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TAXONOMIC STUDIES IN THE GENUS COCCOSPORA

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(WITH 2 FIGURES)

The validity of the genus *Coccospora* Wallroth (1833) has been under question (Shear, 1939; Gilman, 1945) for some time. Since its establishment in the Moniliales on the type *C. aurantiaca*, eight little-known species have been added to the genus. Examination of type material shows *Coccospora aurantiaca* to be sclerotial in structure and suggests more suitable genera in which to distribute the later non-sclerotial species which were placed in the genus. The present study is not meant to be broad enough to indicate the specific position of the type species in the genus *Sclerotium*, although recommendations concerning the disposition of other species are made.

1. COCCOSPORA AURANTIACA Wallroth. 1833. Flora Crypt. Germ. 2: 176.
Sphaerosporium lignatile Schw. 1832. Trans. Am. Phil. Soc. n.s. 4: 303.
Myxosporium aurantiacum Rabh. 1844. Rabh. Krypt. Fl. I. Aufl. 1: 41.
Protomyces xylogenus Sacc. 1879. Michelia 1: 14.
Allescheriella uredinoides P. Henn. 1897. Hedwigia 36: 244.
Bactridiopsis ulei P. Henn. 1904. Hedwigia 43: 397.

Wallroth's original description of *Coccospora* noted large, translucent, globose spores in a distinct membrane, held together in loose, slimy, amorphous, golden masses easily dissolved in water. The type species, *C. aurantiaca* (the only species described at the time), was found on decaying wood in Thuringia.

In the present study, re-examination of the type specimen disclosed small fragments of sclerotial material, apricot color in mass, containing irregularly-shaped, thick-walled cells, brilliant golden-yellow in transmitted light, and measuring 21-33 μ in diameter (FIG. 1, A, B). Although identity is not implied, a comparison of this illustration with that of sclerotia of *Penicillium* (Raper and Thom, p. 53) shows a strong

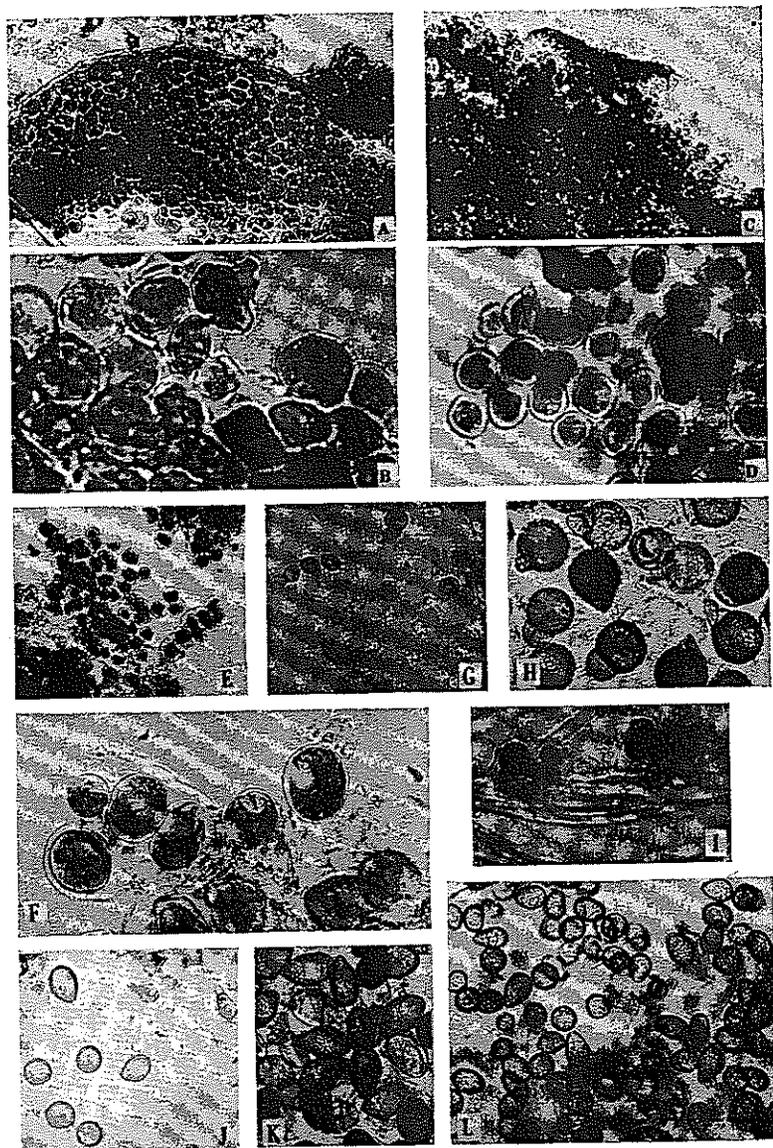


FIG. 1.

similarity of structural detail. Of specimens examined, this material most nearly resembles the type of *Sclerotium applanatum* Schw. (FIG. 1, C, D), which also has irregularly-shaped, more or less globose, rough, thick-walled cells, but which differs in having them arranged in a more nearly linear fashion. Although this evidence indicates that *C. aurantiaca* properly belongs in *Sclerotium*, no satisfactory relocation of the species can be made without a comprehensive study of the latter genus.

2. *COCCOSPORA MUSCORUM* Karst. 1884. *Hedwigia* 23: 88.

Protomyces muscorum Karst. 1884. *Hedwigia* 23: 40.

Described as forming round to variform, rust-colored acervuli which may become confluent, and are 0.5–1 mm broad; spores globose, 30–55 μ in diameter, golden-yellow, enveloped in slime, usually with many massed together.

Habitat: on moss (*Hypna*), Finland.

This organism was first described under the name *Protomyces muscorum* Karst., and it is listed as such by Saccardo (1888) in the *Sylloge Fungorum* 7: 321; and by Oudemans (1919) in *Enumeratio Systematica Fungorum* 1: 273. The latter treats *Coccomyces muscorum* Karst. as a synonym. The type specimen bears the label *Protomyces muscorum* Karst., but the *Protomyces* has been crossed out and the name *Coccospora* written over it in the same handwriting, presumably Karsten's. It contains a moss, one small section of which is covered with masses of brilliant yellow-orange, glistening, hyaline cells which, under low magnification, are similar to the spores of *Sphaerosporium lignatile* Schw. However, a mount shows masses of globose to sub-globose, hyaline to golden-brown, smooth-walled cells enclosed in a hyaline membrane. The cells (FIG. 1, E, F) measure 39.2–47.6 \times 38–44.8 μ , with a wall 1.4 μ thick, and contain a cytoplasm that stains deeply, showing filaments and some spindle-shaped bodies. A mucoid membrane, greatly varying in thickness (2.8–12.6 μ broad), surrounds each cell, either individually or in large masses. Occasionally a small amount of thin (1.4 μ thick) mycelium can be seen around the outside

FIG. 1. A, B. *Coccospora aurantiaca* Wallr. TYPE, A \times 130, B \times 560; C, D. *Sclerotium applanatum* Schw. TYPE, C \times 130, D \times 560; E, F. *C. muscorum* Karst. TYPE, E \times 58, F \times 250; G. *C. casei* Karst. TYPE, \times 250; H. *C. rosea* Karst. TYPE, \times 250; I. *C. rubiginosa* Speg. TYPE, \times 250; J, K. *C. sinensis* Teng: J, Bureau of Plant Industry collection, \times 250, K, Cornell University Herbarium collection swollen in 18% KOH and stained with phloxine, \times 250; L. *Allescheriella crocea* (Mont.) Hughes mounted in lacto-phenol and stained with cotton blue, \times 250. A–J mounted in Hoyer's solution and stained with acid fuchsin.

of the mucoid mass. The cells are first produced within the leaf of the moss and are finally erumpent.

After examining a slide of the material, Dr. George W. Fischer¹ suggests that this organism might possibly be a chytrid. Dr. John S. Karling concurs in this suggestion, stating¹ that it may be a species of *Synchytrium* or of *Physoderma* but that such a determination is difficult to ascertain from preserved material.

It is believed that this material is not hyphomycetous in nature and is definitely not related to the type of *Coccospora*.

3. COCCOSPORA CASEI Karst. 1890. Rev. Mycol. 12: 80.

The original article describes an orbicular, but not confluent, orange-red, loose turf; conidia globose, 9–12 μ in diameter, light golden-orange, with hyaline membrane; hyphae scarce, ramose, up to 70 μ long, 3 μ thick.

Originally found on cheese in Finland.

The present examination of Karsten's type specimen shows the surface of the cheese to be covered with globular, yellow-orange, glistening masses of spores which have taken up some of the oil of the cheese. Individual spores are not distinguishable under stereoptican microscopic power. Microscopic examination shows spores globose to subglobose, hyaline, thick-walled, definitely flattened at one end, borne in chains, and measuring 7.8–15.6 \times 7.8–14.3 μ , with walls 1.4–2.1 μ thick (FIG. 1, G). Except in spore size, this specimen appears to be more closely related to *Sphaerosporium lignatile* Schw. than to the type of the genus *Coccospora*.

4. COCCOSPORA PARASITICA Saccardo, Bommer & Rousseau. 1890. In Bommer & Rousseau, Bull. Soc. Roy. Bot. Belg. 29: 295.

The original macroscopic characters were listed as granular, waxy, transparent, white, becoming dull yellow, densely agglomerated. Conidia hyaline, globose, at first naked, then with very thick membrane, smooth, 15–21 μ .

On old stromata of *Pleomassaria siparia*, *Coryneum notarisianum*, *Eutypella stelulata*, etc., Belgium.

The type specimen has not been available for study, and no illustrations were given by Bommer and Rousseau.

5. COCCOSPORA ROSEA Karst. 1892. Hedwigia 31: 296.

Originally described as follows: Turf effuse, waxy, reddish; hyphae short, branching, jointed and knotty, hyaline, 6–10 μ thick, with a sub-

¹ Personal communication, 1952.

globose knotty surface, very extensive; conidia globose, thick-walled, hyaline to pale yellow, rather tough, 27–30 μ in diameter.

Habitat: on decaying *Tricholoma saponaceum* Fr. at Mustiala, Finland.

Examination of the type specimen reveals clusters of cinnamon-brown to reddish, glistening spores growing over most of the insect-ravaged agaric and spreading over the moss which is attached to the specimen. Mounts from these colonies show the typical, two-celled spores of *Mycogone rosea* Link, with the very rough terminal cell measuring 26–33.8 \times 26–28.6 μ and the lower somewhat smoother cell measuring 13–18.2 \times 10.4–13 μ (FIG. 1, H). This character must have been overlooked by Karsten. It is obvious that *Coccospora rosea* Karst. must be referred to the synonymy of *Mycogone rosea* Link.

6. COCCOSPORA RUBIGINOSA Speg. 1910. Anal. Mus. Nac. Buenos Aires. Series 3. 13: 413.

Described as having acervuli, at first hemispherical, 250–500 μ in diameter, commonly discrete, then confluent in subgelatinous honey-colored liquid; hyphae thin, hyaline, short and soon branching; conidia 20–30 μ in diameter, thickly gathered into a ball and deliquescing on connecting hyphae.

Habitat: on trunk of *Passiflora coerulea*, Tucuman, Argentina, 1905.

The type specimen has been badly damaged by insects, and Prof. Lindquist informs us that an examination made by Prof. Marchionatto revealed only a *Verticillium* on the material. We have seen this but have also noted a very occasional cluster of globose, reddish-brown spores, measuring 15.6–19.5 μ , with a wall 1.4 μ thick, and enveloped in a mucous membrane (FIG. 1, I), much in the manner of the spores in the type of *C. muscorum*. No indication of how the spores were borne could be found. No illustrations were given in the original diagnosis. It is difficult to suggest a disposition of this species on such limited material.

7. COCCOSPORA AGRICOLA Goddard. 1913. Bot. Gaz. 56: 265.

Recently reduced to synonymy under *Botryotrichum piluliferum* Sacc. and March. by Downing (1953) and previously given consideration by White and Downing (1951).

8. COCCOSPORA SINENSIS Teng. 1936. Sinensia 7: 782. ill.

The original description is as follows: Mycelium forming compact tufts 1–1.5 mm in diameter, burnt sienna, becoming confluent and ef-

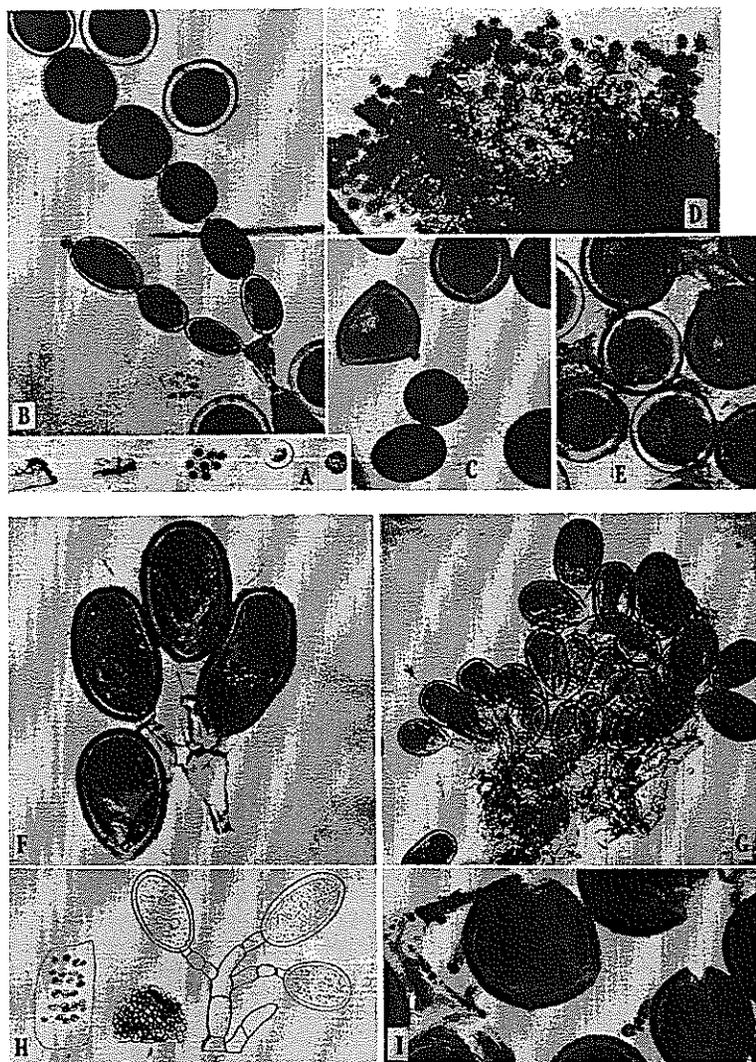


FIG. 2. A-D. *Sphaerosporium lignatile* Schw. A, original illustration reduced one-half from Trans. Am. Phil. Soc. 4: 303; B, C, $\times 250$, from collection of West and Murrill 1940, N. Y. Botanical Garden Herb., B mounted in 7% KOH and stained with phloxine, C mounted in lacto-phenol stained with cotton blue; D, $\times 58$, TYPE from Academy of Natural Sciences, Philadelphia; E, $\times 250$, *Oidium megalosporum* B. & C. AUTHENTIC, coll. Dr. Billings, ex Herb. Curtis; F, G, H,

fused; hyphae creeping, subhyaline to yellowish, short, septate, branched, densely intertwined, 5-7 μ thick; conidia subglobose to obovoid, smooth, thick walled (1.5-2 μ), orange, 14-30 \times 11-20 μ , with coarsely granular contents.

On wood and bark. China.

This organism must be placed in the synonymy of *Allescheriella crocea* (Mont.) Hughes (1951). Compared microscopically and macroscopically, two collections from Hughes, determined by him as *A. crocea*, IMI 38104(a) and IMI 38144 (FIG. 1, L), are similar to two collections from China, determined by Teng as *C. sinensis*, Teng, 2538 (FIG. 1, K) and Deng 5604 (FIG. 1, J). They all show glistening, orange-brown, thick-walled spores borne in clusters, in color in mass near "Mars Orange" or "Mahogany Red" (Ridgway). Spores of the *C. sinensis* collections measured 20.8-26 \times 15.6-20.8 μ , and 18.2-20.8 \times 11.7-15.6 μ ; those of *A. crocea* measured 16.9-23.4 \times 13 μ , and 15.6-23.4 \times 11.7-15.6 μ , with walls 1.4-2.1 μ thick.

Doubtful species:

PROTOMYCES (EXOMYCES) PITHYOPHILUS Karst. 1884. Hedwigia 23: 40.

Shortly after Karsten described this organism, and in the same volume (1884, p. 89), he stated that it might belong to the genus *Sphaerosporium* Schweinitz. Saccardo (1892, p. 512) suggested its disposition in *Coccospora* Wallroth. Actually no record appears of any new combinations ever having been made. Since the type of *Protomyces (Exomyces) pityophilus* is no longer available, it is impossible to properly dispose of this name.

CONSIDERATION OF THE SYNONYMY OF COCCOSPORA WALLR.

1. SPHAEROSPORIUM Schweinitz. 1832.

Saccardo (1886) noted the strong resemblance of *Sphaerosporium* to *Coccospora*, although he did not consider the two synonymous. Then von Höhnell (1911) reduced *Sphaerosporium* to the synonymy of *Cocco-*

Bactridiopsis ulei P. Henn.: F, $\times 250$, G, $\times 125$, TYPE, H, original illustration reduced one-half from Hedwigia 43: 397, showing habit sketch, sporodochium, and conidiophore; I, $\times 250$, *Coccospora ulei* (P. Henn.) v. Höhnell, I.M.I. 38172(b) collected by S. J. Hughes, mounted in lacto-phenol stained with cotton blue. D, E, F, and G mounted in Hoyer's solution and stained with acid fuchsin.

spora which he believed incorrectly to antedate it. This course was adopted by Clements and Shear (1931); but Shear (1939) pointed out the error and, believing *Coccospora* and *Sphaerosporium* to be distinct genera, re-established the genus of Schweinitz. Shear based his opinion on an examination of an isotype of *S. lignatile* Schw. and on his interpretation of Wallroth's description. Our re-examination of the type specimens (FIG. 2, D) confirms Shear's opinion.

Berkeley (1869) independently described *Oidium megalosporum* from a collection of an organism identical with *Sphaerosporium lignatile*. In so doing, this author noted the catenate character of the spores, which had been overlooked by Schweinitz. Linder (1942), after studying specimens of *O. megalosporum* from the Curtis collection, placed it in the synonymy of Schweinitz's earlier name. An examination of isotype (FIG. 2, E) and authentic material from the Curtis collection by the present authors confirms Linder's opinion.

Since *Sphaerosporium lignatile* has been the organism upon which the concept of *Coccospora aurantiaca* of many authors has been based, and because Schweinitz failed to recognize the catenate nature of the aleurio-spores, an emended description of *S. lignatile* is presented here.

SPHAEROSPORIUM LIGNATILE Schweinitz. 1832. Trans. Am. Phil. Soc. n.s. 4: 303. ill.

?*Myxosporium aurantiacum* Rabenhorst. 1844. Krypt. Fl. I. Aufl. 1: 41.

Oidium megalosporum Berkeley and Curtis. 1869. Jour. Linn. Soc. Lond. 10: 363.

Protomyces xylogenus Saccardo. 1877. Mich. 1: 14.

Sterile hyphae mostly within the substratum, external only as a basal cushion below the aleuriospores, hyaline, septate, branching, somewhat torulose in appearance; sporodochia or sporodochioid clumps 0.5–2 mm in diameter, hemispherical, usually separate, sometimes confluent, "Orange-Cinnamon" to "Ochraceous-Buff" in color (Ridgway); aleurio-spores formed by the maturation of torulose elements of the fertile hyphae, catenate, older spores globose (36–50 μ in diam.), younger spores often ovate-truncate (38–66 \times 33–45 μ), all spores having small flattened scars indicating points of attachment to other spores; spores smooth, thick-walled, wall strongly refractile in microscope preparations, central protoplasm faintly or distinctly granular; spores distinctly pale golden-yellow by transmitted light, easily broken by pressure upon coverglass.

Collections of this fungus made by the senior author and by Dr. G. W. Martin of Iowa differ from those of Schweinitz only in that fresh speci-

mens have sporodochia which are yellowish in appearance rather than cinnamon-ochraceous as in the type, and are somewhat gelatinous when fresh. However, this lighter "Ochraceous-Buff" color is not confined to fresh collections. It is found in six specimens in the Herbarium of the New York Botanical Garden, dating from 1889, 1891, 1893, 1932, and 1940. We do not regard this as a difference worthy of specific recognition since the spores of the type and of recent collections are microscopically identical in size, color, and morphology.

The important feature of the present emendation is a recognition of the catenate character of the spores. All spores have one, two, or three small, flattened, faintly protruding scars indicating their points of attachment to other spores. This is seen both in the type and in recent specimens (FIG. 2, C). In one of the specimens (N.Y.B.G. coll. West and Murrill, 1940) the manner of spore formation was observed (FIG. 2, B). It appears to be as described above. Repeated attempts to culture this fungus in order to observe this point more thoroughly have been unsuccessful.

2. *PROTOMYCES* Unger. 1833. Exanth. Pfl. p. 341.

Protomyces xylogenus. Sacc. 1877. Mich. 1: 14.

Protomyces is a genus of parasitic fungi (Taphrinales) forming large, thick-walled, overwintering chlamydo-spores in the tissues of the host (Mix, 1949). As such, there is no room for organisms whose habitat is rotting wood.

P. xylogenus had been placed in the synonymy of *Coccospora aurantiaca* Wallr. by Saccardo (1886), and this arrangement was followed by Lindau (1907). However, Shear (1939) thought it to be *Sphaerosporium lignatile* Schw. It is now referred to this synonymy, since Saccardo's description and illustration clearly indicate a fungus like the one described by Schweinitz.

3. *ALLESCHERIELLA* Hennings. 1897. Hedwigia 36: 244.

A. crocea (Mont.) Hughes. 1951. Mycol. Pap. No. 41, CMI, 17 pp.

Allescheriella has been re-established in a recent discussion by Hughes (1951), and has been shown to bear no resemblance whatsoever to *Coccospora aurantiaca* Wallr. *A. crocea* (Mont.) Hughes had previously been discussed under the name *Oidium simile* Berk. by Linder (1942). Hughes presented evidence that Linder had wrongly based his concept of *O. simile*, and concluded that the species should be removed

from *Oidium*. In any event, *Allescheriella* can no longer be considered for organisms in the *Coccospora* group.

Hughes described *A. crocea* as having conidia globose, subglobose, obovoid, or flask-shaped with markedly truncate base, $14-27 \times 11-19 \mu$, having thick brownish walls when mature; spores borne at the tip of the conidiophore or its lateral branches as "blown-out ends"; conidiophores hyaline, simple or branched, at first yellow, the young pustules finally rust-colored. There is no indication that the conidia are borne in chains.

4. BACTRIDIOPSIS Hennings. 1904. Hedwigia 43: 397.
B. ulei Henn. 1904. Hedwigia 43: 397.

As Shear (1939) has pointed out, von Höhnel (1911), by a comparison of descriptions and illustrations, concluded that *B. ulei* Henn. should be placed under the synonymy of *Coccospora ulei* (P. Hennings) v. Höhnel, and was possibly identical with *Sphaerosporium lignatile* Schw. However, no evaluation of authentic material had been made. There is some similarity in the thick-walled spores of *S. lignatile* and *B. ulei* but they cannot be considered identical here. In the present study, the type specimen of *B. ulei* Henn., collected by Ernest Ule on rotten wood in Brazil in November 1900, has been examined. The spores are large, single-celled, ovate to ellipsoid, truncate at the base, hyaline, containing a granular cytoplasm, measuring $57-128 \times 40-80 \mu$; spore walls smooth, $3.9-6.5 \mu$ thick; spores borne singly at the tips of short, simple or slightly branched, hyaline, thin-walled conidiophores which arise as a sporodochium. Conidiophores usually show two septations just below the base of the spores, one at the point of abstriction of the spore and the other approximately $5-9 \mu$ below, with this septate section often remaining attached to the spore when it becomes separated from the conidiophore. The growth markedly resembles that of *Sphaerosporium lignatile* Schw., except that the spores are larger, definitely elliptic and are not produced in chains (FIG. 2, F, G, H, I). In his original description Hennings pointed to the similarity between this species and *Bactridium flavum* Kunze but keyed them separately because of the larger non-septate spores of *Bactridiopsis ulei*. This fungus resembles species of *Bactridium* except that it lacks cross walls.

MATERIAL EXAMINED

Allescheriella crocea (Mont.) Hughes

1. On *Hevea brasiliensis* (Euphorbiaceae), Tarkwa, Gold Coast Colony, 12 May 1949, coll. and det. S. J. Hughes (558), Herb. I.M.I. 38104(a); through the

courtesy of Mr. E. W. Mason, Commonwealth Mycological Institute, Kew, England.

2. On rotten wood, Tafo, Gold Coast Colony, 14 June 1949, coll. and det. S. J. Hughes (1242), Herb. I.M.I. 38144; through the courtesy of Mr. E. W. Mason, Commonwealth Mycological Institute, Kew, England.
- Bactridiopsis ulei* Henn., on rotten wood, Brazil, 1900. TYPE. E. Ule 2838, Herbarium Brasiliense (Staatsinstitut für Allgemeine Botanik, Hamburg, Germany); through the courtesy of Prof. Dr. Walter Mevius.
- Coccospora aurantiaca* Wallr., on rotten wood, ?Germany, ?1833. TYPE. The Botanical Institute of Strasbourg; through the courtesy of Dr. R. E. Maresquelle.
- C. casei* Karst., on cheese, Finland. TYPE.
- C. muscorum* Karst., on moss, Finland, 1869. TYPE.
- C. rosea* Karst., on *Tricholoma saponaceum*, Finland, 1892. TYPE. The Botanical Museum of the University of Helsingfors; through the courtesy of Prof. Hans Buch.
- C. rubiginosa* Speg., on fallen trunk of *Passiflora coerulea*, Argentina, 1905. TYPE, 9210, Universidad Nacional de La Plata Museo-Instituto Spegazzini, Colecciones Micologicas; through the courtesy of Prof. Lindquist.
- C. sinensis* Teng
1. On a stump, Ling-ku-sze Woods, Nanking, 28 July 1931, coll. and det. S. C. Teng 2538. Reliquiae Herbarii Fungorum Sinensis 6091. Undestroyed portion of the Chinese National Fungus Herbarium given to the Bureau of Plant Industry and Cornell University, 1939-40; through the courtesy of Dr. Richard P. Korf, Curator of the Herbarium, Cornell University.
 2. On rotten wood, Tan-hsien, Hainan, 24 Oct. 1934, coll. S. Q. Deng 5604, det. S. C. Teng, U.S.D.A. Bureau of Plant Industry, Pathological and Mycological Collections; through the courtesy of Mr. John A. Stevenson.
- Oidium megalosporum* B. & C.
1. On rotten polypore, Alabama, Peters (1022), 1856. ISOTYPE, ex Herb. Curtis (B. & C. packet 6094), Farlow Herbarium, Harvard University; through the courtesy of the late Dr. W. L. White.
 2. On rotten logs, Cuba, 1857. Coll. Wright, ex Herb. Curtis, Farlow Herbarium, Harvard University, AUTHENTIC; through the courtesy of the late Dr. W. L. White.
 3. On rotten wood, Washington, D. C., Dr. Billings, ex Herb. Curtis, Brown University, AUTHENTIC; through the courtesy of Dr. Walter B. Snell.
- Sclerotium applanatum* Schw., on oak leaf, TYPE. The Academy of Natural Sciences of Philadelphia; through the courtesy of the late Dr. F. W. Pennell.
- Sphaerosporium lignatile* Schw.; on rotten wood, Bethlehem, Pa., TYPE. The Academy of Natural Sciences of Philadelphia; through the courtesy of the late Dr. F. W. Pennell.
- Six collections on dead wood, New York Botanical Garden; through the courtesy of Dr. D. P. Rogers, as follows:
1. West Haven, Conn., Oct. 1889, coll. and det. R. Thaxter.
 2. West Haven, Conn., 24 Sept. 1891.
 3. Grasmere, Fla., Mar. 1893.
 4. Roaring Brook, Conn., 28 July 1893.

5. Highland Co., Ohio, 31 July 1932, W. B. Cooke coll. 882, det. D. H. Linder (as *Coccospora aurantiaca* Wallr.).
6. Gainesville, Fla., 22 Jan. 1940, coll. West and Murrill, det. W. W. Diehl (as *Coccospora aurantiaca* Wallr.).

The authors are indebted to the individuals noted above, whose courtesy made it possible to study these valuable specimens.

The junior author is deeply grateful to Dr. Donald P. Rogers and to Dr. Emory G. Simmons for their consideration of this manuscript and for their very kind suggestions for its improvement.

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