed by many European authors including Watling (1970) who, however, suggested that "further work will possibly indicate that our European fungus is not conspecific" [with the North American *Boletus hemichrysus*]. "If this is true the valid name of our fungus would be *Boletus sphaerocephalus*." Smith and Thiers (1971) were the first North American authors to use this name. Watling, and Smith and Thiers thought that *B. sphaerocephalus* and *B. sulphureus* were the same, regarding Barla's "veil" as a simple extension of the pileus' margin similar to what is found in some species of *Leccinum.*

Watling and Gregory (1988) transferred *Boletus sulphureus* to *Buchwaldoboletus* and they published *Buchwaldoboletus spectabilis* as a new species from Australia, with similarities to *B. hemichrysus*. Watling (2008) emended the genus *Buchwaldoboletus* based primary on the type species of the genus.

Watling and Hills (2005) proposed two stirpes for the two species of *Buchwaldoboletus* in Europe: Stirps 1: Lignicola and Stirps 2: Phaerocephalus. We propose a third stirps: Stirps 3. Hemichrysus.

We present the first world-wide survey of 12 members of this genus and propose seven new combinations. This survey is based on macro- and micromorphology as culled from the literature.

STIRPS 1. LIGNICOLA GROUP

Pileus and stipe tomentose, with some shade of brown, reddish brown, dry; context yellow, bluing, especially above the tubes; *Buchwaldoboletus lignicola*: Europe and eastern North America; *B. xylophilus*: Sri Lanka, Malaysia, Hong Kong, Philippines; *B. kivuensis*: Africa, Congo; *B. brachyspermus*: Lesser Antilles, Martinique; *B. duckeanus*: Brazil, Amazonia.

BUCHWALDOBOLETUS LIGNICOLA

Pilát, in Friesia IX: 217. 1969.

Basionym:
Boletus lignicola Kallenbach, in Die Pilze Mitteleuropas, Band 1. Die Röhrlinge (Boletaceae) p. 57. 1929.

Type: Not designated, apparently lost.

Synonym: *Boletus sulfureus* Fries forma *silvestris* Kallenbach 1924, Annales Mycologici 22:410–414.

Additional synonymy: *Xerocomus* (Singer, 1942); *Gyrodon* (Heinemann, 1951, description excluded); *Phlebopus* (Moser, 1955); *Pulveroboletus* (Pilát, 1965); *Pulveroboletus* (Dick & Snell, 1965, superfluous). For complete citation, see Both (1993).

Characterized by the yellow-brown to reddish brown pileus and stipe, pileus covered with soft appressed tomentum which is easily detersible, attached to the flesh by a thin gelatinous layer, so that the tomentum can be moved back and forth. Context yellow, bluing above tubes. Tubes detersible, decurrent, pores yellow to golden, bruising greenish-blue. Stipe equal, basal area sulphur-yellow, ending in a golden-yellow mycelium. Spores 6–9 (–12) × 3–4 µm; cystidia 29–80 × 4–9 µm.

Habit/habitat: Usually solitary, rarely two to four specimens fused together, no truly caespitose. At the base of or on top of stumps of conifers, *Picea abies*, *Pinus silvestris*, *P. strobus* and other pines, also with *Larix*, rarely with deciduous trees (*Prunus avium*). Often together with the polypore *Phaeolus schweinitzii*. Widely distributed throughout Europe, from the subartic south to Switzerland. In North America from Quebec and Ontario throughout Eastern North America; south to Pennsylvania, southern limits to be established.

The association of *Buchwaldoboletus lignicola* with the brown-rot *Phaeolus schweinitzii* is well-documented in the European literature, although this association "is not understood but must be very close" (Watling, 2004). Szczepka and Sokol (1984) catalogued the joint appearance of the two fungi in Europe from 1962–1982 and suggested that the wood broken down by the polypore might provide a favorable substrate for the bolete.

In their study the authors found the two fungi to grow in close proximity near *Pinus silvestris*, *P. strobus*, *Larix decidua* and *Prunus avium*. It is interesting to note that the trees favored by the bolete are also the same that are infested by the polypore: the conifers *Pinus*, *Picea*, *Abies*, *Larix*, more rarely deciduous trees, especially *Prunus* (Jahn, 1979). The joint occurrence with *Prunus avium* is especially noteworthy: A number of boletes were collected from 1972–1978 by J. Zedlacek under an old *Prunus avium* (See Dermek 1984, Fig. 99, for J. Sedlacek's collection of *B. lignicola* under *Prunus avium*. Interestingly, Dermek makes no mention of *Phaeolus schweinitzii*). Between 1974 and 1977 *Phaeolus schweinitzii* grew regularly at the base of this tree, often in close proximity with the bolete. Since the bolete grew alone from 1972 to 1974 can it be assumed that it did not need the polypore?

Brown (1985) reported the occurrence of *Boletus lignicola* and *Phaeolus schweinitzii* in a plantation of about 250 Sitka spruce trees (*Picea sitchensis*) in North Wales. Ten trees were found to be infested with *P. schweinitzii* and seven of the infested trees produced 24 fruiting bodies of *B. lignicola*. During four observed seasons the bolete fruited very close to the polypores and their old remains from previous years.

Lipka (1985) studied some 50 fruit-bodies of *Buchwaldoboletus lignicola* collected in a forest near Warsaw, Poland. They grew under 8 trees of *Larix* and 2 of *Pinus*. In the same locality grew *Phaeolus schweinitzii*. Some of the 62 fruit-bodies of the polypore grew near the conifers or on their stumps, but always in the neighborhood of young, deciduous trees o the genera *Corylus, Carpinus, Crasus, Padus, Sorbus* and *Acer*.

Lipka (1987) found that individual fruit-bodies of *B. lignicola* could exist for 4–6 (7) weeks. Since they always occurred in the presence of young deciduous trees identified in the previous paper, it was suggested that this bolete (in addition to being a saprophyte) could form mycorrhizal relationships with some of these trees. While the odor of the context of *B. lignicola* was pleasant ("subaromatico") in young specimens, it became very disagreeable in older ones. A disagreeably foul odor was also recorded by Killermann, who create the taxon *Boletus lignicola* var. *foetidus* Killerman 1925 (cited in Kallenbach, 1929). To our knowledge, these are the only two records of an unpleasant odor associated with *Buchwaldoboletus lignicola*.

Descriptions and illustrations: Bessette et al (2000, from Lamoureux & Després); Breitenbach & Kränzlin (1991); Dähncke (1993, p. 53, three fruit-bodies fused together); Dermek (1984, Fig. 97); Dermek & Lizon (1985, # 118); Heinemann (1988); Kallenbach (1929, Plate 25); Lamoureux & Després (1997, fig. 63): Leclaire & Essette (1969, pl. 13); Phillips (1991, p. 223); Pilát & Dermek (1974, pl. 26. c-m, from Kallenbach); Reid (1966, pl. 2); Singer (1967); Watling & Hills (2005, description).

BUCHWALDOBOLETUS XYLOPHILUS
(Petch) Both & B. Ortiz, comb. nov.

Basionym:
Boletus xylophilus Petch, Annals Royal Botanic Garden, Peradenya 7:283. 1922.

Holotype: SRI LANKA: Central Province: Kandy District, Peradeniya, Nov. 1918, Petch 5812 (K.). Additional material: Peradeniya, Nov. 1909; Western Province: Urumuwella, 1906; Elkaduwa, June 1910 (Pegler, 1986). Petch stated that "specimens, probably of this species, up to a foot in diameter, have been seen … in the low-country." "On lawns or in forest, arising from buried wood, around decaying stumps or on rotting logs of dicolyledonous trees."

Throughout Malaysia, Sri Lanka, Ceylon, Hong Kong, Malaya, Philippines.

Synonyms: *Pulveroboletus xylophilus* (Petch) Singer, in Singer, Araujo and Ivory, Beih. Nova Hedwigia 77: 98 (1983). *Gyrodon xylophilus* (Petch) Heinemann and Rammeloo, Bull. Jard. Bot. Nat. Belg. 53:295 (1983). *Pulveroboletus xylophilus* (Petch) Singer, in Kew Bull. Add. Series 12:465 (1986). Superfluous.

Boletus xylophilus is characterized by the overall ferrugineous-brown colors, the dry to subviscid minutely velvety pileus and the surface of the pileus "with a soft brown layer 1–2 mm thick, attached by a thin subgelatinous layer to the underlying flesh" (Corner, 1972), the yellow context and pore surface that stained blue, and the red-brown stipe with sulphur-yellow mycelium at the base (Petch, 1922). It is further characterized by the very small pores and the small spores: 4.5–5.5 × 3.2–4 µm (type, Pegler & Young, 1981). Cheilocystidia 17–23 × 4–5 µm, pleurocystidia 27–40 × 6–10 µm. Pegler (1986) mentioned "yellow velar remnants over the stipe base," but Petch (1922) described this as the "sulphur-yellow mycelium, sometimes ascending the base of the stem."

The pileipellis is a "poorly developed trichodermial layer of semi-erect hyphae… overlying a gelatinized hypodermium" (Pegler, 1986). *Buchwaldoboletus lignicola* shows a similar structure as noted by Pilát (1965), the upper surface (which covers the hypodermium) can be moved back and forth much like the surface of *Fistulina hepatica* (Singer, 1967). The same structure has been found in *Gyrodon kivuensis* (Neda et al., 1987), but not in *Pulveroboletus brachyspermus*, both of which are close to *B. xylophilus* and *B. lignicola*. All four of these have somewhat similar small spores, ranging from 4.5–5.5 × 3.2–4 µm for *B. xylophilus* to 6–9 × 3–4 µm for *B. lignicola*, with the spores of the other two falling between this ranges.

Singer (1981) noted that "*Boletus xylophilus* Petch (identical with *P. viperinus* Singer) is… quite obviously a *Pulveroboletus*, sect. *Sulphurei*, where the detersile fibrillosity is seemingly or really lacking, and in this case a continuity between sect. *Sulphurei* and sect. *Duckeani*… can be established."

Descriptions and illustrations: Corner (1972); plate 2, three specimens and one cut in half (painting by Corner); Fig. 9, growth of the fruit-body of *B. xylophilus*. Pegler (1986) Fig. 103: A. Habit and section (after Corner) of fruit-body, 0.5x; B. spores; C. pleurocystidia (line drawings).

BUCHWALDOBOLETUS KIVUENSIS
(Heinemann & Goossens) Both & B. Ortiz, comb. nov.

Holotype: AFRICA: Congo, District of the lakes Édouord and Kivu: Panzi-Kivu, alt. 1650 m. abundant on the soil covered with dry branches, in a planting of *Coffea arabica*, near a plantation of Eucalyptus, Jan. 1949. *M. Goosens-Fontana 5087* and picture. Fig. 40, cystidia, line drawings.

Synonyms: *Pulveroboletus kivuensis* (Heinemann and Goossens) Singer, in Singer & Grinling, Persoonia 4(4):374. 1967. *Gyrodon kivuensis* Heinemann and Goossens, in Heinemann, Bulletin du Jardin Botanique de lÉtat a Bruxelles 25(2): 169. 1955.

First published as *Gyrodon lignicola* in Heinemann (1951, pp. 238–241) with detailed descriptions. Fig. 53, microscopic structures, line drawings.

Characterized by the cinnamon-brown tomentose-pulverulent and dry pileus, the ochraceous-decurrent, bluing tubes; the cylindrical eccentric stipe with well-developed mycelium at the base, and the yellow, bluing context. It appears to be closely related to *Boletus xylophilus* and like that species has a subgelatinous epidermis, separating the pileal tomentum from the pileal flesh. Spores 5.3–6.8 × 3.3–4.7 µm; cystidia lanceolate 20–40 × 4–10 µm.

Corner (1972) listed it as a questionable synonym of *Boletus xylophilus*, but that species has somewhat shorter spores (4.5–5.5 vs. 5.3–6.8 µm), and larger pleurocystidia (50–70 × 8–14 µm vs. 27–45 × 5.5–10 µm).

In discussing *Pulveroboletus paspali* Singer & Grinling, the authors noted that "among the African species this species appears

to be similar to *Pulveroboletus kivuensis*… which differs from our new species in larger carpophores, bluing context, less evident veil, consistently arcuate-decurrent tubes." The non-bluing context, cylindrical spores, and veil-remnants exclude *P. paspali* from considerations as a *Buchwaldoboletus* species. Corner (1972) placed it close to *Boletus ravenelii*.

BUCHWALDOBOLETUS DUCKEANUS

(Singer) Both & B. Ortiz, comb. nov.

Basionym: *Pulveroboletus duckeanus* Singer, in Singer, Araujo and Ivory, Beihefte zur Nova Hedwigia 77:95. 1983.

Type: BRAZIL: Amazonas: "Ducke-Forest, about 6 km from entrance, about 25 km N of Manaus, 28.VI.1978, leg. Ermelinda Freire, comm. *Singer B 11247* (INPA)."

Characterized by the brown, viscid pileus, the small, bluing pores, the subferruginous, tapering stipe, the yellow, bluing context and the small spores. Like *Boletus xylophilus* and *Buchwaldoboletus lignicola* it has an "often obsolescent trichodermium … resting on a slightly gelatinized epicutis." Spores (4)5–6 × (3.3)3.5–4.2(4.5) µm; cystidia versiform, 15–39 × 7–11.5 µm; cheilocystidia fusoid-subacute 28–39 × 5–8.5 µm; hyphae without clamps.

"We consider it as the type of a group of strictly tropical species, none of which appear to be obligatorily ectomycorrhizal. These are aside from *P. duckeanus*; *P. rosaemaria* and, in the palaeotropics *P. xylophilus*… (=*Phlebopus viperinus*). This latter species of which I have seen collections from the Philippines, Ceylon, Hong Kong, and India (Calicut University campus on a dead stump palm, leg Leelavathy, F) differs from *P. duckeanus* by a deeper, thicker trichodermium, large average size of the carpophores and different cheilocystidia" (Singer et al., 1983).

Descriptions and illustrations: Singer et al. (1983), Fig. 14, Microscopic structures (line drawings); Fig. 15, two carpophores x1 (line drawings); Plate 17A: color photographs of three carpophores; in appearance similar to Corner's painting of *B. xylophilus*, but smaller in size.

BUCHWALDOBOLETUS BRACHYSPERMUS

(Pegler) Both & B. Ortiz comb. nov.

Basionym: *Pulveroboletus brachyspermus* Pegler, in Kew Bulletin, Additional Series IX:582. 1983.

Holotype: MARTINIQUE: Morne Aca, on a large, decaying trunk in a degraded primary xero-mesophytic forest, 200 m, 23 Sept. 1976, *Fiard 782* (K).

Pulveroboletus brachyspermus is characterized by the brown pileus, the olivaceous yellow bruising greenish blue tubes, the very small pores which bruise blackish brown; the pale brown context that bruises blue green context, and the russet-colored stipe with a yellow floccose layer over the basal area. This layer is an extension of the deep yellow, copious mycelium, also found in *Boletus xylophilus*. Spores 4.7–6.2 × 3.5–4.2 µm; cystidia numerous, 40–55 × 11–14 µm.

It appears to be most closely related to *Boletus xylophilus* and *Buchwaldoboletus lignicola*, but it lacks the gelatinous hypodermal layer found in the pileipellis of these two species. In addition *B. lignicola* is associated with pines, while *B. xylophilus* grows on dicotyledonous wood.

PHLEBOPUS VIPERINUS

Singer, in American Midland Naturalist 37:5. 1947.

Pileus brownish to olivaceous-brown, tinged green, viscid, semi-globose, becoming plano-convex, 10–20 cm broad; hymenophore sulphureus, pores very small, tubes short, decurrent; context slowly bluing when cut. Stipe concolorous with pileus, substriate, cylindrical, 7–12cm × 7–13 mm. Spores 5–6.5 × 3.5–4.2 µm. Among decaying leaves and woody debris under *Acacia*. June to September.

Type: PHILLIPINES (FH – no other information published by Singer). Honk Kong,

U.S.N. Pac. Expl. Exp. *C. Wright 212*, det. Singer, Co-TYPE (FH).

This is based on *Boletus badius sensu* Mendoza, "Phillipine Mushrooms," Phil. Journ. Sci. 65:91. 1938, pl. 54, fig. 1. (not seen). Heinemann & Rammeloo (1983) stated that Singer's diagnosis was a quasi literal translation of Mendoza's description, while Singer's microscopic data were based on a collection by Mendoza [Pandonan, Manila, 12 July 1935, single specimen with spores 4.5–5.00–5.8 × 3.3–3.75–4.0 µm] which Singer designated as the type, "without any certitude that it served as the basis of Mendoza's description." They further stated that the co-type, designated by Singer, was a different species and that *Phlebopus viperinus* should be considered a *nomen dubium*.

Corner (1972) cited it as "*Pulveroboletus viperinus* Singer, Agaricales, 1962" (as did Heinemann & Rammeleo: "*Pulveroboletus viperinus* (Sing.) Singer," Agaricales in modern taxonomy, 2nd Ed: 734 – though Singer did not publish a valid transfer. Corner (ibid.) listed it as a questionable synonym of *Boletus xylophilus*, while Singer (1981) noted that it was identical with that species.

STIRPS 2. SPHAEROCEPHALUS:
Pileus and stipe yellow; pileus silky tomentose, viscid when wet; context bluing; on sawdust of pines, often in enclosed areas. *Buchwaldoboletus sphaerocephalus*/*sulphureus*: Europe, North America and Southwestern Australia; *B. peudolignicola*: Japan.

BUCHWALDOBOLETUS SULPHUREUS
Watling in Watling & Gregory, Proceedings Royal Society of Queensland 99:71. 1988.

Watling (2004) has "*Buchwaldoboletus sulphureus* (Quél. [sic!]) Watling & N.M. Gregory…"

Basionym: *Boletus sulphureus* [sic!] Fries in Epicrisis Systematis Mycologici, p. 413. 1838. *nom. illegit.*

Type: SWEDEN, Uppsala. We have no information of the type.

Synonyms: *Versipellis* (Quélet, 1886); *Xerocomus* (Quélet, 1888); *Suillus* (Kuntze, 1898); *Ixocomus* (Gibbert, 1931); *Phlebopus* (Singer, 1947); *Gyrodon* (Heinemann, 1955).

Pileus compact, hemispheric becoming applanate, sulphur-yellow with innate, silky fibers, margin inrolled; pilei becoming deformed and fused together because of the densely caespitose growth. Context yellow, bruising more or less blue, becoming yellow again after bruising, at times reddening above tubes. Tubes adnato-decurrent, 2–4 mm long, becoming rust-colored when bruised, pores compound, yellow, becoming greenish. Spores yellow-olive. Stipe glabrous, sulphur-yellow, becoming rust-colored. Description after Fries, Epicrisis, p. 413–414, and Hymenomycetes Europaei p. 502. 1874 (Fries changed "sulfureus to sulphureus").

Fries found it only once in a wood-shed in Uppsala, among decaying wood chips of pine, very copious, growing in clusters out of a wide-spread golden yellow mycelium.

Descriptions and illustrations: Singer (1947, as *Phlebopus sulphureus*); Pantidou (1961) published a study of *Phlebopus sulphureus* in culture, based on a specimen collected in Louisiana, with spores 6–10 × 3–4.5 µm; Singer (1967, as *Pulveroboletus hemichrysus*, merely a German translation of his 1947 description). Singer was followed by a number of European authors – see our discussion under *B. hemichrysus*. Kallenbach (1929) pl. 47, figs. 79/80, two views of a cluster of 6, black & white photographs; pl. 25, figs. 17/18 after paintings by E. Neuhoff 9.VII.1919 (on decaying woodchips in a barn of a brewery) – with spores 7–9 × 3.5–4 µm; Pilát & Dermek (1974), pl. 2b, figs. a-d (from Kallenbach); Leclair & Essette (1969), Pl. 17; Dermek (1979) pl. 66a as "*B. hemichrysus*" (on a living *Pinus silvestris*, see Engel 1977); Alessio (1985) pl. 69 as *Pulveroboletus lignicola.*

"With the nomenclatorial protection of Friesian names which appear in *Systema Mycologicum* and *Elenchus* the name *Boletus sulphureus* Fr. must be judged as a later homonym of *Boletus sulphureus* Billiard" [and thus "*B. sulphureus* Fries" becomes a *nom. illegit*.]. The next available name for this bolete

is therefore *Boletus sphaerocephalus* Barla (Watling & Li, 1999).

BUCHWALDOBOLETUS SPHAEROCEPHALUS
(Barla) Watling & T.H. Li, in Watling, Edinburgh Journal of Botany 61: 46. 2004.

Watling and Li (1999) have it (incorrectly) as *Buchwaldoboletus sphaerocephalus* (Barla) T.H. Li. & R. Watling in Edinburgh Journ. Bot. 56:44. 1999.

Basionym: *Boletus sphaerocephalus* Barla, Les Champignous de la Province de Nice, 72. 1859.

Synonyms: *Buchwaldoboletus hemichrysus* f. *sphaerocephalus* (Barla) Estadès & Lannoy, Documents Mycologiques XXXI(no. 121). p. 59. 2001. *Boletus sulphureus* forma *sphaerocephalus* (Barla) Konrad & Maublanc, Icones Selectae Fungorum 6:469. 1937.

Caespitose, pileus at first nearly spherical, becoming strongly convex, glabrous, becoming viscid in humid conditions, yellow to yellow-fulvus; tubes short, adnate ventricose, pores very small; stipe fleshy, ventricose; context yellow, bluing; spores ovoid, pale ochraceous. In the forest of Lamaer, on sawdust of Pinus.

Watling and Gregory (1988) reported *Buchwaldoboletus sulphureus* from Australia (Kalamunda near Perth) growing in a cluster at the base of a dead pine stump under *Pinus radiata*, a conifer introduced from California. They reported the spores to be 5.5–7.2 × 3.3–4.5 µm. Watling and Li (1999) reported on additional material and changd the name to *Buchwaldoboletus sphaerocephalus*. Two primordia in this collection showed "the pileus margin… clasping the stipe, parallel to the phenomenon seen in *Leccinum atrostipitatum*… and its allies. On further development, the pileus… maintains a rather irregular appendiculate narrow skirt" as an extraordinary extension of the pileus margin, a thin, soft and viscous skin." This is the only difference between *B. sulfureus* and *B. sphaerocephalus.*

Habit/Habitat: at the base of pine stumps, single or in groups on sawdust of pines in dense caespitose clusters of up to 15–20 individuals. Often in sheltered areas or indoors in woodstalls, wood-sheds et al. and then year-round. Throughout Europe, from Scandinavia to Italy; in North America from Canada south to Florida, along the Gulf Coast to Texas, west to Michigan and Idaho.

Descriptions and illustrations: Corbière (1922, description in Kallenbach) gave the spores as 7–8 × 4 µm and the dimension of the pileus as 10–12 (-20) cm; Smith & Thiers (1971, pl. 92, black and white photograph of a cluster of 3); Watling (1976) Fig. 8, black and white photograph of a dense cluster of 7 specimens, Great Windsor Park, England, "on sawdust heap in conifer plantation." Bessette, Roody and Bessette (2000), p. 312A, 313B; Galli (2000), pp. 29, 36, 147, 148 at base of *Pinus pinea* (as *B. hemichrysus*).

BUCHWALDOBOLETUS PSEUDOLIGNICOLA
(Neda) Both & B. Ortiz, comb. nov.

Basionym: *Pulveroboletus pseudolignicola* Neda, in Neda, Yokoyama and Furukawa, Trans. Mycol. Soc. Japan 28:319. 1987. Fruitbodies and microscopic structures. Line drawings.

Type: JAPAN, Tsukuba, Ibaraki, 3 July 1986, F-14578, Herbarium of Forestry and Forest Products Research Institute (BCI).

Pileus 4–17 cm, pulvinate to plane, velutinous, yellow to cinnamon-brown, bluing when bruised; tubes arcuate-decurrent; yellow, pores very small, chrome yellow, bruising blue; stipe 5–8 cm × 2–6 mm, central to sub eccentric, firm, yellow to orange, darker toward the base, bruising blue; "attached by the yellow mycelium to the sawdust." Flesh yellow, bluing. Spores 5–7 × 3.5–4.5 µm; cheilocystidia numerous, 26–44 × 5.0–6.5 µm, pleurocystidia similar. "Gregarious or caespitose on sawdust of pine, July to September."

The authors compared it primarily to *Boletus xylophilus* but we believe its true relationship is with *B. sphaerocephalus* on the basis of the overall yellow colors and the strongly caespitose habit on sawdust of pine.

STIRPS 3. HEMICHRYSUS:
Pileus and stipe bright yellow, pulverulent; pore surface yellow, becoming subferrugineous; stipe yellow above, reddish below. *Buchwaldoboletus hemichrysus*: North America, reports from Europe refer to *B. sphaerocephalus*; *B. acaulis*: Lesser Antilles, Martinique; *B. spectabilis*: Australia, Queensland; *B. orovillus*: California.

BUCHWALDOBOLETUS HEMICHRYSUS
(Berkeley & Curtis) Pilát, in Friesia IX: 217. 1969.

Basionym: *Boletus hemichrysus* Berkeley & Curtis, in Ann. Mag. Nat. Hist. ser. 2, 12:429. 1853.

Type: USA: South Carolina, Curtis no. 2928. (K). Pegler and Young (1981) as "Ravenel 2928", spores 6.5–8.5 × 2.7–3.5 µm.

Pileus 6–8 inches across, convex, at length plane or irregularly depressed, very bright golden-yellow, squamulose-floccose disposed to crack. Sprinkled with copious yellow dust. Flesh yellow, tasteless. Mycelium yellow. Stem short, varying in thickness, sometimes 1½ inch in diameter, yellowish tinged with red, irregular, contracted below. Veil none. Hymenium rich red-brown. Tubes angular, adnate, slightly decurrent. Spores ochraceous, dingy, oblong, minute.

Berkeley (1872) provided much smaller dimensions that those given in the protologue: "Pileus 1.5–2.5 in., stem 1 in. high, ¼–½ in. thick."

Berkeley and Curtis stressed the "bright golden yellow" pileus, the obvious and "copious" pulverulence which was not due to the presence of *Sepedonium*, a golden yellow *Hypomyces* which infects many species of boletes. This species did not appear in the North American literature until 1889 when Peck published a description based on the protologue, together with a brief note on his variety "mutabilis." Murrill's (1910) description was also based on the protologue as was the description in Coker and Beers (1943).

Coker and Beers did not collect it in North Carolina but they did report on a collection by Murrill from Green Cove Springs, Florida, stating that "in the dried state the cap is 7.9 cm wide; tubes 10 mm long, distinctly decurrent, mouths irregular, radially elongated near stem but not large; stem about 7 cm long. The size of the tube mouth and length of the stem thus depart from the usual description, but it is otherwise typical and undoubtedly the present species." They published a drawing of the spores (plate 61, fig. 17) with dimensions of c. 7.5–9 × 3.5–4.0 µm (scaled from the drawing). They further stated that "this species seems near *B. sulphureus* Fr., which grows in clusters on sawdust (pine, according to Rea)."

Singer (1947) made *Boletus hemichrysus* a synonym of *Phlebopus sulphureus* (Fr.) Singer, together with *Boletus sphaerocephalus* and *B. lignicola*, the latter as a questionable synonym. In 1967 Singer published essentially the same description (in German) under *Pulveroboletus hemichrysus* (Berk. & Curt.) Sing., Sydowia 15:82. 1961" with *Boletus sulphureus* and *B. sphaerocephalus* as synonyms, but omitting *B. lignicola* from the synonymy. Singer's concept was followed by a number of European authors: Watling (1970), Pilát and Dermek (1974, merely a translation of Singer's description), Skiergiello (1975), Engel (1977), Kallio and Heikkilä (1978), Dermek (1979) and others. Singer himself (1986) maintained the same concept.

Watling (1970) appears to have been the first to suggest that *B. hemichrysus* may not be conspecific with *B. sulphureus* = *B. sphaerocephalus* (Both, 1993). Watling and Li (1999) stated: "Several collections of *Boletus hemichrysus* … have been examined because of the suggestions that this species might be the same as *B. sulphureus*; *B. hemichrysus* was originally described from North America. The two fungi are not the same: the latter differs in the development of a yellow powdery veil" [= the pulverulence in *B. hemichrysus*].

Habit/Habitat: with various pines, growing at the base of pine stumps or pine trees, from Canada south to Florida, along the Gulf Coast to Texas. European reports refer to *B. sphaerocephalus*.

Descriptions and illustrations: Snell & Dick (1970), pl. 28, not convincing; Weber & Smith (1985), pl. 69; Metzler & Metzler (1992), 230; Bessette, Roody & Bessette (2000), 295 A-D, not convincing; Galli (2000), the *Buchwaldoboletus hemichrysus* pp. 29, 36, 147 and 149 is *B. sphaerocephalus*.

Watling & Gregory (1988) described a very similar species from Western Australia: *Buchwaldoboletus spectabilis* Watling.

BOLETUS HEMICHRYSUS
var. MUTABILIS
Peck, Bulletin New York State Museum 2(8):104. 1889.

Type: USA: New York, Gansevoort, July [1886], apparently not preserved at NYs (!).

Characterized by the "dense yellow tomentum … ofthen rimose-squamose," the yellowish flesh changing to blue. The tubes adnate, "yellow becoming subferruginous and the reddish stem" (for a complete description based on Peck's notebook see Both 1993). "A remarkable species both from its habitat and from the dense tomentum of the pileus. The tomentum is about one line thick. Three specimens found. Pulverolenti" (Peck, Pulverulenti, unpublished notebook 15:145.1886/87).

Singer (1947) treated this variety as a synonym of his broad concept of *Phlebopus sulphureus*. Dick and Snell (1965), Pilát and Dermek (1974) and Dermek (1984) treated it as a synonym of *Boletus lignicola*.

BUCHWALDOBOLETUS ACAULIS
(Pegler) Both & B. Ortiz, comb. nov.

Basionym: *Pulveroboletus acaulis* Pegler, in Kew Bulletin Additional Series IX: 581. 1983. Fig. 117, M-Q, line drawings of habit and section.

Type: MARTINIQUE: Morne Aca, in xero-mesophytic forest, Nov. 1976, Fiard 6748 (K). Additional collection: Bois La Roche, on very decayed trunk in xero-mesophytic forest, 20 Oct. 1976, Fiard.

Pileus 3–6.4 cm, subglobose, bright yellow, floccose-pulverulent. Tubes arcuate-decurrent, olivaceous-yellow; pores small, sulphur-yellow, bruising deep blue, becoming pinkish-brown. Stipe rudimentary, lateral to very excentric, concolor with pileus, pulverulent. Context yellowish. Spores 5.5–8 × 2.5–3.5 µm; cystidia numerous, 25–35 × 8–10 µm, upper half encrusted, resinous, brown.

It is very close to *Buchwaldoboletus hemichrysus*, which has more elongated spores (6.2–9 µm) and is always associated with pines.

BUCHWALDOBOLETUS PARVULUS
(Natarajan & Purushothama) Both & B. Ortiz, comb. nov.

Basionym: *Pulveroboletus parvulus* Natarajan and Purushothama in Trans. Br. Mycol. Soc. 90(1):144–145. 1988. Fig. 1. Fruiting bodies and microscopic structures, line drawing.

Holotype: SOUTHERN INDIA: on dead bamboo stumps, in groups, in Poourale Forest, near Sullia (S.K.), Karnataka, India, 4 Sept. 1984, K.B. Purushothama (MUBL 3069).

Pileus 7–13 mm, nearly spherical, reddish-yellow, pulverulent pileus and stipe. Stipe very short, excentric, concolorous with pileus. Tubes adnate, concolorous with the pileus, 3–4 mm deep; context of stipe becoming olive brown when cut; stipe 5 × 4 mm. Spores 5–6 × 3–4 µm. Cystidia abundant, 17–52 × 5–8 µm.

The very brief description (based on a single collection) does not mention any bluing, which would be very unusual for a member of the genus *Buchwaldoboletus*. The yellow, pulverulent pileus and stipe as well as the size of the spores place *Pulveroboletus parvulus* close to *Buchwaldoboletus hemichrysus*. It differs from *Pulveroboletus acaulis* in the absence of encrusted cystidia and the shorter spores (5–6 µm vs. 5.5–8 µm).

BUCHWALDOBOLETUS SPECTABILIS
Watling, in Watling & Gregory, Proceedings of the Royal Society of Queensland 99:70. 1988.

Holotype: AUSTRALIA: Queensland. Bunya Mountains Nature Reserve, Old Dandabah Picnic Area, 9.III.1986, *T. Young 987*, BRIP 15097. Material in E. Gregarious at the base of rotten stump of Bunya Pine (*Araucaria bidwillii*) in rain forest.

Pileus 5.4–9.5 cm, bright orange yellow with a strong yellow pulverulence, viscid when wet. Stipe about 50 × 19–25 (30 mm at base), ferrugineus-fulvus below, in apical area yellowish. Tubes chrome-yellow, bruising blue. Context stramineus, bluing in pileus and apical area of stipe. Odor strong, sweet and fruit. Spores 5.5–6.7 × 3.3–4 µm, cheilocystidia 30–42 × 5.5–7 µm.

"*Buchwaldoboletus spectabilis* comes close to *B. hemichrysus*… the two are undoubtedly related." The spores of *B. hemichrysus* are somewhat longer (6.5–8.5 µm vs. 5.5–6.7 µm).

BOLETUS OROVILLUS

Thiers & Kowalsky, in Thiers, Mycologia 58(6):825. 1966.

Pileus 10–15 cm, stipe 7.5–12.5 × 2–5 cm. Pileus moist; becoming distinctly viscid, velutinous, becoming rimose, color very intense yellow, margin strongly incurved. Context yellow bluing slightly. Tubes yellow, not bluing. Pores very small, "bright red when fresh and with red exudate," not bluing. Stipe with yellow basal mycelium, concolorous with pores in apical region, yellow toward base, context yellow, bruising pale blue. Spores 5.5–6.4 × 3–4 µm, cystidia numerous, 35–47 × 9–14 µm. "Solitary in humus under digger pine (*Pinus sabiniana*)" in the vicinity of Oroville, Butte County, California. Thiers (1975) also mentioned a collection from Olympia, Washington without providing any details.

Type: USA: California. Butte Co., Oroville, 8 Nov. 1964, Kowalsky 895. In herb. San Francisco State College (SFSU).

Thiers (ibid.) stated that "the yellow pileus and small spores are features of the subsection *Sulphurei* of the section *Subtomentosi* [of *Boletus*]; however, no species in that section has red pores and most are lignicolous."

Watling and Gregory (1988, under *Buchwaldoboletus*) noted that "no boletes of this group have been found in California (see Thiers, 1975). Only *B. crovilus* [sic! Misprint for "*orovillus*"] Thiers and Kowalski is indicated as having features of subsection *Sulphurei*… - i.e. yellow pileus and small spores but small spores occur in several unrelated groups and this apparently is where the similarity stops."

The intense yellow pileus, red to reddish brown pores and the stipe with red apical area point to *Buchwaldoboletus hemichrysus*, but that species has a golden yellow pileus, a stipe that is "yellowish tinged with red" and longer spores (6.5–8.5 vs. 5.5–6.4 µm). The photographs by Ron Pastorino (back cover of Mushroom. The Journal of Wild Mushrooming; Issue 105) as *Boletus hemichrysus* may be *B. orovillus.*

PHAEOGYROPORUS BENIENSIS

Singer & Digilio in Lilloa XXX:150. 1960.

Type: Bolivia. Departamento Beni, Provincia Vaca Diez, Guayaramerín, 6.III.1956, leg. R. Singer n° B 1613 (LIL, tipo).

Pileus 53–123 mm, convex becoming applanate, glabrous to subtomentosus, viscid when wet, drying quickly; fuscus-brown, fading to isabelline. Hymenophore tubulose, pores 2 to 2.5 per mm, yellow to olivaceous, bruising brownish. Stipe bulbous-ventricose, 40–60 × 24–27 mm, subglabrous, yellow above, bruising brown, glabrous below. Context yellow, bruising blue when fresh and wet. Spores 6–7 × 4.2–5.5 µm, basidia clavate 22 × 7.5 µm. Cystidia present near pores, 22–41 × 7–8.5 µm with resinous incrustations. Hymenophoral trama of the *Phylloporus*-type. Hyphae with clamp connections.

Synonyms: *Phlebopus beniensis* (Singer & Digilio) Heinemann & Rammeloo, Mycotaxon XV:390. 1982. *Phlebopus beniensis* (Singer & Digilio) Singer in Singer, Araujo & Ivory, Beih. Nova Hedwigia, Heft 77, p. 46. 1983. Superfluous *comb. nov.*

Descriptions: Singer (1964) based on the protologue, with habit/habitat as "on humus and rotting detritus in low tropical rain forest, singly

or in small groups, fruiting in the rainy season especially towards the end of the maximum precipitation period, in the neighborhood of many genera of dicotyledonous trees, especially leguminous trees." "Brazil: Paraibo: Joao Pessoa, II.VII.1960, Singer B 3312 (BAFC)." The description in Singer, Araujo and Ivory (op.cit) is essentially the same as that of Singer (1964) except that the spores are said to be "5.8–7.5 × 4.3–6.2 µm, mostly 6–7 × 4.8–5.8 µm" and the habitat as "on the ground in partially destroyed Amazonian rain forest, ectomycorrhizal?, perhaps also in gardens and parks of the subtropical zone." They list a collection from Argentina "Tucumán: under *Salix brumboldtiana*, 15/17.II.1957, Singer T 2981 (LIL) - probably identical."

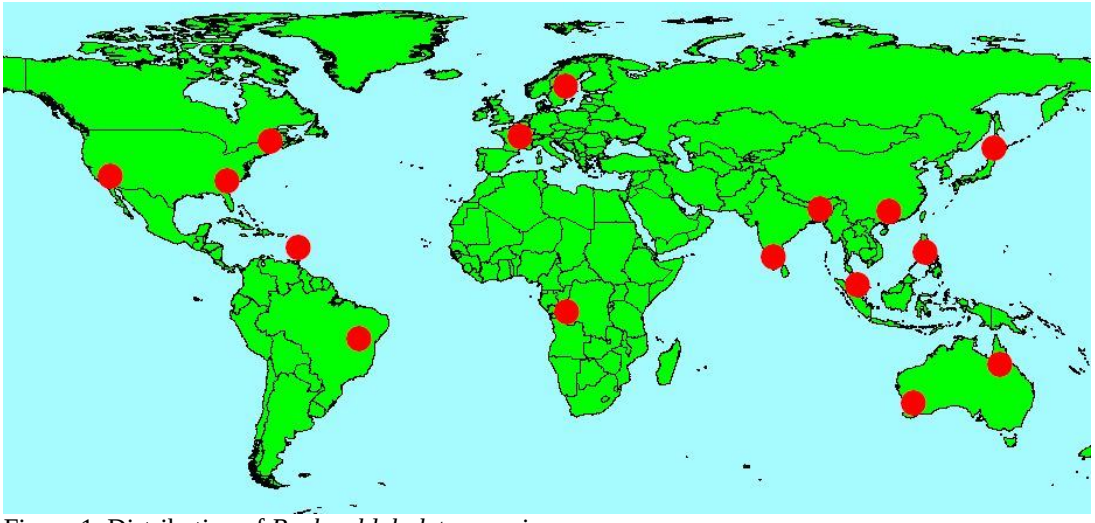

Figure 1. Distribution of *Buchwaldoboletus* species

Singer, García and Gómez (1990) reported a collection from Costa Rica (*Lincoff CR126*) with similar characteristics, but also with "pores yellow (concolorous with tubes) bluing on injury when quite fresh, but after bluing or in non-bluing specimens tending to become brown", with spores 6–7.5 × (3.5)4.5–6.2 µm, cystidia of 14–44 × 3.5–14.5 µm, frequently "with resinous stramineous incrustation" and also "hyphae with clamp connections."

Pegler (1983) reported on two collections from Martinique with spores 6–7.5 × 4.2–6.6 µm (*Fiard 147c*), while Pegler and Young (1981) gave the spores as 6.5–8.5 × 4–6 (7.2) µm (Fiard 389).

In discussing the genus *Buchwaldoboletus*, Watling (2008) observed "the S. American *Phlebopus beniensis* (Sing. &

Digilio) Heinem. & Rammeloo, unlike other members of this genus (i.e. *Phlebopus*) also belongs here." We do not believe that this species belongs to *Buchwaldoboletus*, based on the size of the spores, the hyphae with clamp connections, and the possibility that it is mycorrhizal. This conclusion is also suggested by the results obtained by Binder & Hibbett (2006).

COMMENTARY

The largest concentration of members of the genus *Buchwaldoboletus* is found throughout Europe and in North America (Figure 1). In Asia *B. xylophilus* has the widest distribution. Without molecular data is impossible to determine whether the genus is monophyletic or polyphyletic. Only *B. lignicola* has been sequenced (Binder & Hibbett, 2006), coming out between a questionable "*Phlebopus beniensis*" and *Chalciporus* under the suborder Boletineae. Certainly members of the Stirps Lignicola are morphologically similar to some members of *Chalciporus*. Based on this analysis the "true" *Phlebopus beniensis* is grouped with other *Phlebopus* species within the suborder Sclerodermatineae, a group that "includes a few

boletoid forms such as *Boletinellus* and *Gyroporus*."

The question of whether *Buchwaldoboletus* originated in the Northern Hemisphere is a present unanswerable until more molecular data become available. We believe that *Buchwaldoboletus* is a useful morpho-genus since it unites species with similar characteristic: lignicolous habit, small spores, predominantly yellow to brownish colors, bluing in some parts, and yellow mycelium. Whether some members of the genus may also at least be facultatively ectomycorrhizal (those that occur with conifers) is difficult to answer at present.

REFERENCES

Alessio, C.L. 1985. *Boletus* Dill. ex. L. (sensu lato). Libreria Cditrice Biella Giovanna, Saronno, pp. 705.

Barla, J.B. 1859. Les Champignons de la Province de Nice. pp. 138.

Berkeley, M.J. 1872. Notices of North American Fungi. *Grevillea* 1(3):33–39.

Berkeley, M.J. and Curtis, M.A. 1853. Centuries of North American fungi. *Annals and Magazine of Natural History* 12:417–435.

Binder, M. and Hibbett, D.S. 2006. Molecular systematics and biological diversification of the Boletales. *Mycologia* 98(6):971–981.

Bessette, A.E., Roody W.C. and Bessette, A.R. 2000. North American boletes: a color guide to the fleshy pore mushrooms. Syracuse University Press. pp. 396.

Both, E.E. 1993. The Boletes of North America. A compendium. Buffalo Museum of Science, Buffalo, New York. pp. 436.

Breitenbach, J. and Kränzlin, F. 1991. Fungi of Switzerland. Boletes and agarics. Vol 3. First Part. Edition Mykologia Lucerne, pp. 361.

Brown, R.P. 1985. Is there an association between *Boletus lignicola* and *Phaeolus schweinitzii*? *Bulletin of the British Mycological Society* 19:61–63.

Coker, W.C. and Beers, A.H. 1943. The Boletaceae of North Carolina. University of North Carolina Press, Chapel Hill, pp. 91.

Corner, E.J.H. 1972. *Boletus* in Malaysia. Government Printing Office. Singapore. pp. 263.

Dähncke, R.M. 1993. 1200 Pilze in Farbfotos. AT Verlaz, Aarau/Switzerland. Leinen. pp. 1179.

Dearness, J. 1924. New and noteworthy fungi – III. *Mycologia* 16:143–176.

Dermek, A. 1979. Fungorum Rariorum Icones Coloratae. Pars IX. Boletes I. J. Cramer, Vaduz. pp. 34.

Dermek, A. 1984. Fungorum Rariorum Icones Coloratae. Pars XIII. Boletes II. Cramer, Vaduz. pp. 16.

Dermek, A. and Lizon, P. 1985. Malý atlas húb. Bratislava: Slovenske pedagogicke nakladatelstvopp. pp. 546.

Dick, E.A. and Snell, W.H. 1965. Notes on Boletes. XV. *Mycologia* 57(3):448–458.

Engel, H. 1977. *Pulveroboletus hemichrysus* und andere seltene oder übersehene Röhrlinge. *Zeitschrift fur Pilzkunde* 43: 187–192.

Estadès, A. and Lannoy, G. 2001. Validations diverses. Documents Mycologiques 31(no. 121):57-61.

Fries, E.M. 1838. Epicrisis Systematis Mycologici. pp. 610.

Fries, E.M. 1874. Hymenomycetes europaei sive Epicriseos systematis mycologici editio secunda. pp. 755.

Galli, R. 2000. I Boleti. Atlante practico-monografico per la determinazione dei boleti. Milano, Edinatura, pp. 287.

Groves, J.W. 1962. *Phlebopus lignicola* in North America. *Mycologia* 54:319–320.

Heinemann, P. 1951. Champignons récoltés au Congo Belge par Madame Goossens-Fontana I. *Boletineae. Gyrodon. Bulletin du Jardin botanique de l'État a Bruxelles* 21:223–346.

Heinemann, P. 1955. Champignons récoltés au Congo Belge par Madame M. Goossens-Fontana. I. Boletineae. Note coplémentaire 2. *Bulletin du Jardine Botanique de l'État a Bruxelles* 25(2):169–181.

Heinemann, P. 1988. "Zur systematischen Stellung des *Boletus lignicola* Kallenbach." *Zeitschrift für Mycologie* 54(1):25–27.

Heinemann, P. and Rammeloo, J. 1982. Observations sur le genre *Phlebopus* (Boletineae). *Mycotaxon* 15:384–404.

Heinemann, P. and Rammeloo, J. 1983. Combinaisons et taxons nouveaux de *Gyrodontaceae* (Boletineae). Bulletin de

Jardin, *Botanique National Belgique* 53:294–297.

Jahn H, 1979. Pilze die an Holz wachsen. Busse Herford. pp. 268.

Kallenbach, F. 1924. *Boletus sulphureus* Fries forma silvestris. *Annales Mycologici* 22:410–414.

Kallenbach, F. 1929. *Boletus lignicola*, in: Die Pilze Mitteleuropas. Band 1. *Die Röhrlinge* (Boletaceae): 56–60.

Kallio, P. and Heikkilä, H. 1978. The boletes of Finland. 7. Genus *Boletus*. *Karstenia* 18:1–19.

Konrad, P. and Maublanc, A. 1937. Icones selectae fungorum. P. Lechevalier. Paris.

Kuntze, C.E.O. 1898. Revisio generum plantarum 3:536.

Lamoureux, Y. and Després, J., 1997. Champignons du Québec: Tome 1 Les bolets. Circle des mycologues de Montréal. pp. 115.

Leclair, A. and Essette, H. 1969. Les Bolets. Editions Paul Lechevalier, Paris. pp. 81. 72 plates.

Lipka, J. 1985. Weiteres über *Buchwaldoboletus lignicola* (Lallenbach) Pilát und *Phaeolus schweinitzii* (Fries) Patouillard. *Zeitschrift für Mykologie* 51(1):47–50.

Lipka, J. 1987. Beitrag zur Kenntnis der Variabilität, Ökologie and Phänologie des *Buchwaldoboletus lignicola*. *Beiträge zur Kenntnis der Pilze Mitteleuropas* III:63–66.

Metzler, S.; Metzler, V. 1992. Texas Mushrooms: A Field Guide. University of Texas Press, Austin. pp. 350.

Murrill, W.A. 1910. Boletaceae. North American Flora. *Bulletin of the New York Botanical Garden* 9(3):133–161.

Natarajan, K. and Purushothama, K.B. 1988. *Pulveroboletus parvulus* sp. nov. from South India. *Transactions British Mycological Society* 90(1):144–146.

Neda, H. Yokoyama, T. and Furukawa, H. 1987. A new lignicolous *Pulveroboletus* from Japan. *Transations Mycological Society Japan* 28:319–324.

Pantidou, M.E. 1961. Carpophores of *Phlebopus sulphureus* in Culture. *Canadian Journal of Botany* 39:1163–1167.

Pantidou, M.E. 1962. Cultural studies of Boletaceae. Carpophores of *Phlebopus lignicola* in Culture. *Canadian Journal of Botany* 40:1313–1319.

Peck, C.H. 1889. Boleti of the United States. *Bulletin of the New York State Museum* 2(8):73-166.

Pegler, D.N. 1983. Agaric flora of the Lesser Antilles. Kew Bulletin Additional Series IX:1–668.

Pegler, D.N. 1986. Agaric flora of Sri Lanka. Kew Bull. Additional Series XII:1–519.

Pegler, D.N. and Young, T.W.K. 1981. A natural arrangement of the Boletales, with reference to spore morphology. *Transactions British Mycological Society* 76(1): 103–146.

Petch, T. 1922. Additions to Ceylon fungi II. *Annales Royal Botanic Gardens Peradeniya* VII:279–322.

Phillips, R. 1991. Mushrooms of North America. Little, Brown and Company, Boston. pp. 319.

Pilát A. 1965. Hřib dřevožijny – *Pulveroboletus lignicola* (Kallenb.) na Šumavě? *Česka Mykologie* 19(3): 180-181.

Pilát, A. 1969. *Buchwaldoboletus*, genus novum Boletacearum. *Friesia* 9:217–218.

Pilát, A. and Dermek, H. 1974. Hribovite huby. Slovenska Akadémie, Bratislava. p 207, pl. 103.

Quélet, L. 1888. Flore Mycologique de la France et des Pays Limotrophes. Octave Doin, Paris, France.

Reid, D.A. 1966. Coloured Icones of rare and interesting fungi: *Supplement to Nova Hedwigia* XI:1–32.

Singer, R. 1942. Das System der Agaricales. II. *Annales Mycologici* 40:1-132.

Singer R. 1947. The Boletoideae of Florida. The Boletineae of Florida III. *American Midland Naturalist* 37:1–135.

Singer, R. 1961. Diagnoses fungorum novorum Agaricalium II. *Sydowia* 15:45–83.

Singer, R. 1964. Boletes and related groups in South America. VI. *Nova Hedwigia* VII:43–132.

Singer, R., 1967. Die Röehrlinge. Teil. II. Boletoideae und Strobilomycetaceae. J. Klinkhardt, Bad Heilbrunn. pp. 151.

Singer, R., 1981. Notes on Bolete Taxonomy III. *Persoonia* 11(3):269–302.

Singer, R. 1986. The Agaricales in Modern Taxonomy. 4th Edition. Koenigstein, Koeltz Scientific Books, Germany. pp. 981.

Singer, R. and Digilio, A.P.L. 1960. Las Boletaceas de Sudamerica tropical. *Lilloa* 30:141–146.

Singer, R. and Grinling, K. 1967. Some Agaricales from the Congo. *Persoonia* 4(4):355–377.

Singer, R., Araujo, I. and Ivory, M.H. 1983. The ectotrophically mycorrhizal fungi of the neotropical lowlands, especially central Amazonia. *Beih. Nova Hedwigia* 77:1–352.

Singer, R., García, J. and Gómez, L.D. 1990. The Boletineae of Mexico and Central America. I, II. Beih. Nova Hedwigia 98: 1-70.

Skiergiello, A. 1975. Fungi – Basidiomycetes, Boletales. Warsaw, Poland. p. 131, pl. 29.

Smith, A.H. and Thiers, H.D. 1971. The boletes of Michigan. University of Michigan Press, Ann Arbor, USA. pp. 428.

Snell, W.H. and Dick, E.A. 1970. The Boleti of Northeastern North America. pp. 115.

Szczepka, M.Z. & Sokól, S. 1984. *Buchwaldoboletus lignicola* (Kallenb.) Pilát and *Phaeolus schweinitzii* (Fr.) Pat. – das Problem ihres gemeinsamen Auftretens. *Zeitschrift für Mykologie* 50(1):95–99.

Thiers, H.D. 1966. California boletes. II. *Mycologia* 58(6):815–826.

Thiers, H.D. 1975. California Mushrooms. A field guide to the boletes. Hafner Press, New York. pp. 261.

Watling, R. 1970. Boletaceae, Gomphidiaceae and Paxillaceae. In: Henderson, D.M., Orton, P.D. & Watling, R. (eds) British Fungus flora: agarics and boleti, vol. 1. Royal Botanic Garden, Edinburgh. pp. 106.

Watling, R. 1976. A journey thru' the bolete genera. *McIlvainea* 2(2):8–22.

Watling, R. 2004. New combinations in Boletaceae and Gomphidiaceae (Boletales). *Edinburgh Journal of Botany* 61(1):41–47.

Watling, R. 2008. A manual and source book on the boletes and their allies. Synopsis Fungorum 24. Fungiflora, Oslo. 248 pp.

Watling, R. & Gregory, N.M. 1988. Observations on the boletes of the Cooloola Sandmass, Queensland and notes on their distribution in Australia. Part 2B. Smooth-spored taxa of the family *Gyrodontaceae* and the genus *Pulveroboletus*. *Proceedings of the Royal Society of Queensland* 99:65–76.

Watling, R. & Li, T.H. 1999. Australian Boletes. A Preliminary Survey. Royal Botanic Garden, Edinburgh. pp. 71.

Watling, R. & Hills, A.E. 2005. British Fungus Flora. Agarics and Boleti. 1. Boletes and their allies. Royal Botanic Garden, Edinburg. pp. 172.

Weber, N.S. and Smith, A.H. 1985. A field guide to southern mushrooms. University of Michigan press, Ann Arbor. pp. 280.