Confistulina, the anamorph of Fistulina hepatica

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The anamorph of Fistulina hepatica is described in detail and a new genus, Confistulina, is proposed to accommodate it. A relationship to Ellula is suggested, followed by a more general discussion on anamorph–teleomorph homologies.


L’anamorphe de Fistulina hepatica est décrit en détail et un nouveau genre, Confistulina, est proposé pour cet anamorphe. Les données suggèrent qu’il existe une affinité entre ce genre et Ellula. Les auteurs présentent une discussion générale sur les homologies entre anamorphes et téléomorphes.

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Introduction

In the course of a revision of the species described in Psychogaster Corda and Ceriomyces Corda, Ceriomyces hepaticus Sacc. was studied. This is the anamorph of Fistulina hepatica (Schaeff.) Sibth., a species widespread in the temperate regions of both the northern and the southern hemispheres. It occurs as a wound parasite or saprophytic on wood of angiosperms (one of the examined cultures is reported from Pinus in the U.S.A.), mainly on Quercus and Castanea, but also for example on Fagus, Platanus, Prunus, and Tilia. The early stage of the infection is known as “brown oak,” the wood being stained reddish brown by fungal products. The stained wood is highly esteemed in the furniture trade since the quality hardly decreases (Cartwright and Findley 1936; Cartwright 1938).

Cultural characters of F. hepatica have been described by various authors (Rothenberg 1937; Davidson et al. 1942; Stalpers 1978). A good description of the anamorph is that of de Seynes (1874), based on an in vivo study of conidia in the basidiocarp. The process of conidiogenesis, which has, however, remained unclear, is dealt with in the present paper.

Methods

Isolates were grown in plastic Petri dishes on neutralized 2% malt extract agar (MEA) and cherry decoction agar (CHA) at room temperature (18–20°C) in diffuse daylight. Drop tests on laccase and tyrosinase were performed as described by Käärik (1965) and Stalpers (1978). Preparations for scanning electron microscopy were made according to Samson et al. (1979). Capitalized colour names refer to Ridgway (1912), colour codes to Kornerup and Wanscher (1978).

Descriptions

Confistulina Stalpers anamorph gen. nov.


HOLOMORPHIS: Fistulina (Basidiomycetes).

SPECIES TYPICA: Ceriomyces hepaticus Sacc.


HOLOMORPH: Fistulina.

TYPE SPECIES: Ceriomyces hepaticus Sacc.

Confistulina hepatica (Sacc.) Stalpers comb. nov.

Figs. 1–19

Growth on MEA slow, radius 1–20 mm in 14 days; on CHA 10–25 mm in 14 days. Odour insignificant. Advancing zone raised or appressed in the outermost 2 mm, even in outline, hyphae dense to rather distant. Mycelial mat at first cottony, white, soon with, at least locally, pale buff tinges (Pinkish Buff, Light Buff, 5A4, 4A3), later becoming denser cottony to cottony woolly or locally farinaceous, Ochraceous Buff to Yellow Ocher, Ochraceous Tawny or Tawny (4B8, 5B6, 5C6-8, 5D8, 6D8). In some strains the mycelium behind the first cottony zone collapses and a velutinatus mat develops, which is even or forms distinct warts, at first warm buff to Light Ochraceous Buff, becoming Apricot Yellow and finally Tawny (4A4-7, 6D8). The cottony woolly mycelium often produces reddish drops of exudate (near Brazil Red, 7C8, 8C8). Reverse may become darker. Reaction with α-naphthol negative
(somewhat ochraceous); reaction with p-cresol positive. Cardinal temperatures: minimum 6°C, optimum 24–26°C, maximum 33°C.

Marginal hyphae hyaline, thin walled, 1.5–4.7(–7) μm wide, with few septa, some of which have clamps with a diameter equal to or narrower than that of the supporting hyphae. Clamps may grow out to form a hypha. Branching typically at acute angles; wide hyphae often bearing much narrower hyphae, normally at right angles. Hyphae occasionally with numerous parallel branches which may develop into hyphal knots (Fig. 1). Crystals may be present.

Aerial hyphae hyaline, thin walled, 2.5–4.5 μm wide. Clamps present at most septa, but sometimes lacking, particularly on specialized hyphae. Hyphae sometimes with brownish oily contents, especially in older mycelium, where many hyphae are also covered with small or big exudate drops (Figs. 18, 19), often concentrated at hyphal tips or septa. The mycelium also contains narrow (1.8–2.5 μm) dendrohyphidium-like hyphae with repeated dichotomous branching at the apex (Fig. 2); the apices are covered with small (sub)hyaline granules. Sometimes single short side branches show a similar encrustation. The velutinous parts are composed of a pallisade of 5 to 8 μm wide hyphae, of which especially the apical cell is often covered with exudate drops (Fig. 3). The contents of these hyphae are hyaline. The central hyphae of the warts are hyaline, somewhat irregular in outline, up to 8 μm wide.

Blastic conidia are formed at random or in seemingly retrogressive sequence from a determinate conidiogenous cell apex (Figs. 12–14) or they form dense clusters (Figs. 6, 16, 17). In this last type the second conidium is formed below the first one, but the third and fourth conidia are formed more or less simultaneously below conidium one and two. This results in a dense cluster of up to 8(–10) conidia. One of these conidia, normally the lowest, may in an early state of differentiation grow out into a hypha on which one or more further conidial clusters may be formed (Fig. 10). Secondary clusters generally comprise fewer conidia; maturation may
cease. The fertile hyphae finally become septate in retrogressive order; the separate cells inflate slightly and may secede as arthroconidia. The walls of both blastoconidia and arthroconidia may become thickened, generally before secession, but the process may continue afterwards. Mature blastoconidia (Figs. 7–8) pale yellowish, ellipsoid to ovoid, (4.5–)5.5–9.5 × (3–)4–5 μm; arthroconidia (Fig. 9) ellipsoid to subcylindrical, (3–)5–10(–22) × 3–4 μm, or knee shaped. Chlamydospores, when present, terminal (Fig. 4), intercalary, or (in CBS 510.80) developing from an inflation of the basal part of a terminal, up to 50 μm long, hyphal cell (Fig. 15); the 4 to 18 μm long apical appendage then disintegrating after delimitation. Chlamydospores hyaline, ellipsoid, 11–15 × 5–7 μm, with walls 0.6–1.5 μm thick. Clamps are absent from septa between conidiogenous loci but may be present immediately below the lowest locus.

Submerged hyphae hyaline, thin walled, 2.5–7(–8) μm wide, sometimes with swellings. Chlamydo-

spores (Fig. 5) intercalary, ellipsoid to broadly ellipsoid, 9–15(–25) × 5–8(–10) μm.

**SPECIES CODE (STALPERS 1978):** 2, (9), (10), 11, (12), (13), (14), 18, 21, (22), (26), 30, 31, 34, 35, (38), (39), (40), 42, (44), (45), 50, 52, 53, 54, (55), (57), 58, 60, 61, (65), (80), (82), 83, 84, 85, 86, 87, 89.

**SPECIES CODE (NOBLES 1965):** 1, 5, 21, (26), 33, 34, 35, 37, (38), (39), 46–47, 54.

Figs. 10–14. Conidiogenous structures. Figs. 10, 12. CBS 339.69. Figs. 11, 14. CBS 316.75. Fig. 13. CBS 305.80. Bar represents 5 μm.
Conidiogenesis in these genera is similar. The conidia arise by conversion of preexisting elements and can be considered as solitary and terminal chlamydospores (Kendrick and Watling 1979). They are formed in cupulate to tubular conidiomata, while those of *Fistulina* are only found in the mycelium. Nevertheless, there are similarities. In a young stage basidioecarp of *Fistulina* are entirely covered with cupulate structures. The downwards-oriented cupulae are converted into fertile tubes, while those at the upper surface disintegrate. This last type of cyphellaceous structure is very close to that of the conidiomata of *Ellula guaducae* (Viégas) Nag Raj. The cupulae are initially closed or have a narrow pore, which opens like a sea anemone, the wide occluding hyphae bending outward (Fig. 20). These hyphae form the sterile part of the then cupulate to tubular body. The bottom of the cupulae generally remains sterile, but sometimes a hymenial layer is formed, of which only few basidia mature before the whole structure withers away. Up to the formation of the basidioles each single cupula or tube is comparable with a conidioma of *Ellula*. In *Ellula*, however, basidiole-like structures develop into chlamydospores, while in *Fistulina* they either remain undifferentiated or become basidia. In conclusion, although cypheloid conidiomata have not (yet?) been found in *Fistulina*, there appears to be a taxonomic relationship with *Ellula*.

*Michenera* differs in several respects from both *Ellula* and *Fistulina*: it has strongly branched, thick-walled "binding hyphae," it lacks clamps, the conidioma is cup shaped rather than tubular, and the chlamydospores are coloured.

**Anamorph–teleomorph homologies**

In the above discussion arguments are given for the hypothesis that the thalic chlamydospores of *Ellula* and *Michenera* are homologous with basidioles casu quo basidia. However, there are also two types of blastic conidiogenesis in basidiomycteous anamorphs which are comparable with teleomorphic structures. (1) Blastocladia which are simultaneously formed on denticles at the apical part of a conidiogenous cell are homologous with basidiospores. This is supported by the following arguments. (i) The shape of the conidia and the basidiospores is nearly identical (examples: *Bondarzewia berkeleyi* (Fr.) Bond. & Sing., *Heterobasidion annosum* (Fr.) Bref., *Hyphoderma mutatum* (Peck) Donk, all species of *Dichostereum* Pilat). (ii) The ornamentation of the conidia is comparable with that of the basidiospores, though less pronounced. The basidiospores of *Bondarzewia berkeleyi* have distinct ridges, while the conidia are warted or have very low ridges; the basidiospores of *Laurilia sulcata* are echinulate, the conidia minutely warted to roughened; the basidiospores of *Heterobasidion annosum* are
Figs. 16–17. CBS 316.75, conidiogenous structures. Figs. 18–19. CBS 161.30, hyphae with exudate drops. Fig. 20. Young basidiome. Bar represents 5 μm in Figs. 16–19, 50 μm in Fig. 20.
minutely warted, the conidia seem to be smooth, even when examined with the SEM. Ultrathin sections, however, revealed some local wall thickening (Hanlin 1982). (iii) The reaction of the basidiospores with Melzer’s reagent is comparable with that of the conidia, but stronger. The intensity of the amyloid reaction seems to be correlated with the degree of ornamentation. The wall layer responsible for the ornamentation is the perisporium, which is very thin in smooth spores or conidia (Capellano and Keller 1978). The basidiospores of Bondarzewia berkeleyi and Laurilia sulcata are strongly amyloid, as are the conidia of B. berkeleyi, but the conidia of L. sulcata are weakly amyloid. The basidiospores of Heterobasidion annosum are weakly amyloid, the conidia are not. (iv) The ultrastructural development of the conidial denticles and the stigmata is identical. Hanlin (1982) described the development of conidial denticles in Spinaer meineckelli (A. J. Olson) Stalpers, the anamorph of Heterobasidion annosum. They are formed by an extension of the two innermost wall layers, which break through the two outer layers. Tu et al. (1977) demonstrated the same phenomenon for the stigmata of Thanatephorus cucumeris (Frank) Donk. Examples of anamorphic basidiomycetous genera belonging to this group are Deschordia J. J. Taylor and Spinaer meineckelli. (2) Blastosconidia which are broadly attached and are formed in more or less sympodial order seem to be homologous with basidioles cas qua basidia. The following facts support this hypothesis. (i) The shape of the conidia and immature basidia is similar. The conidia of Allescherella crocea (Mont.) Hughes and the young basidia of its teleomorph Botryobasidium croceum Lentz are globose to subglobose; the conidia of Sporostrichium aureum Link and the young basidia of its teleomorph Portia (Pycnoporellus) metamorphosa Fückel are ellipsoidal. The same applies to Conspinaerina and Fistulina. (ii) The branching pattern of the conidiogenous and basidiogenous hyphae is identical. (iii) The conidia of Sporostrichium aureum have two, four, or finally eight nuclei, the same number found in the basidia. Examples of anamorphic basidiomycetous genera belonging here are Allescherella P. Henn., Conspinaerina Stalpers, Glutinoagger Sivanesan & Watling, and Sporostrichium Link.

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