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NOTES ON BOLETE TAXONOMY

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(With two Text-figures)

Newly discovered mycorrhizal relationships of boletes (with *Nothofagus*, *Shorea*, *Quercus humboldtii*, *Alnus jorullenses*, *Eucalyptus*, and *Leptospermum*) are discussed. Type studies on *Fistulinella*, *Boletus granulatus* var. *capricollensis*, *Boletogaster*, and *Gastroboletus* are reported. The following new combinations are proposed: subsections *Pictini* and *Spectabiles* in sect. *Solidipes* of *Suillus*; *Suillus ochraceoroseus*; *Chalciporus piperatus*, *C. rubinus*, *C. rubinellus*, and the new section *Eximia* of *Leccinum*, with *L. eximium* (Peck) Sing. The interpretation of *Porphyrellus pseudoscaber* on the basis of topotypical material is indicated.

Recent field and type studies on boletes (Boletaceae and Strobilomycetaceae) have been carried out on both fresh and dried as well as alcohol material. Some of the results as far as they refer to thus far unpublished data or lead to new combinations or new taxa have been found to be of general interest in Basidiomycete taxonomy and will be discussed in the following notes.

1. Mycorrhizal relationships

Thus far, ectomycorrhizal associations of trees with South American and Asiatic as well as tropical African boletes have been restricted to introduced trees, particularly *Pinus* and to a few isolated ectotroph associations with *Alnus jorullensis* (*A. jorullensis/Gyrodon monticola*) and *Salix humboldtiana* (*S. humboldtiana/Leccinum griseum*) in Argentina, not counting of course, the associations with Pinaceae and Fagales, sometimes *Tilia*, in the extratropical regions of Asia and South America. In the latter continent we know even now only two associations between *Nothofagus* and Boletaceae: *N. obliqua/Boletus loyo* and *N. obliqua/Boletus chilensis* (Singer, 1969). But in India, Singer & Singh (1971) have described the ectotrophs *Shorea robusta/Pulveroboletus shoreae* Sing. & Singh and *Shorea robusta/Xerocomus bakshii*, providing evidence regarding a further, thus far overlooked family of Cormophyta forming ectomycorrhiza with boletes, viz. the Dipterocarpaceae (see also Singer, 1971).

Ectotroph formation has also been indicated by Singer (1963) from the Colombian oak forests, but no boletes had been observed then. During a second visit in the Querceta of Colombia (provinces of Cundinamarca and Valle to Cauca) it was shown that Boletaceae are likewise involved in the ectotrophic mycorrhiza of

Quercus humboldtii H. & B. The following species are now known to enter symbiosis with this species of oak: *Boletus fuligineotomentosus* Sing. (see also *in* Sydowia, Beih., in print) and *B. atkinsonianus* Murr. as well as *Phylloporus purpurellus* Sing. (Sydowia l.c.)

A new ectotroph association has been discovered in the *Alnus*-woods of the montane zone of the neotropics: *A. jorullensis/Phylloporus caballeroi* Sing. (Sydowia, in print).

It was formerly not known with certainty that *Eucalyptus* forms ectomycorrhiza with boletes. It has now been established by ecological and anatomical research in the *Eucalyptus* plantations of both Argentina and Chile that *Xerocomus* is involved. We have consequently two new ectotrophs in South America: *E. globulus/Xerocomus brasiliensis* in Argentina (prov. of Buenos Aires) and *E. globulus/Xerocomus chrysenteron* in Chile (prov. Valparaiso). This shows that Myrtaceae are obviously ectomycorrhizal under certain conditions. Ectomycorrhiza has now also been established with *Eucalyptus* and *Leptospermum* in New Zealand by McNabb and Horak which is now confirmed by our observations (see also Singer, 1971).

This latter information is particularly interesting since our (Singer & Moser, 1965) research has definitely shown that the South American Myrtaceae (*Myrceugenia, Myrceugenella, Nothomyrcia*) are not ectotrophically mycorrhizal. It is furthermore remarkable that *Gyrodon* is often non-mycorrhizal. I have been able to demonstrate that ectomycorrhiza is absent in the undisturbed tropical rain forest of Mexico and Colombia where *Gyrodon proximus* and *G. exiguus* have been collected, the latter obviously a lignicolous species like *Pulveroboletus hemichrysus.*

The wide range of mycorrhizal hosts for *Xerocomus chrysenteron* and *X. brasiliensis* and the absence of mycorrhizal hosts for some Gyrodontoideae and some Pulveroboleti shows clearly that the relative selectivity and the degree of dependency on symbiotic relationships increase gradually from a group of low specialization and/or dependency to a group of high specialization and dependency in Gyrodontoideae, Xerocomoideae and Boletoideae, whereas in Suilloideae even the 'lowest' forms (whatever one's criterium for determining the level of evolutionary progression) are in their vast majority highly specialized Pinaceae/Suilloideae ectotrophs. On the other hand, in the series *Boletus-Tylopilus-Leccinum* even the most recent observations confirm the statement, generally accepted, that here we have obligatory ectomycorrhiza whereby the preferred symbiont becomes, as we progress from *Boletus* to *Tylopilus* to *Leccinum* and *Xanthoconium*, increasingly the frondose tree (Salicales and Fagales), and association with Pinaceae becomes rarer. If then we want to make mycorrhizal association the principal measure of phylogenetic development, we would certainly not consider the Suilloideae the most primitive group (as has been done by Smith & Thiers, 1971) but would agree with Benedix (1963) who thinks that *Boletinus* is relatively more recent ("abgeleitet").

2. Types revised at Dahlem and Vienna

A large number of species is based on types now lost or supposedly lost. This is often regrettable because of the different interpretations of classical species by different authors or the impossibility to come to a correct interpretation. Singer & Clemençon (in print) have emphasized the possibilities still existing in Europe to replace, for the study of species whose type specimen is no more existent, the holotype by a topotype—a procedure still often successful in the case of taxa proposed by Secretan, Fries, Schulzer, and Quélet and as we have shown (Machol & Singer, 1972) even in the case of Micheli. On the other hand, fortunately not all type material thought to have been lost is actually lost but only temporarily misplaced. The following examples will illustrate the point I am particularly indebted to the Director of the botanical collections at the Botanical Museum in Berlin-Dahlem and the Botanical Institute in Vienna, for permission to search for and analyse the type material of Boletaceae (and other fungi) at these institutions.

Fistulinella staudtii P. Henn. (*in* Bot. Jb. **30**: 44. 1901). – This is based on Zenker & Staudt 229 (B) from Yaundé, Cameroon, still well preserved in the collections of alcohol material. The pileus is now whitish in one, grayish bister in the other carpophore; the stipe is now white, not reticulated and without traces of a veil, 24–32 × 2–2.5 mm and equal or slightly thickened in the lower half but again narrower at the base; pores 3–4 per millimeter, about 1/4 mm wide and now as wide or smaller than the wall diameter, pallid, depressed around the apex of the stipe; a broad sterile band running around the margin of the pileus; ornamentation of the stipe finely punctate-verruculose. Spores fusoid or cylindric-fusoid, smooth, with suprahilar depression and heterotropic, occasionally with a round oil drop, with 0.5–0.6 μ thick wall which is homogeneous and cyanophilic, 15–20 × 4.5–6.2 μ basidia about 28–30 × 11–11.3 μ, 2–4-spored; cystidia ventricose-ampullaceous, obtuse, hyaline, 35–43 × 6–13.5 μ; hyphae without clamp connections, hymenophoral, trama bilateral of the *Boletus*-type, with a narrow less gelatinized, melleous mediostratum consisting of filamentous hyphae 1.5–3.7 μ broad and not divergent, and a broad lateral stratum consisting of hyaline recurved-arcuate-divergent hyphae 3.7–7 μ broad; epicutis of pileus apparently a trichodermium but with applanate horizontal hyphae predominent in the uppermost tier, 1.2–9 μ broad, where pigmented, the pigment intracellular, but a (now) subhyaline incrustation also present on some of the hyphae; hyphae of the context of the stipe all inamyloid (now).

This type analysis indicates that the fungus is boletaceous and belongs in the Boletoideae. The spores, rather pale under the microscope, do not permit a conclusion as to the color of the fresh spore print except that it was not white. One cannot help but think that *Fistulinella* which has the same basic characters as *Ixechinus* is indeed synonymous with the latter (as was also concluded by Horak, 1968 on the basis of literature data). The habitat (lignicolous in both *Fistulinella* and *Ixechinus*) and the shape of the stipe would indicate *Pulveroboletus*.

The pale spores, in spite of being larger than usual in *Tylopilus* may suggest that the spore print was ochre or pinkish and that the genus is closer to *Tylopilus*. It is,

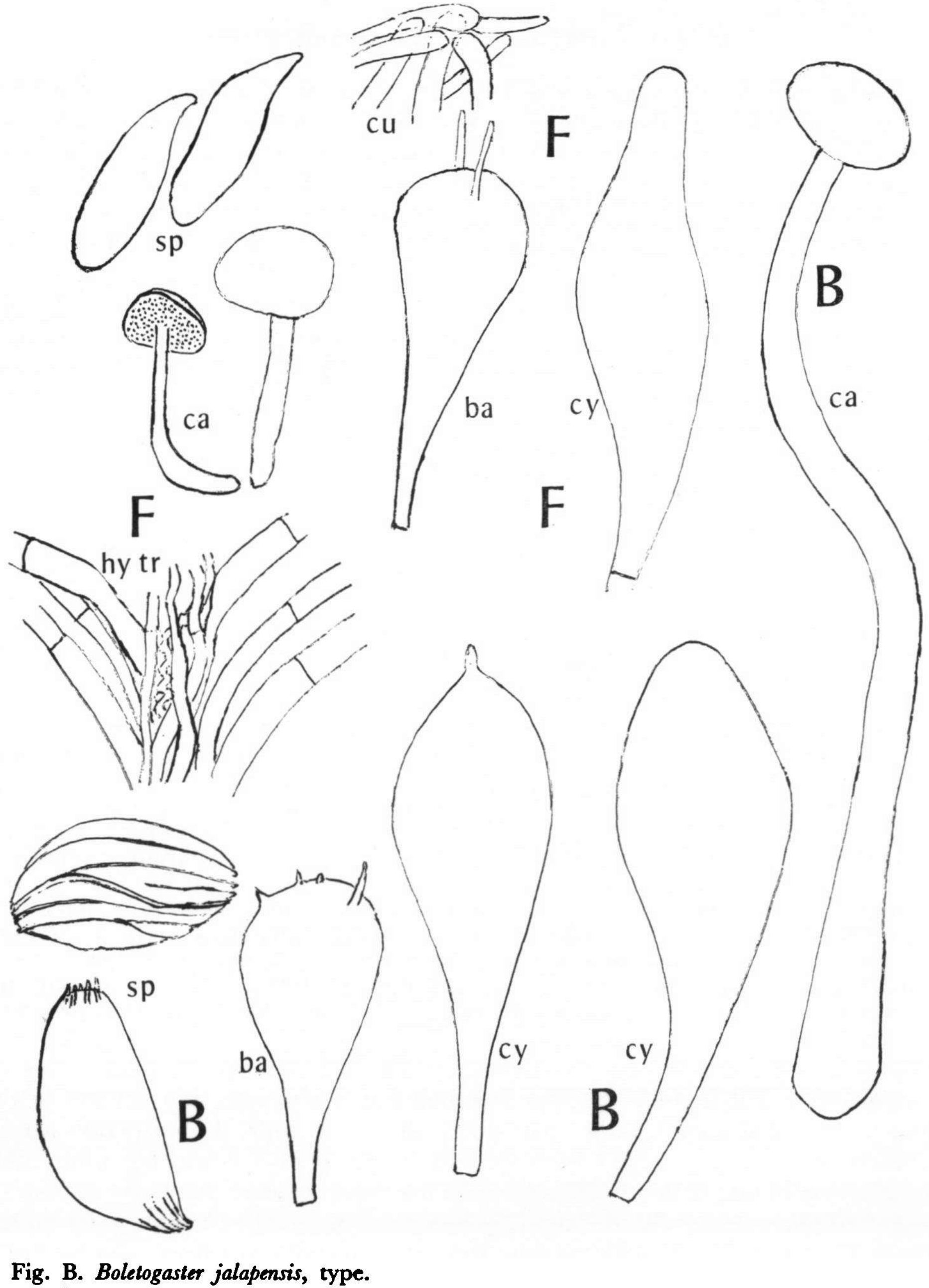

Fig. B. *Boletogaster jalapensis*, type.

Fig. F. *Fistulinella staudtii*, type. ca, carpophore (× 0.8); ba. basidium; cu, fragment of cuticular layer; cy, cystidium; hy tr, section of hymenophoral trama; sp. spores (microscopic elemets × 800); lower left spore schematic, with ornamentation only indicated at the hilar (below) and distal (above) pole.

however, also possible that the combination of stipe size and shape, spore color, and absence of mycorrhizal association (?) might in the end justify a separate genus within the Boletoideae. As for the isolation of the tubes in *Fistulinella* and *Ixechinus*, it is certainly no part of the normal development of the carpophores. Some of the alcohol material of common European boletes (like *Tylopilus felleus*) shows partial separation of isolated tubes; dried material of *Ixechinus* does not. It was M. A. Donk who first directed my attention to this phenomenon. Consequently, the latter can hardly be used as an additional generic character specific to *Fistulinella* and *Ixechinus*.

Boletus granulatus var. *capricollensis* Buchs & P. Henn. (*apud* P. Henn. *in* Hedwigia **42**: 215. 1903). — The topotype and authentic material, under *Boletus capricollensis*, the type later relabeled "*Boletus* (*Gyrodon*) *placidus* Bon." (B, sub P 240) is undoubtedly *Suillus placidus* (Bon.) Sing. in spite of the fact that the label says "unter Fichten.'

Boletogaster jalapensis (Murr.) H. Lohwag sensu H. Lohwag.—*Ceriomyces jalapensis* Murr. (*in* Mycologia **2**: 248. 1910) was based on Mexican material; it was correctly referred to *Boletellus* by Gilbert, as is shown by the type studies and redescription by me (1945, 1970); Lohwag's genus is based on material from China which was determined *B. jalapensis* by Lohwag. The material was supposed to have been lost but was rediscovered in Vienna (W) by me. Its description runs thus:—

The pileus (20–22 mm) is relatively small in relation to the stipe which before drying must have been 169 × 13, at apex × 4 mm, gradually tapering upwards; otherwise macroscopically quite like Murrill's description. The stipe appears to be slightly sulcate in places but is definitely devoid of a raised network. Spores ellipsoid with slight suprahilar applanation or depression, melleous, later with brown wings on yellowish ground, with ornamentation of type X with the longitudinal wings projecting 0.7–1.7 μ, some of them forked, some shorter, not cross-striate as in *B. ananas*, suddenly rounded off at distant pole, attenuated-concurrent at hilar end, with wall proper up to 1.5 μ thick, (with ornamentation) 15.2–20 × 8.3–11 μ; basidia 25–31 × 11.7–14.5 μ, (2)–(3)–4-spored; cystidia ventricose, some with apical mucro, hyaline, thin-walled, 30–62 × 11.7–16.7 μ; hyphae without clamp connections; hymenophoral trama bilateral, subhyaline; epicutis of pileus consisting of loosely arranged hyphae which are 2–4.5–(8.5) μ broad and hyaline to subhyaline in KOH; hyphae of the trama of the base of the stipe longitudinally arranged, without clamp connections, not gelatinized, inamyloid. The collectors note indicates the color as "brunneus, brunneus luteus". Pores 0.2–0.5 mm wide, subirregular in size but subisodiametric; tubes depressed-subfree.

These data show that aside from the still more elongated stipe there are no important differences between Murrill's and Lohwag's *B. jalapensis*, and the microscopical characteristics are in close agreement. The Asiatic specimens cannot be more than a geographic race at most.

Gastroboletus boedijnii H. Lohwag [Beih. bot. Zbl. (II) **42**: 273, 1926].—This was likewise based on Chinese material of the Handel-Mazzetti collection and was considered by Horak (1968) to be "verschollen." However, the type exists at W. It comes from Yünnan around the village Ngulukö near Lidjang, in temperate zone, collected by "Collectores indigeni," early October 1916.

The fungus, as preserved, corresponds well with Lohwag's description and drawing the pileus is now brownish and somewhat finely rivulose-rimulose and minutely fibrillose-asperulate; the stipe is not preserved. Spores fusoid to cylindric, more or less asymmetrical, with a deep melleous-brown episporium and a very pale melleous endosporium (both together 1 μ thick), smooth, cyanophilic, with a short hilar appendage which is more often obliquely than centrally attached, with or without a suprahilar applanation, inamyloid, cyanophilic; basidia clavate, 23–43 × 6.8–11 μ, 2–3–4-spored, sterigmata straight or recurved, (excepting a minority) not half-sickle-shaped as in typical bolete-basidia but obviously apobasidial; cystidia moderately numerous in the interior of the tubes and on the pores, ventricose and mucronate, hyaline, thin-walled, 20–34 × 5.2–11.7 μ; cheilocystidia smaller than the pleurocystidia, cylindric to clavate, 15–16 × 4–5.5 μ; hyphae of the trama of the pileus in part running radially and 3.3–5.5 μ broad, filamentous, without clamp connections, inamyloid; hymenophoral trama bilateral consisting of a melleous to hyaline mediostratum of parallel hyphae 4–4.5 μ broad, without noticeable gelatination and a divergent lateral stratum consisting of somewhat broader or equally broad filamentous hyphae, not paler or deeper colored than those of the mediostratum, partly touching each other (partly not); subhymenium differing from the lateral stratum by the fact that here the hyphae are multiseptate (these up to the base of the basidia also clampless); epicutis of pileus a trichodermium consisting of pigmented hyphae running in all directions and the end-cells more or less ascendant or erect and sometimes in fascicles of parallel elements which may or may not be cystidiform, or broad and short, 5–14 μ diam. Under the dissecting microscope, the context appears bright yellow.

This is obviously conform with the interpretation of the fungus by Smith & Singer (1959) which was likewise based on the type of *Gastroboletus boedijnii.* I have studied the type in 1971 so the data can be compared with our earlier analysis (l.c., fig. 1, 2–4). It is obvious that here we have a genus which approaches the Boletaceae as much as *Macowanites* approaches *Russula* but still on the secotiaceous level. *Gastroboletus* is an important genus since it is the type genus of the family Gastroboletaceae (Gasteromycetes), see Singer (1962). It is remarkable that, as far as can be determined from the type specimen of *Gastroboletus boedijnii*, the hymenophoral trama is much like the *Boletus*-type established in *G. turbinatus* (Snell) Smith & Sing. and *B. fascifer* Sing. & Smith but in the first of these species perhaps more similar to that of *Truncocolumella.*

3. New combinations

A revision of the limits between *Boletinus* and *Suillus* as worked out by Singer (1967) makes it necessary to propose the following new combinations:—

SUILLUS sect. **Solidipedes** (Sing.) Sing. subsectio **Pictini** (Sing.) Sing., *c.n.* Basionym: *Boletinus* sect. *Solidipedes* Sing. subsectio *Pictini* Sing. *in* Revue Mycol. **3**: 158. 1938.

SUILLUS sect. **Solidipedes** (Sing.) Sing. subsectio **Spectabiles** (Sing.) Sing., *c.n.*, *st. n.* Basionym: *Boletinus* sect. *Spectabiles* Sing., ibid. p. 157.

Suillus ochraceoroseus (Snell) Sing., *c. n.* Basionym: *Boletinus ochraceoroseus* Snell *apud* Snell & Dick *in* Mycologia **33**: 35. 1941.

Data obtained by a recent revision of some species belonging to section *Piperati* of *Suillus*, combined with the findings of Bresinsky & Rennschmid (1971) on the distribution of pigments in this group have made it necessary to separate this section from *Suillus* and to recognize Bataille's genus *Chalciporus*, inasmuch as this will also make the mycorrhizal specialization of the remaining sections of *Suillus* more uniform (see also Benedix, 1963).

Chalciporus piperatus (Bull. ex Fr.) Sing., *c. n.* Basionym: *Boletus piperatus* Bull. *ex* Fr., Syst. mycol. **1**: 388. 1821.

Chalciporus rubinus (W. G. Smith) Sing., *c. n.* Basionym: *Boletus rubinus* W. G. Smith *in* J. Bot., Lond. **6**: 33. 1868.

Chalciporus rubinellus (Peck) Sing., *c. n.* Basionym: *Boletus rubinellus* Peck *in* Rep. N.Y. St. Mus. nat. Hist. **32**: 33. 1879.

The anatomy of the scales of the stipe, the size of the spores and the characteristics of spore color and cystidia make it necessary to transfer *Boletus eximius* to *Leccinum* where it is placed in a new section close to sect. *Roseoscabra*:—

LECCINUM sect. **Eximia** Sing. A sectione *Roseoscabra* differt basi stipitis vix chromeo-lutea. — Typus sectionis: **Leccinum eximium** (Peck) Sing., *c. n.* Basionym: *Boletus eximius* Peck *in* J. Mycol. **3**: 54. 1887.

4. On Porphyrellus pseudoscaber

A revision of the species of the *Porphyrellus pseudoscaber* complex has made it clear that here we have two European species, one being *P. porphyrosporus* (Fr.) Gilbert which I have described as *P. pseudoscaber* var. *pseudoscaber* (1967: 109–111) and another which I have described as *P. pseudoscaber* var. *fuligineus* (Fr. in Fr. & Hök) Sing. (p. 112) but which is the true *P. pseudoscaber* (Secr.) Sing. (*B. fuligineus* being its later synonym).

P. porphyrosporus (Fr.) Gilbert is the bluing species, usually medium to large, growing in mixed and frondose woods, mostly at lower altitudes. *P. pseudoscaber* is the non-bluing species, usually small to medium, growing in coniferous woods, mostly in the lower montane zone.

The identity of *P. porphyrosporus* in the sense of Fries is easy to establish since Fries himself states that the pores become blue where bruised. Although Fries indicates the habitat as „in . . . pinetis" on sandy roadsides, it must be assumed that as in most such habitats in South Sweden *Fagus* was also present. The identity of *P. pseudoscaber* has been established by material collected by Ch.-Ed. Martin at the type locality

(Chalet-à-Gobet) September 2, 1894 where I have likewise observed it in 1971, in both cases under conifers ("sous les sapins", under *Picea*). The plate made by Martin is still in the Iconothèque Ch.-Ed. Martin at Geneva, Switzerland, and represents the earliest topotype in existence. Descriptive data fully establish the identity with *B. pseudoscaber* Secr. and *P. pseudoscaber* var. *fuligineus* (Fr. in Fr. & Hök) Sing.

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