Reprinted from MYCOLOGIA, Vol. LXXII, No. 6, pp. Nov.–Dec. 1981
Printed in U. S. A.

SYZYGOSPORA ALBA, A MYCOPARASITIC HETEROBASIDIOMYCETE[1]

F. OBERWINKLER

Lehrstuhl Spezielle Botanik und Botanischer Garten der Universität Tübingen, Auf der Morgenstelle 1, D 7400 Tübingen 1, West Germany

AND

B. LOWY

Department of Botany, Louisiana State University, Baton Rouge, Louisiana 70803

SUMMARY

Syzygospora alba is recognized as a mycoparasite and its anamorphs and teleomorphs are illustrated and redescribed from a recent collection from Mexico. The basidiocarps are similar to those of some species of the genus *Tremella*. Haustoria of the *Tremella* type attach to and penetrate into the basidiomycetous host cells. Holobasidia produce basidiospores capable of yeast-like budding. The dolipore septa appear to be similar to those in species of the genera *Filobasidium* and *Filobasidiella*. On the basis of these characters a heterobasidiomycetous affinity is proposed. The name *Syzygospora alba* is accepted for the holomorph of the species. It appears that this taxon is generically different from *Christiansenia pallida*.

Mycoparasitism is widespread among different species of Basidiomycetes, especially of Heterobasidiomycetes. Many species of *Tremella* are parasitic on other fungi. The parasitic behavior is often clearly indicated by the presence of haustorial hyphae which penetrate into the host cells. In addition, the host-parasite interaction sometimes can be observed in the changed morphology of the host, as in *Tremella encephala* Pers. ex Pers. on *Stereum sanguinolentum* (A. & S. ex Fr.) Fr. (Bandoni, **1961**) or *Tremella aurantia* Schw. on *Stereum hirsutum* (Willd. ex Fr.) S. F. Gray. Several of these *Tremella* species share a common fruiting body structure by which they can be recognized in the field.

A fungus collected by G. Guzmán in Mexico, and with the external appearance of a *Tremella*, was sent to us for identification. The

[1] Part 10 in a series "Studies in Heterobasidiomycetes" of the Institut für Biologie I, University of Tübingen.

species lacked the leading character of the Tremellaceae, *viz.*, the cruciate-septate basidium. Therefore a more detailed study was carried out to determine the appropriate taxonomic position of the fungus.

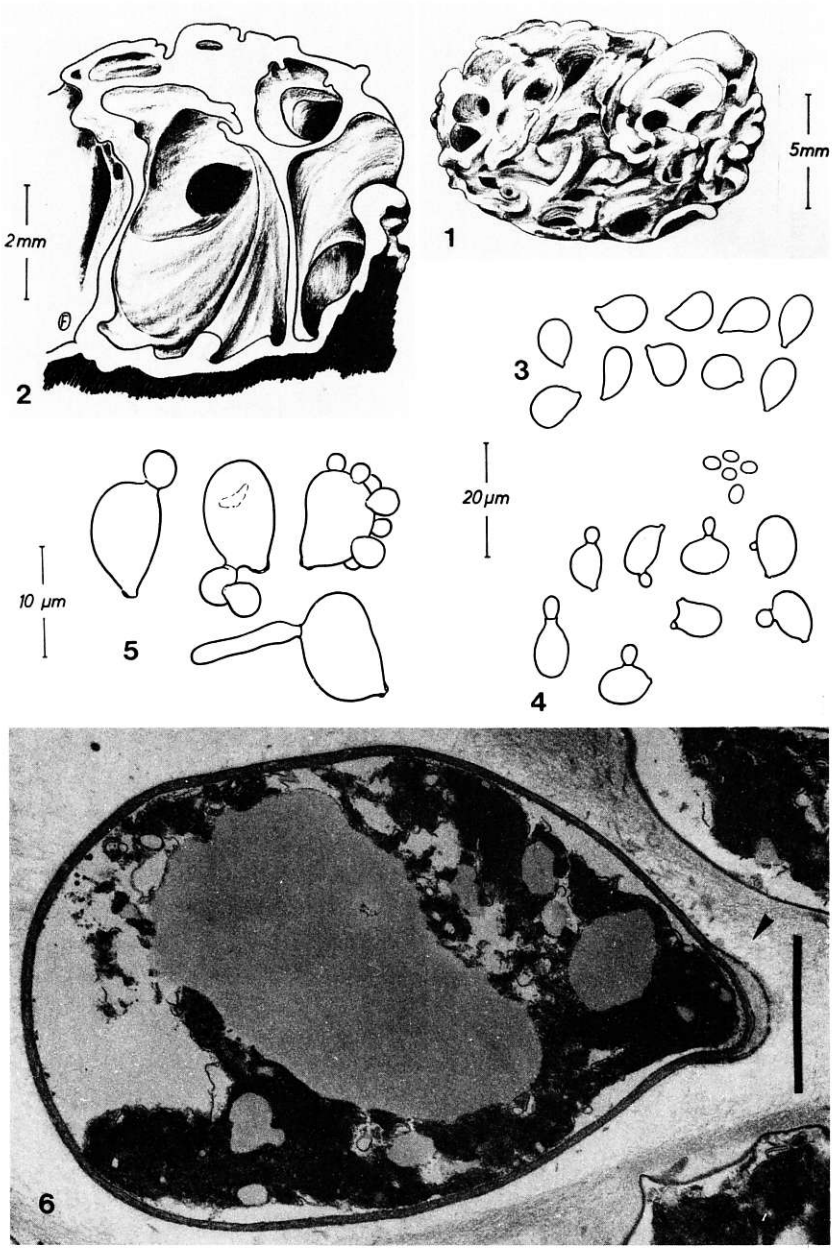
MATERIALS AND METHODS

The following specimens are described and illustrated in the present contribution. *Syzygospora alba* Martin, Fungi of Panama, Prov. Chiriquí: Valley of the upper Río Chiriquí Viejo, alt. 1600–1800 m, July 1, 1935; G. W. Martin No. 2167, holotype (Herb. State Univ. Iowa, now BPI). *Syzygospora alba,* Mexico: Entre Los Guayabos y Las Cabanãs, 15 km al SW de Mazamitla, Carretera a Tamazula, Jalisco; bosque de *Pinus-Quercus,* muy perturbado, en transacción con vegetación subtropical; alt. 1700–1800 m, Agosto 24, 1974; Col. G. Guzmán, No. 11843 (Herbario de la Escuela Nacional de Ciencias Biólogicas, Instituto Politécnico Nacional, México, D. F.).

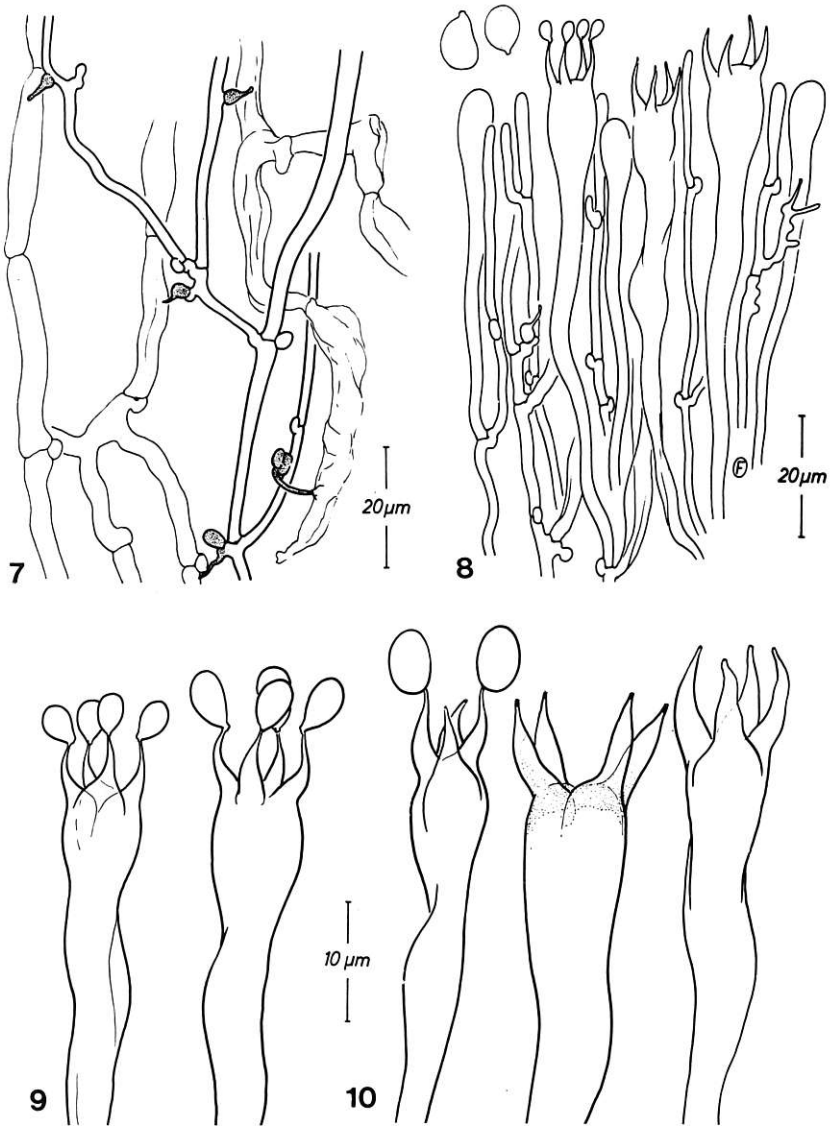
For transmission electron microscopy material was soaked in water, then fixed with glutaraldehyde and osmium tetroxide, washed with distilled water, dehydrated in an alcohol series, and embedded in ERL according to Spurr (**1969**). Ultrathin sections were mounted on unsupported mesh copper grids, poststained in uranyl acetate and lead citrate solutions, and examined in a Zeiss EM 9 S-2 transmission electron microscope.

RESULTS

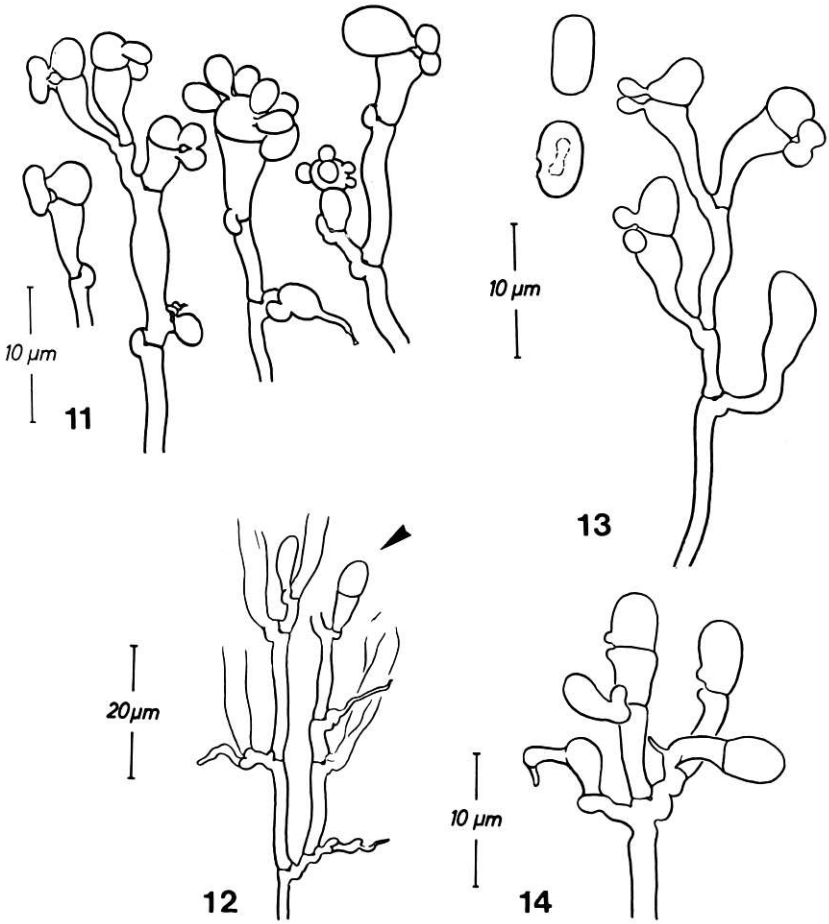
The basidiocarps of *Syzygospora alba* are tremelloid and gyrose (FIGS. 1, 2). This structure is apparently not or not essentially produced by gall-like, hypertrophic growth of the host. In dried specimens the fruiting bodies are brownish and have a very tough to hardhorny consistency, but may be soft-gelatinous when they are fresh. The trama consists of a layer of hyphae 2–4 μm in diam, hyaline, thin-walled, loosely branched, the branches commonly originating from clamps (FIGS. 7, 8). Short, very narrow hyphal outgrowths capable of functioning as haustoria (FIGS. 7, 8, 12) are formed mainly from clamp swellings. The hymenium (FIG. 8) is composed of long, apically swollen basidia (50–100 $\times$ 6–8 μm) with four curved, stout sterigmata (FIGS. 9, 10), which bear asymmetrically formed basidiospores. Sometimes partly cruciate-septate basidial apices can be found (FIGS. 9, 10), which appear *Metabourdotia*-like as described by Olive (**1957**), and by Lowy (**1964**) for *Pseudotulasnella.* The basidia are in-



FIGS. 1–6. *Syzygospora alba.* 1. Habit sketch of dried herbarium specimen. 2. Section through a dry basidiocarp showing the gyrose morphology. 3. Mature basidiospores. 4. Budding basidiospores and yeast cells. 5. Basidiospores showing yeast-like budding (above) and germination by hypha (below). 6. TEM micrograph of a median section of a basidiospore. Note the splitting of the cell wall of one side of the apiculus (arrow). Bar equals 2 μm.



FIGS. 7–10. *Syzygospora alba*. 7. Hyphal context of the inner part of the basidiocarp; hyphae of the parasite connected to the host cells with tremelloid haustoria. 8. Part of the hymenium with different stages of basidial development, and basidiospores. 9. Apical parts of basidia with young basidiospores. 10. Apical details of mature basidia with central figure showing a partial septum.



FIGS. 11–14. *Syzygospora alba.* 11. Conidiophores with different stages of zygoconidium formation. 12. Conidiophore (arrow) showing connection with haustoria and collapsed basidia (from holotype of *Syzygospora alba,* Martin 2167). 13. Conidiophores and conidia (Martin 2167). 14. Young conidiophores with haustoria (Martin 2167).

termixed with small, thin-walled hyphae which obviously represent young developmental stages. These hyphae sometimes branch to form lateral haustoria. It appears that the hymenium is thickened by hyphal proliferation below the basidia. All hyphae in the hymenium and at the bases of the basidia are septate at the locus of clamp connections. The basidiospores are hyaline, depressed and drop-like (FIG. 3), 9–11 × 6–8 µm, asymmetrically apiculate (FIG. 6), the walls thin, smooth, and non-amyloid.

Germinating basidiospores showed predominantly a yeast-like

budding of the *Tremella* type (FIGS. 4, 5). Rarely, germination by hyphal formation could also be observed (FIG. 5). We do not know whether or not secondary spores are produced. In all known collections, conidial formation is very striking and is apparently the only propagative state in special developmental stages of the fruiting bodies. Short-celled conidiophores produce two terminal cells that simultaneously begin to form opposed beak-like outgrowths (FIGS. 11, 13, 14). The outgrowths extend to globose bodies that fuse to form a one-celled conidium that finally becomes detached. The conidiogenous cells are capable of repeated conidium formation around the circumference of the transverse septum separating the cells. The conidiophore-bearing hyphae proliferate strongly to form successive conidiophores. An immense quantity of conidia is produced, and these are distributed over the outer and inner surfaces of the fruiting body.

In addition to examination with the light microscope, we also studied the fungus with the transmission electron microscope. Surprisingly, the herbarium material, though several years old, yielded successful results when prepared for ultrastructural study. Two septal pore types are present, both with dolipore structures. Many dolipores, however, seem to be without parenthesomes, as in the septal pores of *Filobasidium floriforme* L. Olive (Moore and Kreger van Rij, **1972**) and *Filobasidiella neoformans* Kwon-Chung (Kwon-Chung and Popkins, **1976**). Because they are present in the hymenial region, we are convinced that these dolipores belong to the hyphae of *Syzygospora alba*. In basal portions of the basidiocarp, on the other hand, the second dolipore type with perforated parenthesomes can also be found. We are fully aware of the difficulties of studying ultrastructural details in old herbarium material. However, some of the structures revealed are quite significant and useful in understanding the taxonomic relationships of this fungus.

The parasite produces hyphae that are thin-walled and clamped (FIG. 7), therefore the host must be a basidiomycete, but because of the paucity of additional characteristics a more detailed interpretation of the host cannot now be given. To our knowledge, *Syzygospora alba* is presently known only from six collections from Panama and one collection from Mexico.

DISCUSSION

The genus *Syzygospora* was erected by Martin in 1937 to describe the species *Syzygospora alba*. This fungus is characterized by the formation of paired blastogenous cells that fuse and are released from the supporting hyphae (FIGS. 11, 12). Martin (**1937**) interpreted this struc-

ture as a special type of auriculariaceous basidium. However, in a restudy of the species by Kao (**1956**), it was shown that the unusual structures were conidia and that the conidiophores were connected with generative hyphae that produce holobasidia. This can now be confirmed by our investigations. Furthermore, Kao elucidated nuclear behavior during conidium formation. She indicated that the primary outgrowths of the conidiogenous cells are uninucleate, and after fusion, a dikaryotic conidium is formed. In a study of *Christiansenia pallida* Hauerslev, Boidin (**1970**) demonstrated that conidium formation in this species is essentially similar to that found in the fungus under consideration. Because of the unique development, he proposed the term "zygoconidium" for the propagule.

After a detailed discussion, Boidin (**1970**) accepted the interpretation of Donk (**1962**) to consider the name *Syzygospora* as a "nomen anamorphosis." It seems obvious that Martin (**1937**) assigned the basidial stage to the anamorph in his description. However, in the type material the true teleomorph is also present. Figure 1a of Martin's (**1937**) illustration shows a young basidium and not a cystidium, as Boidin (**1970**) already correctly reinterpreted this figure. Our study of a holotype specimen (Martin 2167) confirms that collapsed basidia are connected with the conidiophore-bearing hyphae (FIG. 12). In another holotype (Martin 2517) Boidin (**1970**) found several basidiospores intermixed with innumerable conidia. Our study shows that anamorphs and teleomorphs can be present in the same fruiting body. Because the same condition is found in the type material, we are inclined to accept the interpretation of Art. 59 of the Nomenclatural Code in the sense of Weresub et al. (**1974**), ". . . that the application of a name is determined by its type material." We consequently propose to use the name *Syzygospora alba* Martin for the teleomorph and the holomorph of this fungus. Therefore, we cannot accept the nomenclatorial transfer of the species to "*Christiansenia alba* Boidin ex Martin" (Boidin, **1970**). On the other hand, it seems justified to accept *Christiansenia* (Hauerslev, **1969**) as a separate genus mainly because of the very different fruiting body morphology. We are unable at present to assess the generic value of the different characteristics of the basidia and of basidiospore germination types.

ACKNOWLEDGMENTS

The late Dr. G. W. Martin provided the holotype material used in this study. We are grateful to Dr. G. Guzmán for sending the specimen of *Syzygospora alba* from Mexico.

LITERATURE CITED

Bandoni, R. J. 1961. The genus *Naematelia*. *Amer. Midl. Naturalist* **66**: 319–328.

Boidin, J. 1970. Homobasidiomycètes resupinés et Hétérobasidiomycètes saprophytes: XII. Le genre *Christiansenia* Hauerslev 1969. *Bull. Mens. Soc. Linn. Lyon* **39**: 132–137.

Donk, M. A. 1962. The generic names proposed for Hymenomycetes. XII. Deuteromycetes. *Taxon* **13**: 75–104.

Hauerslev, K. 1969. *Christiansenia pallida* gen. nov. A new parasitic Homobasidiomycete from Denmark. *Friesia* **9**: 43–45.

Kao, C. J. 1956. The cytology of *Syzygospora alba*. *Mycologia* **48**: 677–684.

Kwon-Chung, K. J., and T. J. Popkin. 1976. Ultrastructure of septal complex in *Filobasidiella neoformans (Cryptococcus neoformans)*. *J. Bacteriol.* **126**: 524–528.

Lowy, B. 1964. A new genus of the Tulasnellaceae. *Mycologia* **56**: 696–700.

Martin, G. W. 1937. A new type of heterobasidiomycete. *J. Wash. Acad. Sci.* **27**: 112–114.

Moore, R. T., and N. J. W. Kreger-van Rij. 1972. Ultrastructure of *Filobasidium* Olive. *Canad. J. Microbiol.* **18**: 1949–1951.

Olive, L. S. 1957. Two new genera of the Ceratobasidiaceae and their phylogenetic significance. *Amer. J. Bot.* **44**: 429–435.

Spurr, A. R. 1969. A low-viscosity epoxid embedding medium for electron microscopy. *J. Ultrastruct. Res.* **26**: 31–43.

Weresub, L. K., D. Malloch, and K. A. Pirozynski. 1974. Response to Hawksworth & Sutton's proposals for Art. 59. *Taxon* **23**: 569–578.

Accepted for publication June 22, 1981