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TAXONOMY OF *CORTICIUM CHRYSOCREAS* AND *PHLEBIA LIVIDA*

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SUMMARY

A fungus causing heartrot in hardwoods, long misidentified by U.S.D.A. forest pathologists *as Corticium lividum,* has been identified as *C. chrysocreas.* Basidiocarps and cultures of C. *chrysocreas* and C. *livida* are described and illustrated. The new combination, *Phlebia chrysocrea, is* proposed.

Since the late 1920's a fungus causing heartrot in hardwoods in the southern, eastern, and central United States has been encountered in decay surveys conducted by the Division of Forest Pathology (now Forest Insect and Disease Research, Forest Service) of the United States Department of Agriculture. Although the identity of the fungus was not known earlier, its distinctive white and bright yellow cultures were readily recognized when isolated in the various decay studies. Hepting (12) first reported it as the "yellow hymenomycete" from overcup oak in Louisiana and Mississippi in a study of decay following fire. Later, these and cultures from other heartrot decay studies were found to be identical to a rot isolate from oak in Pennsylvania (L. 0. Overholts-15084-R) that was associated with a basidiocarp mistakenly identified as *Corticium lividum* Pers. ex Fr. In all instances, the name *C. lividum,* as used by this Division for this species, has been based on cultures isolated from decay and identified by comparison with the isolate from rot associated with the Overholts basidiocarp.

Davidson et al. **(9)** included *C. lividum* in their comprehensive study of the oxidase reactions of wood-decaying fungi and later **(8, 10)**

published a cultural description of this species based on the Overholts rot isolate and 27 other isolates from decay in oak. The fungus has been recorded also as a species that decays heartwood in other studies of oak (**13, 20, 22, 24**), black cherry (7), and hardwood slash (**23**).

In 1952 Davidson collected basidiocarps of C. *lividum* on conifers in Colorado and isolated the fungus from mass basidiospore deposits. These cultures and cultures from basidiocarp spore prints collected later in other areas formed fast-growing, sodden orange-colored mycelia, quite distinct culturally from the species with white and yellow mycelia previously identified as *C. lividum.* Our study of the basidiocarps showed that they were correctly identified as *C. lividum* and that the orange-colored cultures derived from these specimens are the vegetative state of that species. Thus, our use of the name *C. lividum* for the white and yellow heartrot cultures was in error and the fungus was designated "Unknown H" in the Division. *Corticium lividum is* now commonly referred to as *Phlebia livida* (Pers. ex Fr.) Bres.

In recent years "Unknown H" has been isolated repeatedly from decayed hardwoods in the central states of the United States (**1, 2, 3**). In these studies dissected trees, known to be infected with the fungus and left in the forest for fruiting, did not yield basidiocarps. However, inoculated wood blocks incubated in "decay chambers" by F. H. Berry and rot isolates grown on malt agar medium in our laboratory occasionally developed fruiting areas that produced basidiospores. Single-basidiospore isolates were obtained from some of these. The characters of the vegetative mycelia, basidia, and basidiospores indicated to us that the "Unknown H" isolates were very likely *Corticium chrysocreas* Berk. et Curt.

In 1968 Burdsall collected a corticiaceous basidiocarp (HHB-1751) on a chestnut log in Maryland and subsequently obtained a culture from mass basidiospore deposits. Haploid basidiospore isolates from this basidiocarp formed clamp connections when paired with haploid isolates of "Unknown H." Study and comparison of the isotype specimens (BPI, FH) of *C. chrysocreas* and the specimen, HHB-1751, showed that the two are conspecific. Because *C. chrysocreas* possesses many of the characters of the genus *Phlebia* Fr. as emended by Donk (11, p. 8), a new combination in the genus *Phlebia* is proposed.

Before 1952 the Division distributed to various laboratories cultures of *P. chrysocrea* under the name *Corticium lividum.* Thus, isolates Nos. Overholts-15084-R and 5159 in the studies by Robbins et al. **(19)** and Robbins and Hervey **(18)** and CBS 114.40 at the Centraal-

bureau voor Schimmelcultures, Baarn, The Netherlands, are *P. chrysocrea.*

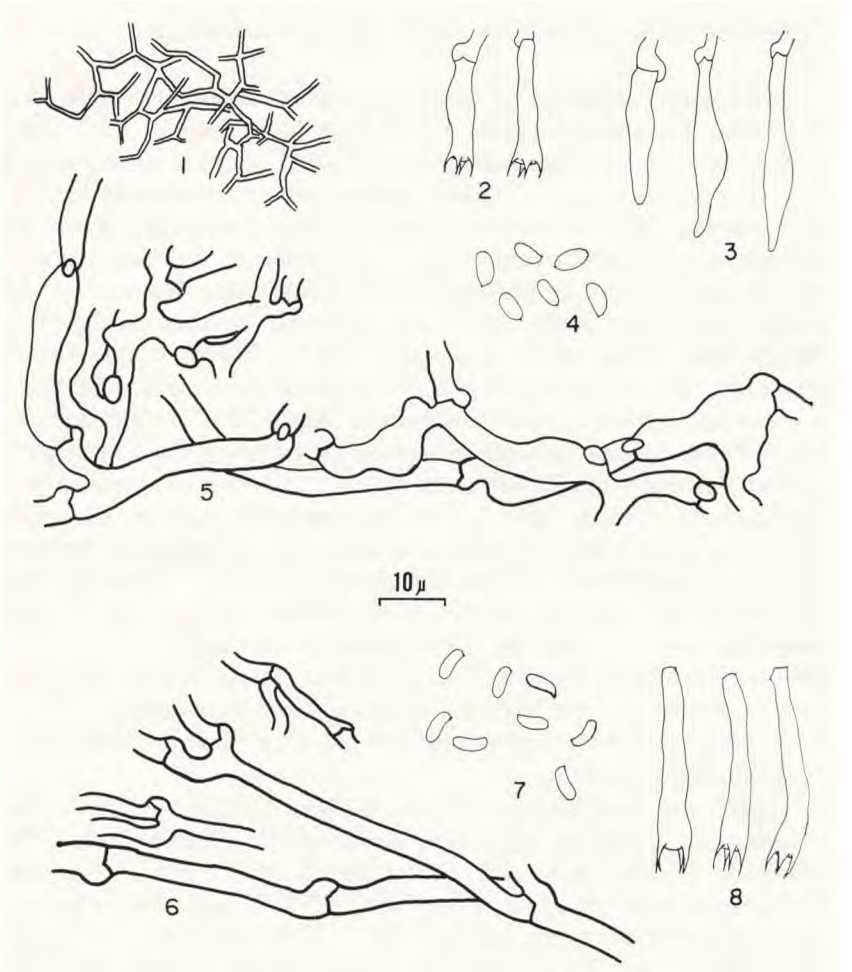
Microscopic characters of basidiocarps were studied from free-hand and freeze-microtome sections placed first in a drop of 95% ethyl alcohol, then mounted in a drop of 2% KOH solution mixed with a drop of phloxine solution. Other sections were also mounted in Melzer's reagent. The methods employed in studying the cultures and the arrangement of the descriptions and explanation of the "key pattern" are the same as used in previous studies (10). Mat descriptions and growth rates were based on 7- and 14-da-old cultures incubated in 90-mm Petri dishes at 25 C on 2½% (w/v) Fleischmann's diamalt agar (10), with an initial *p*H of 5.3 ± 0.1 after autoclaving. Test-tube cultures were grown at room temperature (about 25 C) in diffuse light. Extracellular oxidase production was tested by using the Bavendamm method described by Davidson et al. **(9)** and the gum guaiac test described by Nobles **(16).** For the constant-temperature studies, Petri-dish cultures on malt agar were placed in incubators 24 hr after plating. Measurements of mat diameters represent averages of three replications of individual isolates of a species. Killing temperatures were determined by removing the cultures from the higher test temperatures and incubating them at 25 C for 3 wk. Those that did not grow were presumed to have been killed at the test temperatures. Microscopic structures were drawn with the aid of a camera lucida and a Zeiss drawing apparatus.

Capitalized color names are from Ridgway (17). Abbreviations of herbarium names are taken from Lanjouw and Stafleu **(15).** The herbarium of the Center for Forest Mycology Research (formerly BFDL at Laurel, Md.) is abbreviated, CFMR, and the herbarium accession numbers are prefixed by "'FP ." The herbarium of the State University of New York College of Environmental Sciences and Forestry at Syracuse University is abbreviated, SYRF. Abbreviated collector's names are as follows : H. H. Burdsall, Jr., HHB, and **R.** L. Gilbertson, RLG.

Phlebia chrysocrea (Berk. et Curt. in Berk.) Burds., comb. nov.
FIGS. 1-8, 9-11, 15-18

≡*Corticium chrysocreas* Berk. et Curt. in Berk., Grevillea 1: 178. 1873 (Basionym).

≡*Terana chrysocreas* (Berk. et Curt. in Berk.) O. Kuntze, Rev. Gen. Plant. 2 : 872. 1891.



FIGS. 1-8. Microscopic characters of basidiocarps. FIGS. 1-5. *Phlebia chrysocrea* (HHB-1751). 1. Narrow much-branched hyphae (yellow crystals dissolved) found in substrate below basidiocarp. 2. Basidia. 3. Cystidia. 4. Basidiospores. 5. Subicular hyphae. FIGS. 6-8. *P. livida* (Lowe-7854). 6. Subicular hyphae. 7. Basidiospores. 8 Basidia

≡*Gloeocystidium chrysocreas* (Berk. et Curt. in Berk.) T. Ito, Bot. Mag. Tokyo 43: 641. 1929.

=*Kneiffia chromoplumbia* Berk. et Br., J. Linn. Soc. Bot. 14: 62. 1875.

=*Corticium flavo-croceum* Bres. in Bourd. et Galz., Bull. Soc. Mycol. France 27: 256. 1911.

Basidiocarps annual, broadly effused, adherent, up to 1 mm thick, membranous to cartilaginous ; *hymenial* surface smooth to slightly warted, Ochraceous-Buff to Yellow Ochre or Buckthorn Brown, with translucent aspect and slight bloom, sometimes with hyaline granular material on warts ; *margin* frequently not differentiated, if differentiated, then White to Wax Yellow, up to 2 mm wide, thin, granular, sterile. Wood below basidiocarp (especially rays and worm holes) with deposits of Wax Yellow granular material that stains purple[1] in 2% KOH.

Hyphae in substrate of two types, one kind like those of subiculum (FIG. 5), either smooth or encrusted by yellow granular material, the other kind less than 1µm broad (FIG. 1), appearing rigid, thin walled, or slightly thickened, many without distinguishable lumina, hyaline, aseptate, branched, not agglutinated, densely encrusted by yellow granules that dissolve in 2% KOH, turning solution red ; *subiculum* a textura intricata, 10-200 µm thick, with scattered deposits of orange-brown granular material and with occasional large deposits of hyaline crystals, hyphae (FIG. 5) 2-4 µm broad (rarely swollen to 8 µm broad), short celled, with slight wall thickening, smooth or more or less heavily encrusted by bright yellow granules that dissolve in 2% KOH, turning solution red, frequently septate, with clamp connections, frequently branched, agglutinated; *hymenium* arising from subiculum, thickening, sometimes layered, up to 75 µm thick, a compact palisade of cystidia and basidia, more or less agglutinated and difficult to observe, orange-brown granular material distributed throughout, often penetrated by hyaline, crystalline deposits from subiculum; *cystidia* (FIG. 3) 15-30 X 3-6 µm, nearly cylindrical to ventricose-rostrate, protruding up to 10 µm beyond basidia, thin walled, hyaline, clamped at base, smooth or with an apical cap of orange-brown material, not dissolving in 2% KOH; *basidia* (FIG. 2) 15-21 x 4-5 µm, cylindrical to clavate, thin walled, hyaline, clamped at base, 4-sterigmate; *sterigmata* (FIG. 2) 3-4 µm long, narrow, slightly curved ; *basidiospores* (FIG. 4) 4-5.5 (-6) x 2-2.5 µm, narrowly ovoid, adaxially flattened, thin walled, hyaline, smooth, negative in Melzer's reagent.

Specimens examined.—ut Corticium chrysocreas: U.S.A. FLORIDA : HHB-6600*,[2] on *Quercus* sp., Upper Sugarfoot Prairie, Alachua County (CFMR) ; HHB-6630*, on *Liquidambar styraciflua* L., San Felasco Hammock, Alachua County (CFMR).—GEORGIA : HHB-2005 and -2006, on *Sassafras albidum* (Nutt.) Nees, Rabun County (CFMR).—MARYLAND : HHB-1751*, on *Castanea dentata* (Marsh.) Borkh., Prince Georges County (CFMR).—NORTH CAROLINA : HHB-2457*,

[1] The color of this reaction is red, when observed tinder the microscope.

[2] An asterisk (*) denotes a specimen from which a culture was obtained and studied.

on *Betula* sp., Coweeta Exp. Forest, Macon County (CFMR) ; HHB-4157, on *Robinia pseudoacacia* L., Haywood County, Great Smoky Mts. Natl. Park (CFMR).—PENNSYLVANIA: Overholts-15084*, on *Quercus sp.*, Armstrong County (PAC).—SOUTH CAROLINA: On *Liriodendron tulipif era* L., Ravenel, Fungi Car. V: 27, ISOTYPES (BPI, FH).—TENNESSEE : HHB-3946*, -3948, and -4192, on *S. albidum*, HHB-4304*, on *Prunus* sp., all in Great Smoky Mts. Natl. Park, Sevier County (CFMR) ; HHB-4415, on *Quercus* sp., Great Smoky Mts. Natl. Park, Blount County (CFMR).—*ut Corticium chromo-plumbia:* CEYLON. May 1868, ISOTYPES (K, BPI).—ut *Corticium flavo-croceum:* FRANCE. Galzin 5803, ad cerasi, l'Aveyron, HOLO-TYPE (S) ; Galzin-3336, "sur cerinei," Tarn (PC) ; Galzin-3927, sur peuplier, Pl. d l'Aveyron (PC) ; Galzin-13473, on apple, Barthe (Lloyd collections, BPI) ; Bourdot-29958, sur cerisier, l'Aveyron (S).

Remarks.—Phlebia chrysocrea is characterized by a smooth or slightly warted yellowish-brown hymenium when fresh and is usually accompanied by bright yellow mycelium in worm holes, rays, or open areas in the wood substrate. These areas stain purple in 2% KOH. Microscopically it possesses small cylindrical to ventricose-rostrate cystidia and two types of hyphae, some of which are coated with yellow granules that dissolve and turn KOH solution red.

Microscopically, *P. chrysocrea* differs from *P. livida* in having small, smooth or capitately encrusted cystidia that protrude slightly, smaller basidia, frequently branched hyphae, almost entirely short celled, and a second type of very narrow, nonseptate hyphae in the substrate, coated with the characteristic yellow granules.

Cunningham (6, p. 95) treated *P. chrysocrea (Corticium)* as a synonym of *Odontia archeri* (Berk.) Wakef. Since the *O. archeri* holotype (K) is fragmentary and poorly preserved, we could not be certain of its identity and, therefore, consider the name a *nomen dubium.*

Cunningham (6, p. 95) also considered *P. chrysocrea* and *Odontia wrightii* (Berk. et Curt.) Burt to be synonomous. Burt (5, p. 270) indicated a similarity but did not mention synonomy. Our studies show that *O. wrightii* differs in possessing well-defined teeth, the axes of which are composed of hyphae with penicillately arranged, elongated, hyaline crystals. In less hydnaceous areas the hyphae are oriented mostly perpendicular to the substrate and are heavily encrusted with hyaline crystals. The yellow granules in the subiculum dissolve in *2%* KOH and turn the solution red.

The chemistry of the reaction of the yellow granules dissolving and forming a red solution in KOH has not been studied. Further study

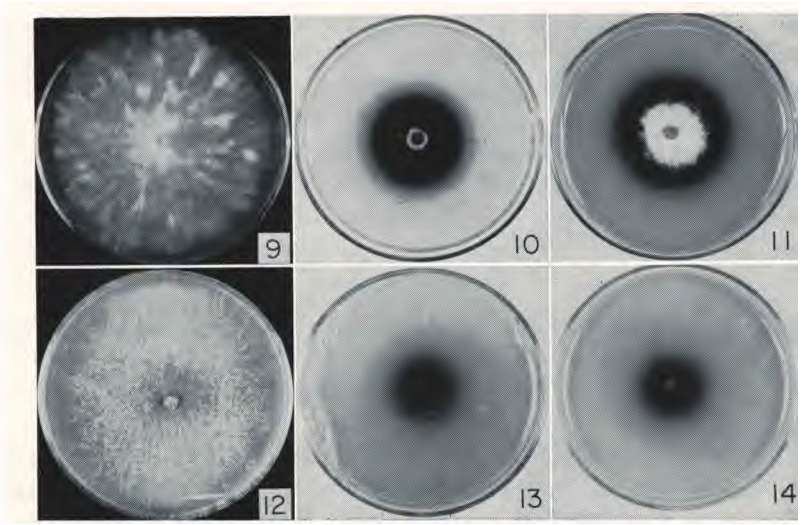
is planned to determine the nature of this reaction. It is possible that results of such studies will indicate a close relationship to such fungi as *Odontia wrightii* and *Mycoacia uda* (Fr.) Donk, both of which have yellow crystals that dissolve and turn KOH solution red. These species, along with *P. chrysocrea,* may form a homogeneous group beyond the limits of *Phlebia.*

Phlebia chrysocrea causes a white mottled or small pocket rot of hardwoods in the eastern United States from nothern Pennsylvania to Florida and west to the Mississippi River. It has been found in Missouri and probably occurs in other areas just west of the Mississippi River, throughout eastern Texas, and along the Texas coast adjacent to the Gulf of Mexico.

Description of cultures

Key pattern.—B-P-I-1-2-10-16.

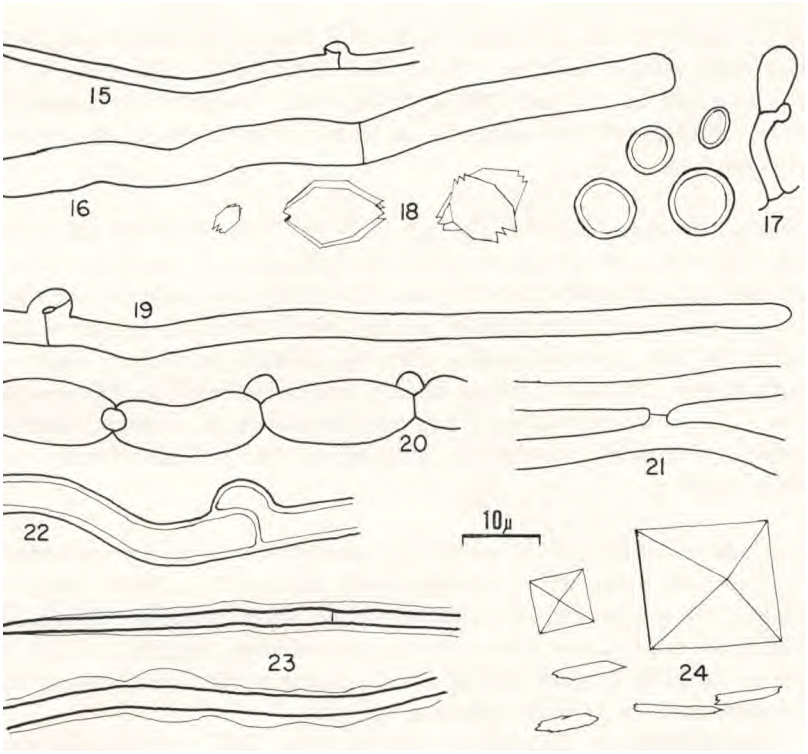
Growth characteristics.—Growth moderately rapid, forming a mat (63—)78-89 mm in diam in 7 da (FIG. 9) ; mat White, occasionally



FIGS. 9-14. Petri-dish cultures. FIGS. 9-11. *Phlebia chrysocrea* (HHB-1751-Sp) and FIGS. 12-14. *P. livida* (FP-90102-Sp). 9, 12. Two weeks old on malt agar. 10, 13. One week old on gallic acid agar. Mat in FIG. 10 extends beyond limit of reaction but mycelium is mostly submerged and so thin that it does not show in photograph. 11, 14. One week old on tannic acid agar.

with Massicot Yellow to Bartya Yellow over or around the inoculum by 7 da and usually present, at least as scattered patches, by 14 da, mycelium appressed, at first with downy-cottony area around inoculum merging irregularly into an extensive translucent marginal zone with driftlike or veined pattern of thin to thickened downy areas, by 14 da sometimes completely appressed but more often with some raised cottony-woolly patches of superficial growth around inoculum or scattered, these rarely coalescing and covering the whole mat in thick and thin areas ; margin indistinct, finely fimbriate ; no reverse discoloration, with occasional isolates bleaching the medium ; odor moderately strong, near almond or carbide ; yellow mycelium turning deep purple when touched with KOH solution, imparting a light purple color to the solution ; oxidase reactions positive, weak to moderately strong with the Bavendamm test, making a mat (45-) 50-77 mm in diam with the reaction not extending to the margin of growth (rarely making only a trace of growth and giving a very strong reaction) on gallic acid agar (FIG. 10) and (26-)30-38 mm in diam with moderately strong reaction on tannic acid agar (FIG. 11) in 7 da, and negative at the end of 3 min with the gum guaiac test, in 30 min giving a reaction varying in color between Porcelain Blue and Chessylite, rarely as pale as Lumiere Blue or as dark as Dark Chessylite Blue. At 14 da mat on gallic acid agar White over the inoculum, rest of mat is dirty white to Olive-Buff becoming as dark as Cinnamon-Buff, appressed, with thick and thin drifts and veins through which the very dark oxidase reaction shows ; mat on tannic acid agar White, developing bands or scattered areas of pale Massicot Yellow to Pinard Yellow as the cultures age, nodulose to tufted cottony-woolly, usually zonate, with a narrow wispy marginal zone. Occasionally, small fertile fruiting areas may develop in 4-6 wk on malt agar medium. The species is heterothallic, having the tetrapolar type of mating system.

Hyphal characteristics.—All hyphae staining in phloxine, septate with abundant clamp connections, some septa lacking clamps, (1.5-) 2-5 (-9) μm in diam (FIG. 15) ; hyphal segments, lacking clamps, with bluntly rounded ends, free-floating, 5-9 μm in diam (FIG. 16) ; all hyphal elements in the colored portions of the mat encrusted with a thin sheath of crystalline material that dissolves instantly in KOH ; chlamydospores abundant to rare, terminal on short side branches with clamp connection immediately below or at base of branch, or intercalary, globose to subglobose, with thick hyaline wall, 6-10 μm in diam (FIG. 17) ; crystals thin plates appearing hexagonal in optical section and apparently fused into bundles (FIG. 18).



FIGS. 15-24. Microscopic structures from cultures. 15-18. *Phlebia chrysocrea* (HHB-1751-Sp). 15. Staining hypha. 16. Hyphal segment. 17. Chlamydospores. 18. Crystals. 19-24. *P. livida* (RLG-2640-Sp). 19. Staining hypha. 20. Enlarged hyphal cells. 21. Hyphal fusion. 22. Hypha with slightly thickened walls and brown contents. 23. Encrusted hyphae with slightly thickened walls. 24. Crystals.

Test-tube cultures.—In 28 da mycelium covers slant and extend down agar cylinder to the bottom of tube, mat on slant usually appressed, White, thin downy with compacted cottony areas Massicot Yellow, Pinard Yellow, or Mustard Yellow around inoculum and scattered on upper slant, rarely with a White downy roll at top of slant; mat on agar cylinder usually white, occasionally spotted yellow, dense to thin fine downy; no reverse discoloration, medium slightly bleached in a few isolates ; occasionally fruiting areas beginning to develop on upper slant as small yellow knobs.

Temperature relations.—Average diameters of mats grown on malt agar in 4 da at 12 constant temperatures for seven isolates follow :

12 C, trace ;[3] 16 C, 11.4 mm ; 20 C, 21.7 mm ; 22 C, 27.5 mm ; 24 C, 45.2 mm ; 26 C, 48.5 mm ; 28 C, 53.3 mm ; 30 C, 52.5 mm ; 32 C, 49.7 mm ; 36 C, 18.9 mm ; 40 C, trace; 44 C, 0—trace. Optimum 28-30 C. Mycelia of five isolates in at least two of three dishes survived 44 C for 4 da.

Cultures studied.—HHB-1751-Sp,[4]-2457-Sp, -3946-Sp, -4304-Sp,-6600-Sp, -6630-Sp, and Overholts-15084-R, each from or associated with a basidiocarp. In addition 48 isolates from decay, including five of those that formed in part the basis of the published descriptions from earlier works (9, 10), were studied. The rot isolates were from decay in black cherry (Prunus serotina Ehrh.), honey locust (Gleditsia triacan-thos L.), various species of oak, and sassafras in Georgia, Illinois, Indiana, Kentucky, Louisiana, Mississippi, Ohio, Pennsylvania, and West Virginia.

Remarks.—Cultures of *P. chrysocrea* are characterized by moderately rapid growth rates, white cottony-downy mats with scattered areas of bright yellow mycelium that turns purple when touched with KOH solution, a strong odor (near almond or carbide), positive oxidase reactions, staining hyphae with abundant clamp connections, and usually abundant globose to ovoid chlamydospores.

The reaction of the yellow mycelium to KOH solution is quite distinctive and characteristic. As stated earlier it can be demonstrated on the tissue of the basidiocarps, pockets of mycelium in the host wood, and wood in which the fungus hyphae are present, as well as in the cultures (No. 16 in the "Key Pattern"). The yellow mycelia in cultures of *Odontia wrightii* and certain species in the *Mycoacia uda* complex also give this reaction.

Davidson et al. (9, 10) have published cultural characters of *P. chrysocrea* (as *C. lividum).* Humphrey and Siggers (14) published the temperature relations of an isolate as *C. chrysocreas.*

PHLEBIA LIVIDA (Pers. ex Fr.) Bres., Atti J. Roy. Accad. Sci. Lett. Arti Rovereto, (Ser. 3) 3: 105. 1897. FIGS. 6-8, 12-14, 19-24

≡*Corticium lividum* Pers., Obs. Mycol., p. 38. 1796.
≡*Thelephora livida* Pers. ex Fr., Syst. Mycol. 1: 447. 1821.
≡*Corticium lividum* (Pers. ex Fr.) Fr., Epicr. Syst. Mycol, p. 563. 1838.

[3] Less than 11 mm.
[4] Sp, culture from spore print ; R, culture from rot in host wood.

=*Terana livida* (Pers. ex Fr.) 0. Kuntze, Rev. Gen. Plant. 2 : 872. 1891.

Basidiocarps annual, broadly effused, up to 1 mm thick, adherent, cartilaginous; *hymenial surface* smooth to slightly warted, Tilleul Buff or Vinaceous-Buff to Mouse Gray or Hay's Brown, sometimes with light-colored granules distributed more or less densely over surface; *margin* narrow to broad, thin, hyaline, fertile.

Subiculum detail difficult to discern, a textura intricata, 20-200 µm thick; *hyphae* (FIG. 6) 2-4(-6) µm broad, thick walled (walls up to 0.5-1(-2) µm thick), hyaline, refractive, smooth or with scattered large deposits of hyaline crystals, long celled (mostly more than 40 *µm* long), septa with clamp connections, branched at various angles, tightly agglutinated ; hyphae like those in subiculum also found penetrating the substrate but these are not so tightly agglutinated and are oriented parallel to and often inside the vascular cells of the substrate ; *subhymenium* usually not well delimited, a compact textura intricata up to 40 *µm* thick ; hyphae 2.5-4 µm broad, thin walled, hyaline, smooth, short celled (cells mostly less than 15 µm long), septa with clamp connections, agglutinated ; *hymenium* up to 75 µm thick, composed of basidia only, frequently thickening; *basidia* (FIG. 8) 20-35 x 4-5 µm, narrowly clavate with slight median constriction, thin walled, hyaline, clamped at base, mostly 4-sterigmate but 1-sterigmate basidia also found; *sterigmata* (FIG. 8) 4-6 µm long, narrow, slightly curved (sterigmata of one-spored basidia are very narrow and protrude up to 30 µm beyond hymenium) ; *basidiospores* (FIG. 7) 4-5(-6) x 1.5-2.5 , broadly allantoid, thin walled, hyaline, smooth, negative in Melzer's reagent.

Specimens examined.—U.S.A. **ARIZONA**: K. J. Martin-235*, on *Picea engelmannii* Parry, Coronado Natl. Forest, Graham County (CFMR, ARIZ) ; RLG-9883*, on *P. engelmannii*, Coronado Natl. Forest, Cochise County (CFMR, ARIZ).—COLORADO: FP 100274*, on conifer, near Steamboat Springs (CFMR).—MONTANA: RLG-6251 on *Pinus contorts* Dougl., Glacier Natl. Park, Flathead County (CFMR, ARIZ).—NEW **YORK**: RLG 2640*, -2684*, FP-90102*, on conifer, Paul Smith's (SYRF, CFMR) : J. H. Ginns-455*, on conifer, Warrensburg (SYRF, CFMR).—NORTH **CAROLINA**: HHB-1905*, on *Pinus* sp., and HHB-2411, on *P. strobus* L., Nanthala Natl. Forest, Macon County (CFMR, ARIZ).—OREGON: FP-133464*, on *Picea* sp., near Iron Mt., Willamette Natl. Forest (CFMR).—WASHINGTON: J. L. Lowe-7854*, on *Tsuga* sp., Olympic Natl. Park (SYRF, CFMR) ; Lowe-10655*, on conifer, Snoqualmie Pass, Snoqualmie Natl. Forest (SYRF, CFMR).—DENMARK. M. P. Christiansen-500, on *Alnus*

sp., M. P. Christiansen-673, on *Fagus* sp., and M. P. Christiansen-774, Sjaell (C).—FRANCE. Galzin-8952 (Lloyd Cat. no. 46872), on *Alnus* sp., Loubotis (Lloyd coll.-BPI).—SWEDEN Lloyd Cat. no. 35024, on *Pinus* sp., and Lloyd Cat. no. 46879, Bygget (Lloyd coll.-BPI).

Remarks.—Phlebia livida is characterized macroscopically by its pinkish-buff to bluish-gray hymenial surface and microscopically by the lack of cystidia, and the presence of nearly cylindrical to broadly allantoid basidiospores and refractive, clamped, thick-walled hyphae. One-spored basidia with long protruding sterigmata seem to be a constant character of this species, although they occur in varying numbers depending on the specimen being studied. They are common in some specimens (e.g., Ginns-455).

Unfortunately, the type specimen of *P. livida* is apparently not extant, but comparison with European collections indicates that the North American species is conspecific with that in Europe.

Although *P. livida* has been confused by us with *P. chrysocrea,* it is distinguished macroscopically by its pinkish-buff to bluish-gray color and microscopically by possessing longer basidia, narrower basidiospores, and refractive thick-walled, long-celled hyphae. *Phlebia chrysocrea* occurs exclusively on hardwoods, while *P. livida* seems to be only on softwoods in North America. In Europe, however, *P. livida* fruits on both hardwoods and softwoods, while *P. chrysocrea* (as *C. flavocroceum)* seems to be restricted to hardwoods.

Although *Phlebia livida* is quite distinctive macroscopically and microscopically, the name *Peniophora livida* Fr. in Burt may cause confusion **(5,** p. 239). *Peniophora livida* has allantoid spores and subulate cystidia and would not be confused microscopically.

Phlebia livida is a weak white rotter that appears to be a late invader and apparently is confined to coniferous woods in North America. In a study of deterioration in second-growth Douglas-fir logs at 2, 4, and 6 yr after felling, Smith et al. **(21)** found *P. livida* to be restricted to the 6-yr-old logs.

Description of cultures

Key patterns.—B-P-I-1-10-14-16, E-P-M-1-10-14-16.

Growth characteristics.—Growth moderately rapid or rarely medium, forming a mat (74—)85-90+ mm in diam in 14 da (FIG. 12) ; at 7 da mat with scant aerial mycelium, colorless with light yellow around

the inoculum, the inoculum usually orange; at 14 da mat appressed with very scant and collapsed aerial mycelium, sodden, central area denser, becoming thinner and more translucent toward the margin, adherent, fragile at first, becoming firm and tough, mycelium Light Buff to Cream Color but usually so scant that by 14 da color of substrate (restricted to the depth of the submerged mycelium) shows through, coloring the mats Antimony Yellow, Ochraceous-Orange, Zinc Orange, or as dark as Orange-Rufous, occasional isolates as light as Warm Buff to Yellow Ocher; margin indistinct, fimbriate; no discoloration of substrate beyond the depth of the submerged mycelium but color of mat can be seen from the reverse side of dish; odor none to slightly fruity; oxidase reactions positive, moderately strong to weak with the Bavendamm test, making no growth to a trace (rarely with thin waspy growth up to 20 mm in diam) with a moderately strong reaction on gallic acid agar (FIG. 13) and no growth to a trace with a moderately strong to weak reaction or only a faint strain on tannic acid agar (FIG. 14) in 7 da, and negative at the end of 3 min with the gum guaiac test, in 30 min giving a reaction varying in color from Court Gray to Celandine Green to Glaucous-Blue to no reaction. When stored under Squibb's mineral oil, most of the isolates impart a deep yellow color to the oil.

Hyphal characteristics.—All hyphae staining in phloxine, septate with abundant to rare clamp connections, some septa lacking clamps, (1.5—) 3.5-5.5(-10) μm in diam (FIG. 19) ; older hyphae frequently 'swollen with cell ends rounded making the end wall conspicuous (FIG. 20) ; bridging hyphae fairly common in colored portions of mat (FIG. 21) ; hyphae with slightly thickened hyaline walls and cell contents rich in heavily staining materials that eventually become yellow to light brown in color common in the orange-colored areas of the mat (FIG. 22), septate, lacking clamps or with occasional clamp connections, frequently encrusted with a colorless gelatinous or crystalline sheath (FIG. 23) or rarely with very fine individual crystals, 2.2-5 (-10) μm in diam; free crystals large to small octahedrons and small scattered or clustered needles (FIG. 24).

Test-tube cultures.—In 28 da mat covers slant and cylinder, appressed to sodden, most isolates uniformly Ochraceous-Orange to Cinnamon-Rufous and Xanthine Orange from color in substrate, restricted to depth of submerged mycelium, which shows through very scant creamy white aerial mycelium, a few isolates as pale as Warm Buff to Yellow

Ocher with the color in patches on slant or cylinder, all isolates show a very narrow band of slightly darker color directly under the mat along sides of cylinder; medium not discolored, although color of submerged mat visible from reverse side.

Temperature relations.—Average diameters of mats grown on malt agar in 8 da at 11 constant temperatures for six isolates follow : 12 C, trace ; 16 C, 19.3 mm ; 20 C, 43.5 mm ; 22 C, 58.9 mm; 24 C, 59.4 mm ; 26 C, 47.4 mm; 28-30 C, 0-trace; 32-40 C, 0. Optimum, 24 C; killing, 40 C.

Cultures studied.—Martin-235-Sp, Ginns-455-Sp, HHB-1905-Sp, RLG-2640-Sp, -2684-Sp, -3822-Sp, Lowe-7854-Sp, RLG-9883-Sp, Lowe-10655-Sp, FP-90102-Sp, FP-100274-Sp, and FP-133464-Sp. In addi-tion, one isolate from Douglas-fir decay in British Columbia was in-cluded in the study.

Remarks.—Cultures of *P. livida* are characterized by moderately rapid growth rates, sodden orange-colored mats, weakly positive oxidase reactions, hyphae with clamp connections, and encrustations on hyphae with yellowish-brown contents.

Boidin **(4)** has published a cultural description of *P. livida* (as *Corticium).*

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