Spore ornamentation in the Tricholomataceae. II.

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Abstract. – The study of spore ornamentation in the Tricholomataceae is continued by an examination of the holotypes of *Agaricus albissimus, Collybia olympiana, Prunulus farinaceus, Fayodia xeraphila, Fayodia pseudoclusilis,* as well as non type specimens of *Lyophyllum tesquorum, Gamundia leucophylla* and *Mycenella margaritospora.* The new species, *Clitocybe femoralis,* is described.

Introduction

The following is a continuation of my study of spore ornamentation found in the taxa of the Tricholomataceae. Several additional North American representatives are included and some European species are sampled in order to compare the ornamentation in hopes of clarifying the relationship of certain species to one another. Not surprisingly, the results seem to suggest more problems than they solve. (These are indicated under the appropriate species.) It is clear though that studies of spore ornamentations should be continued with the scanning electron microscope. While the spores of most species examined to date seem to be consistent from one collection to another, a few have showed disturbing variations which may be assignable merely to different populations of the organism. On the other hand, perhaps there is some taxonomic significance which has not been fully appreciated yet.

Descriptions

1. *Agaricus (Clitocybe) albissimus* Peck, Bull. Buffalo Soc. Nat. Sci. 1: 45. 1873. – Fig. 1

Holotype collected by C. H. Peck at Croghan, Lewis Co., New York, USA (NYS).

As far as I have been able to determine, the spores of the holotype have not been presented as they appear under the scanning electron microscope. The verruculae appear as would be expected from their appearance under an oil immersion lens, but the smooth plage is more evident. This plage appears identical to that shown previously for *Leucopaxillus albissimus* var. *lentus* by Bigelow & Rowley (Fig. 3, 1968). The verruculae seem to be smaller than those found in *Leucopaxillus rhodoleucus, L. paradoxus* and *L. amarus* as illustrated by Pegler & Young (Pl. 26 & 27, 1973), but this may be

caused by a difference in preparation or ages of the spores. BESSON (1970) has also published a transmission electron micrograph of the spore wall of *Leucopaxillus paradoxus (= L. cerealis)*. According to SINGER's (1961) study of authentic material *Agaricus cerealis* LASCH is identical to some European mycologists' concept of *L. paradoxus* as well as to *Agaricus albissimus* PECK. *Leucopaxillus cerealis* (LASCH) SINGER of course has priority.

The holotype has the following microscopic characteristics according to my examination: Spores: 6–7.5×3–5 μm (excluding ornamentation), verruculae ±0.5 μm high, amyloid, wall and apiculus below ornamentation inamyloid, ellipsoid with base slightly narrowed. – Basidia: 4-spored, 25–38×5–8 μm. – Cystidia absent. – Pileus: tissue yellowish in KOH, cutis hyphae cylindric, 2–3 μm diam; context hyphae cylindric, 2–6 μm diam. Hymenophoral trama of undulate-subparallel hyphae, cylindric, 2–5 μm diam. Clamp connections present.

2. *Collybia olympiana* A. H. SMITH, Contrib. Univ. Michigan Herb. 5: 13. 1941. – Fig. 2

Holotype (SMITH, n. 14506) from Crescent Beach, Joyce, Washington, USA (MICH).

The microscopic characters revealed by my study of a holotype specimen agree with the original description published by SMITH (1941) for the most part, but a few larger spores (up to 7.5×6.5 μm) were found. In addition, siderophilous granules were obvious in the basidia.

A comparison of Figures 2 and 4 *(Lyophyllum tesquorum)* indicates an identical nature to the spore ornamentation. BESSON (1970) has provided a photomicrograph of the spore wall and its ornamentation as they appear in a section under the transmission electron microscope.

LANGE & SIVERTSEN (1966) have discussed *Collybia olympiana* in regard to its identity with *Lyophyllum tylicolor* (FRIES) LANGE & SIVERTSEN, and they include *L. tesquorum* (FRIES) SINGER among the synonyms. *Collybia erosa* ss. J. E. LANGE and *L. plexipes* (FRIES) ss. KÜHNER & ROMAGNESI also appear to be synonyms from the variations LANGE & SIVERTSEN have discovered for *Lyophyllum tylicolor*. BON (1977) further studied the situation of these species and includes the additional *Tephrocybe graminicola* BON and *T. oldae* SVERCEK. A total of six species and two varieties are included in a descriptive key. More recently ARNOLDS (1982) has summarized the confusing information about the taxa, but he preferred to use the name *Tephrocybe tesquorum* (FRIES) MOSER in order to avoid the varied interpretations of *Tephrocybe tylicolor* (FRIES) MOSER, and concludes that only one variable species is involved. The spores of collections

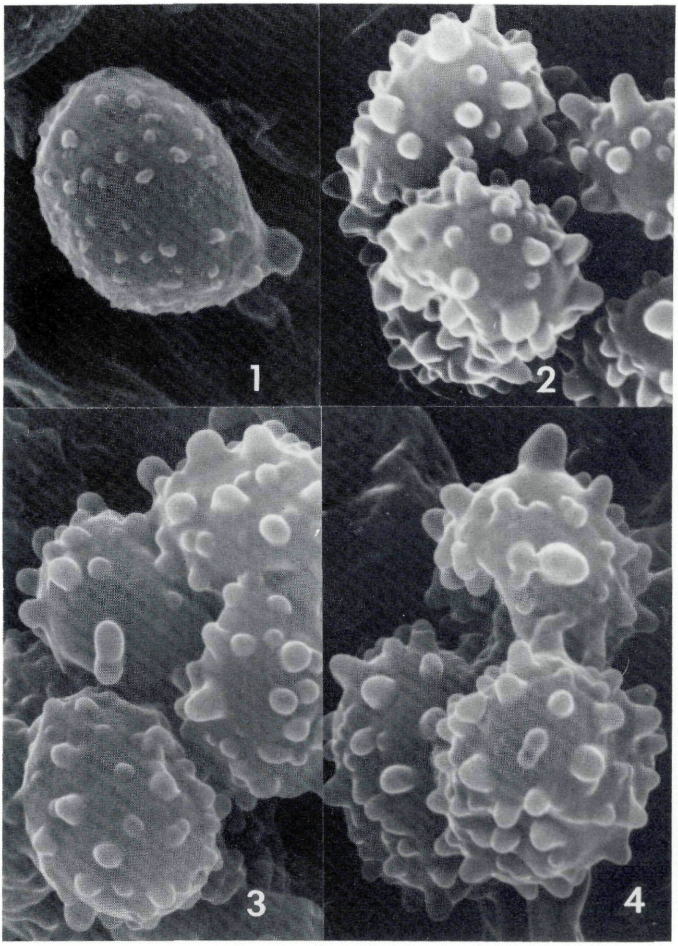


Fig. 1. *Agaricus albissimus* (holotype), ×7000.
Fig. 2. *Collybia olympiana* (holotype), ×6000.
Fig. 3. *Prunulus farinaceus* (holotype), ×7000.
Fig. 4. *Lyophyllum tesquorum* (Romagnesi 58.182), ×7000.

studied under the scanning electron microscope thus far certainly do not reveal any outstanding differences between species, but a more extensive sampling is desirable.

3. *Prunulus farinaceus* MURRILL, North Amer. Flora 9: 326. 1916. – Fig. 3

Holotype collected by W. A. MURRILL and E. C. VOLKERT at the New York Botanical Garden, Bronx, New York, USA (NY).

This species also placed in *Mycena* by MURRILL (1916) and illustrated (1914, Pl. 137, fig. 3), is another lyophyllaceous agaric as indicated by the presence of siderophilous granules in the basidia. The spores were (5–)7–8.5(–10)×(4–)5–6(–7) μm, excluding the ornamentation, and this varied from 0.5–1 μm in height. In SMITH's (1947) examination of the holotype, he also found variation in size: some caps had spores 5–6×4–5 μm whereas other caps had spores measuring 7–9×5–6 μm. We both noted a gelatinous pellicle to the pileus when sections are mounted in KOH. Clamp connections are present on the hyphae, and I found some rare narrow cylindric hyphae in the cutis which had fine encrustations.

MURRILL's original description of *Prunulus farinaceus* gives macroscopic characters which appear to represent specimens which may be mature or faded, but his earlier painting shows dark brown pilei as well. The basidiocarps were found in an open mossy field, apparently in a habitat similar to that of some collections of *Lyophyllum tesquorum* found by LANGE & SIVERTSEN or *Tephrocybe graminicola* as reported by BON. It is not difficult to reconcile MURRILL's description of field characters with these species, but the authors do not provide sufficient data about the pileus cutis. BON does note cutis hyphae which are "rarement finement pointellé," but it is not clear if this is pigment encrustation. Perhaps more important is the gelatinized pellicle of *Prunulus farinaceus* if such is absent from European collections identified as *Tephrocybe tesquorum, T. tylicolor, T. graminicola,* et al. On present information though, the spore ornamentation found for *Prunulus farinaceus* is the same as *Collybia olympiana* and *L. tesquorum,* and the other characters do not give sufficient basis for recognizing *P. farinaceus* as anything but one form of *L. tesquorum.*

4. *Lyophyllum tesquorum* (FRIES) SINGER, Ann. Mycol. 41: 105. 1943. – Fig. 4

H. ROMAGNESI kindly provided a specimen (ROMAGNESI, n. 58.182, as *Tephrophana tesquorum*) which he collected at Thiers (Oise) France, under *Pinus silvestris.* Figure 4 shows spores of this specimen and the ornamentation appears to be identical with that found

for the spores of *Collybia olympiana* holotype (Fig. 2) and *Prunulus farinaceus* holotype (Fig. 3).

Other microscopic data of the ROMAGNESI specimen are: Spores: 6–7.5×5–5.5 µm, ornamentation ±0.5 µm, subglobose to broadly ellipsoid or ellipsoid, ornamentation cyanophilous, wall weakly cyanophilous, inamyloid. – Basidia: 4-spored, 24–35×7.5–8.5 µm, siderophilous granules present. Hyphae of pileus with clamp connections. – Pileus cutis thin, of narrow cylindric hyphae 2–3.5 µm diam, without encrustations or gelatinous pellicle; context hyphae cylindric or somewhat inflated, (3–)7.5–16(–21) µm diam. Hymenophoral trama of parallel hyphae, cylindric to inflated, 3.5–15 µm diam.

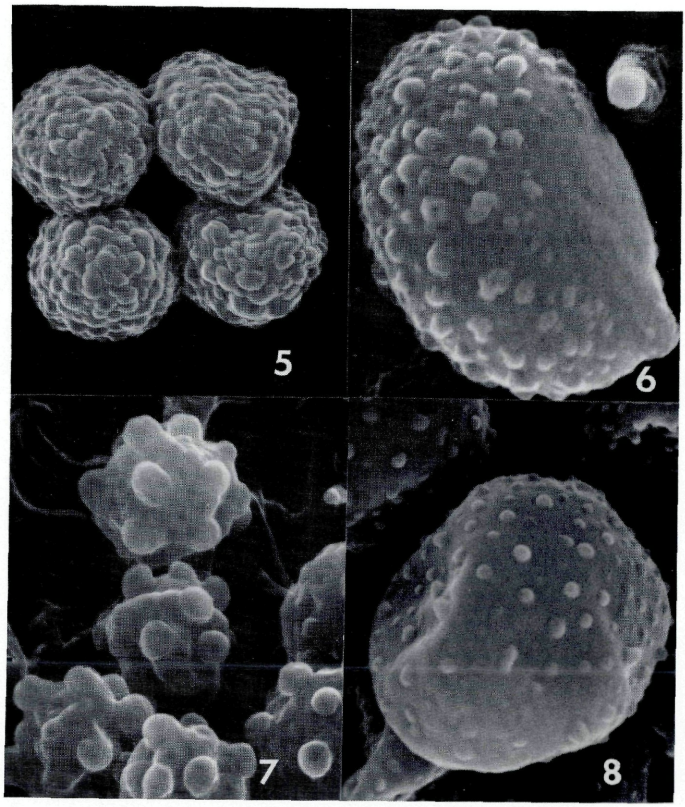
As alluded to above, in regard to *Prunulus farinaceus,* the presence or absence of a gelatinous pellicle and/or encrusting pigments in the pileus needs to be examined in more European specimens variously identified as *Lyophyllum* (or *Tephrocybe*) *tesquorum, L. tylicolor,* etc. One variable species is indicated by the other data, but the microscopic characteristics of the pileus may prove significant.

5. *Clitocybe femoralis* BIGELOW, sp. nov. – Figs. 5, 6

Pileus 9–31 mm latus, badius, pallescens, demum cinnamomeo-bubalinus, interdum testaceo-maculatus, convexus vel subconvexus, interdum subumbonatus, margo haud striatus, siccus, glaber. Lamellae pallidae tum straminiae, adnexae tum adnatae, in vetuste decurrento-densae, confertae, margine crenulatae, Stipes 2–5.2 cm longus, 4–7 mm crassus, alutaceus vel incarnatus, cavus, siccus, basim mycelialis. Sporae 7.5–9×4.5–5 µm, ellipticae, verruculosae, cyanophilae, inamyloideae. Hyphae fibulatae nullae. Humicolus infra *Cupressus macrocarpus.* Holotypus legit W. SUNDBERG, n. 4198, Crystal Springs, near Belmont, San Mateo Co., California, USA, 1 Feb 1979 (MASS, SIU).

Pileus 0.9–3.1 cm broad; vinaceous brown („roods brown") or somewhat paler, becoming paler in age to cinnamon buff (dull "cinnamon buff"), at times with darker areas ("mikado brown" to "cinnamon"); broadly convex to nearly planoconvex, sometimes slightly umbonate, margin not striate, incurved to decurved; surface dry, glabrous; context 2–3 mm thick near stipe, off white. Odor and taste not distinctive. – Lamellae pallid then yellowish (dull "pinkish buff") in age; adnexed at first, becoming adnate, sometimes with a short decurrent tooth in age, close, thin, edges concolorous with faces, crenulate eroded. – Stipe 2–5.2 cm long, 4–7 mm broad at apex, equal or tapered slightly downward; pale yellowish or incarnate ("pale pinkish buff") above, tinged "pinkish buff" below); hollow, cortex concolorous with surface, surface dry, innately fibrillose, base white mycelioid or sometimes tinged with vinaceous.

Spores 7.5–9×4.5–5 µm, ellipsoid, verruculose except for a smooth plage, ornamentation cyanophilous, inamyloid. – Basidia



Figs. 5, 6. *Clitocybe femoralis* (holotype): 5, ×4000; 6, ×10,000.
Fig. 7. *Mycenella margaritospora* (Smith 25382), ×5000.
Fig. 8. *Mycena cineraria* (holotype), ×8500.

27–39×6.5–8 μm, faintly granose (KOH, phase) but not siderophilous, bases lacking clamp connections. – Cystidia not present. – Pileus: light yellowish brown to brownish yellow, pigment finely encrusted on cutis hyphae (Congo red, phase) cutis hyphae cylindric, 2–6 μm diam, cells short; context hyphae cylindric to broad cylindric or slightly inflated, 4–13(–16) μm diam., cells short, often femoralic in shape. – Clamp connections absent. – Hymenophoral trama broad, parallel, hyphae cylindric or broadly cylindric, 5–15 μm diam.

Habitat. – Scattered to gregarious (7 specimens). In humus under *Cupressus macrocarpus,* February.

Material examined. – USA: California: Sundberg 4198 (holotype, MASS, SIU).

Figure 5 shows a tetrad of immature spores in polar view, while Fig. 6 provides a mature spore in lateral view. Low hemispheric verruculae, sometimes lobed, and a smooth plage are evident.

The placement of this species in *Clitocybe* probably will provoke some controversy, but in doing so the type of spore ornamentation is emphasized in conjunction with the colors of the basidiocarp and the decurrent tendency of the lamellae in age. These characteristics are compatible with the species of section Eulepistae. (The spores of this section are illustrated in Bigelow, 1981: Figs. 12, 13, 14.) The habit of *Clitocybe femoralis* is more like the general form of a *Collybia,* but this species would be more of a divergent element in *Collybia,* as defined by Halling (1983), where ornamented spores are not known to occur and all species have clamp connections on the hyphae. Clampless species of course do occur in *Clitocybe* in several sections (Clitocybe, Candicantes, Omphalina). The cyanophilous spore ornamentation probably indicates a colored spore deposit, thus, placement in *Rhodocybe* might be considered. The colors of the basidiocarp would be acceptable in section Rufrobrunnea (Baroni, 1981), as would the absence of clamp connections, but the spores of *C. femoralis* are not angular in polar view and none of the spores Baroni illustrates have the same type of ornamentation. The colors noted in quotation marks in the description above are from Ridgway, 1912.

6. *Mycenella margaritospora* (Lange) Singer, Lilloa 22: 291. (1949) 1951. – Fig. 7

The collection examined was A. H. Smith, n. 25382, identified originally as *Mycena margaritospora* Lange (MICH).

The spore ornamentation clearly differs in the size and number of warts from the other species illustrated here, in my previous contribution on the spores of the Tricholomataceae (Bigelow, 1981)

or those shown in PEGLER & YOUNG (1973, 1974). Probably either of the adjectives "verrucose" or "tuberculate" might be applied to describe the warts. In any case, such a type of ornamentation seems characteristic of a small group of agarics.

Further study of the spores of North American and European collections variously identified as *M. margaritospora, M. bryophila* (VOGLINO) SINGER, *M. trachyspora* (REA) BON, *M. lasiosperma* (BRESADOLA) SINGER, *M. kuehneri* ROMAGNESI, *Mycena nodulosa* SMITH, is in order. When comparing various accounts of these species there is some confusion about the definitive characteristics of each, and an examination of spores under the scanning electron microscope may provide additional information which will aid in clarifying the number of species which actually exist. Initially, type material, or at least specimens collected at the type localities, should be utilized as far as possible to provide the source for spores.

7. *Mycena cineraria* A. H. SMITH, North American Species of *Mycena,* p. 450. 1947. – Fig. 8

Holotype collected by Dr. A. H. SMITH (n. 17099) near Mt. Angeles, Olympic Mts., Washington, USA. (MICH).

This species was illustrated previously (BIGELOW, 1979) and although the spores were not taken from the type specimen, they are identical in ornamentation to the spores of the type (Fig. 8). At that time also, *Mycena cineraria* was placed in synonymy with *Stachyomphalina striatula* (KÜHNER) BIGELOW, but unfortunately the genus *Gamundia* RAITHELHUBER has priority (May vs. June, 1979, publication) over *Stachyomphalina* as a segregate from *Fayodia* ss. lato. In reviewing LANGE & SIVERTSEN's (1966) discussion of *Fayodia leucophylla* (GILLET) LANGE & SIVERTSEN, it would now seem that the correct epithet should now be *Gamundia leucophylla* (GILLET) BIGELOW, comb. nov. (basionym: *Omphalia leucophyllus* GILLET, Hyménomycètes de France, p. 296. 1874.) (cf. Figs. 9–12 and discussion of *Fayodia* ssp.)

8. *Gamundia leucophylla* (GILLET) BIGELOW, loc. cit. – Fig. 9

The spores depicted came from a specimen collected by Dr. EGON HORAK (ZT 79/330, identified as *Fayodia striatula*) in Switzerland. The collection was found in meadows near the margin of a *Pinus–Larix* forest.

Aside from the presence of a farinaceous odor, which is rare in North American specimens, the field characters agree with those I have studied to date. However, the ornamentation of the spores of ZT 79/330 appears to be somewhat denser and with sharper tips to the verruculae in profile when compared to the verruculae shown in Fig. 8. This may be the result of relative immaturity of the spores,

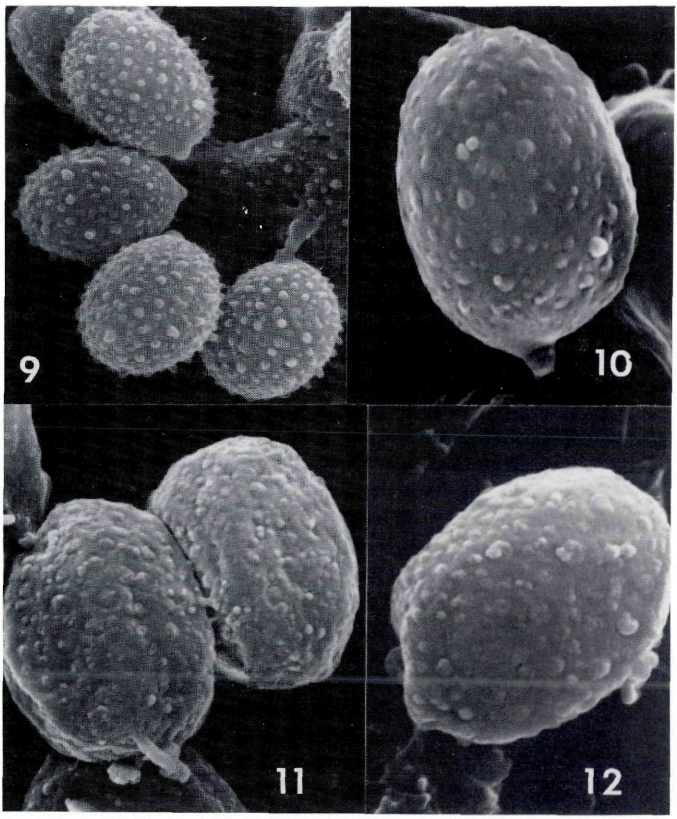


Fig. 9. *Gamundia striatula* (ZT 79/330), ×4500.
Fig. 10. *Fayodia xerophila* (holotype), ×8500.
Figs. 11, 12. *Collybia pseudoclusilis* (holotype): 11, ×7000; 12, ×8500.

but could also represent some variation in the species. The spores do not look identical to those found either in *Fayodia xerophila* holotype (Fig. 10) or in *Collybia pseudoclusilis* holotype (Figs. 11 & 12) as well.

9. *Fayodia xerophila* LUTHI & RÖLLIN, Bull. Soc. Mycol. France 88: 174. (1972) 1973. Fig. 10

Holotype specimen collected in Switzerland (ZT).

This was described in detail and illustrated with excellent water colors of habit and colors fresh as well as line drawings of microscopic structures (LUTHI & RÖLLIN, 1983, Pl. 88). The authors also compared the species to *Fayodia pseudoclusilis,* but the principal difference would seem to be the presence of a strong odor. They also mentioned that the verruculae on the spores were less dense, less prominent and visible than in *Fayodia pseudoclusilis.* While Fig. 10 would seem to show fewer verruculae than Figs. 11 & 12, they do not seem more prominent. The verruculae of *Fayodia xerophila* do seem comparable to those of *Gamundia striatula,* but as noted elsewhere, any variations evident from comparing Figs. 8 through 12 may well be the result of factors unrelated to any species differences. Any taxonomic significance seems dubious at present.

This species is recognized by some investigators as *Gamundia xerophila* (LUTHI & RÖLLIN) RAITHELHUBER (Metrodiana 9: 48. 1980).

10. *Collybia pseudoclusilis* JOSSERAND & KONRAD, Bull. Soc. Linn. Lyon 10: 22. 1931. Figs. 11, 12

Fragment of holotype collected at Lyon, France, by M. JOSSERAND, loaned by Dr. E. HORAK.

The spores of *C. pseudoclusilis* did not revive quite as well as those of the related *Gamundia leucophylla* or *G. xerophila,* and some debris also is apparent on the surface. Nevertheless, the verruculae do seem slightly more numerous than those found on the spores of the other two species. Whether or not the verruculae are more prominent in *Collybia pseudoclusilis* as LUTHI & RÖLLIN also claimed is doubtful.

As with *Gamundia leucophylla* there is a possibility that the difference in appearances between the spores illustrated in Figures 8 through 12 may only be the result of differences in the age of the spores, but it is also possible that only variations of a single species are encountered. As with some other species, such variations need to be correlated carefully with other features of the basidiocarps. The spores of more specimens need to be examined, and samples need to be taken from a single basidiocarp to determine if all variations in ornamentation may be found there before attaching any taxonomic

significance to a particular configuration of verruculae (see also discussions under *Fayodia xerophila* and *Gamundia leucophylla*).

The species is recognized by some investigators as *Gamundia pseudoclusilis* (JOSSERAND & KONRAD) RAITHELHUBER (Metrodiana 9: 48. 1980).

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Literature

ARNOLDS, E. (1982). Ecology and coenology of macrofungi in grasslands and moist heathlands in Drenthe, the Netherlands. – Vol. 2, 501 p. J. Cramer, Vaduz.

BARONI, T. J. (1981). A revision of the genus *Rhodocybe* Maire (Agaricales). – 194 p. J. Cramer, Vaduz.

BESSON, M. (1970). Ultrastructure de la paroi sporique de quelques Agaricales à ornements cyanophiles non amyloides. – Compt. Rend. Acad. Sci. Paris. 271, Ser. D: 1508–1510.

— (1972). Contribution à la connaissance de l'infrastructure de la paroi sporique des Hyménomycètes. – Thèse. L'Université Claude Bernard de Lyon.

BIGELOW, H. E. (1979). Notes on *Fayodia* ss. lato. – Mycotaxon 9: 38–47.

— (1981). Spore ornamentation in the Tricholomataceae I. – Mycologia 73: 128–140.

BIGELOW, H. E., & J. R. ROWLEY (1968). Surface replicas of the spores of fleshy fungi. – Mycologia 60: 869–887.

BON, M. (1977). Macromycètes de la zone maritime Picarde. – Docum. Mycol. 7: 63–80.

HALLING, R. (1983). The genus *Collybia* (Agaricales) in the northeastern United States and adjacent Canada. – Mycol. Mem. 8: 1–148. J. Cramer, Braunschweig.

LANGE, M., & S. SIVERTSEN (1966). Some species of *Lyophyllum, Rhodocybe* and *Fayodia* with rough spores. Nomenclature and taxonomic position. – Bot. Tidssk. 62: 197–211.

LUTHI, R., & O. RÖLLIN (1973 (1972)). Une nouvelle espèce hivernale: *Fayodia* (Heterosporula SINGER) *xerophila*, nov. spec. – Bull. Soc. Mycol. France 88: 171–174.

MURRILL, W. A. (1914). Illustrations of fungi XIX. – Mycologia 6: 220–225.

— (1916). North American Flora 9, pt. 5: 297–373.

— (1916). *Pleurotus, Omphalia, Mycena* and *Collybia* published in North American Flora. – Mycologia 8: 218–221.

PEGLER, D. N., & T. W. K. YOUNG (1973). Basidiospore form in the British Leucopaxillae. – Kew Bull. 28: 365–379.

— (1974). Basidiospore form in the British species of *Lepista* and *Ripartites* (Agaricales). – Kew Bull. 29: 659–667.

RIDGWAY, R. (1912). Color standards and color nomenclature. – Published by the author, Washington, D. C. 43 p. 53 pl.

SINGER, R. (1961). Type studies on agarics IV. – Sydowia 15: 133–151.

SMITH, A. H. (1941). Studies of North American Agarics I. – Contrib. Univ. Michigan Herb. 5: 3–73.

— (1947). North American species of *Mycena*. – Univ. of Michigan Press, Ann Arbor. 507 p.