Reassessment of Mycosphaerella spp. and their anamorphs occurring on Platanus

Pedro W. Crous and Michael Corlett

Abstract: Several species of Mycosphaerella, some of which have been linked to cercosporoid anamorphs, have been described from Platanus. A reassessment of these species revealed several synonymies and incorrect anamorph–teleomorph connections. Mycosphaerella albocrustata (Schwein.) Cooke & Corlett is recognized as an earlier name for Mycosphaerella platanifolia (Cooke) F.A. Wolf, a species with no known anamorph. Mycosphaerella stigmata-plantani F.A. Wolf is shown to be the teleomorph of a new anamorph species, Xenostigmina wolfii, which has a Cerostigmina synanamorph. The latter synanamorph was previously confused with Cercospora platanicola Ellis & Everh., which has recently been placed in Pseudocercospora. Xenostigmina wolfii is known only from the United States and is distinguished from Stigmina platani (Fuckel) Sacc. and Stigmina platani-racemosae Dearn. & Barthol. by its mode of conidiogenesis, longer conidia, and Cerostigmina synanamorph.

Key words: Mycosphaerella, Platanus, Stigmina, systematics.

Résume: On a décrit plusieurs espèces de Mycosphaerella venant sur Platanus, dont certaines ont été reliées aux anamorphes cercosporoïdes. Un nouvel examen de ces espèces a révélé plusieurs synonymies et nouveaux couplages anamorphe-œcumorphe. On reconnaît le Mycosphaerella albocrustata (Schwein.) Cooke & Corlett comme nom antécédent pour le Mycosphaerella platanifolia (Cooke) F.A. Wolf, une espèce sans anamorphe connu. On montre que le Mycosphaerella stigmata-plantani F.A. Wolf est le téléomorph d’une nouvelle espèce anamorphe, le Xenostigmina wolfii, ayant un synanamorph de type Cerostigmina. Ce dernier synanamorph a déjà été confondu avec le Cercospora platanicola Ellis & Everh., lequel a été récemment placé dans les Pseudocercospora. Le Xenostigmina wolfii n’a été trouvé qu’aux États-Unis, et on le distingue du Stigmina platani (Fuckel) Sacc. et du Stigmina platani-racemosae Dearn. & Barthol. par son mode de conidiogénèse, ses conidies plus longues et son synanamorph Cerostigmina.

Mots clés : Mycosphaerella, Platanus, Stigmina, systématique.

[Traduit par la Rédaction]

Introduction

Several species of Mycosphaerella have been described from species of Platanus L., namely Sphaeria albocrustata (Schwein.) Cooke, Mycosphaerella circundans (Pass.) Tomlin, Mycosphaerella platani (Ellis & G. Martin) Tomlin (possible anamorph “Phyllosticta” fide Corlett 1991). Mycosphaerella platanifolia (Cooke) F.A. Wolf (anamorph Cercospora platanicola Ellis & Everh.), Mycosphaerella stigmata-plantani F.A. Wolf (anamorph Stigmina platani (Fuckel) Sacc., = Mycosphaerella polymorpha D.J. Sm. & C.O. Sm., anamorph Stigmina sp.), and Sphaeria veneta (Sacc. & Spreg.) Cooke (as Laestadia veneta Sacc. & Spreg.). Cercosporoid anamorphs described from this host include Stigmina platani, Stigmina visianica Sacc., Stigmina platani-racemosae Dearn. & Barthol., Pseudocercospora platanicola (Ellis & Everh.) U. Braun, Cercospora plantaginis Sacc. (= Cercospora plantaginella Tehon), and Pseudocercospora platani (J.M. Yen) J.M. Yen (Table 1). This study was undertaken to assess the taxonomic placement of these taxa, excluding C. plantaginis and P. platani.

The genus Mycosphaerella Johnson has been linked to numerous anamorph form genera based on association on the same host material or, in several cases, through cultural studies (von Arx 1983; Corlett 1991; Sutton and Hennebert 1994; Crous and Wingfield 1996). Some species of Stigmina Sacc. have been reported to be anamorphs of species of Mycosphaerella (Sivanesan 1984). However, Stigmina is heterogeneous, and the generic concept was narrowed by Sutton and Pascoe (1989) to include species that were foliculois, associated with stomata, and with pigmented, disoseptate conidia that are produced enteroblastically and percurrently on brown, verrucose conidiophores. To date, no species of Stigmina sensu stricto have been proven to be anamorphs of Mycosphaerella.

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1 This article is dedicated to Stanley Hughes, an outstanding mycologist and a friend of many years, on the occasion of his eightieth birthday.
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Several of the reported Stigmata anamorphs of Mycosphaerella have been transferred to other anamorph forms as discussed below. Another goal of this study, therefore, was to establish whether, in fact, any species of Stigmata sensu Sutton and Pascoe (1989) on Platanus have Mycosphaerella teleomorphs.

Corlett (1991) listed three Stigmata species reported to be anamorphs of Mycosphaerella species, namely Stigmata concentrica (Cooke & Ellis) Deighton (teleomorph Mycosphaerella deightoni M. Morelet), Stigmata platani (Funkel) Sacc. (teleomorph Mycosphaerella stigmata-platani F.A. Wolf), and Stigmata zillieri A. Funk (teleomorph Mycosphaerella mycopappi A. Funk & Dorworth). Stigmata concentrica was transferred to Cercostigmata U. Braun as C. concentrica (Cooke & Ellis) U. Braun based on its eusepate, sclecoporous conidia and the absence of transverse or oblique conidial septa (Braun 1993). Stigmata zillieri was reconsidered by Crous (1998), who placed it in a separate genus, Xenostigma Crous, based on its extensively branched conidiophores with intercalary and terminal conidigenous cells that were sympodially and percurrently proliferating. Furthermore, conidia were muriform, eusepate, and developed apical and basal beaks with age, characters not seen in Stigmata sensu stricto. The teleomorph of X. zillieri was shown to be either Didymella mycopappi (A. Funk & Dorworth) Crous (Crous 1998) or a species of Mycosphaerella that also occurred on the type specimen. The identity of the teleomorph of the remaining species of Stigmata, S. platani, has been the topic of much controversy (Wolf 1938; Smith and Smith 1941; van Arx 1983; Braun 1993). The aims of the present study, therefore, were to either confirm (Wolf 1938; Sivanesam 1984; Farr et al. 1989) or refute (Smith and Smith 1941; von Arx 1983; Braun 1993) S. platani as the anamorph of a Mycosphaerella sp. and to establish the correct name of the teleomorph.

**Materials and methods**

Type and several additional specimens of the respective species were requested from various herbaria and examined (see specimens examined). Slide preparations were made in clear lactic acid and lactophenol cotton blue. Measurements and line drawings were made at 1000x magnification. Whenever sufficient material was available, thirty measurements were taken from structures mounted in lactic acid, and the extremes are given in parentheses.

**Taxonomy and discussion**

*Sphaerella veneta* (Sacc. & Spec.) Cooke, Grevillea, 16: 77 (1888)  
= *Laestadia veneta* Sacc. & Spec., Michelia, 1: 351 (1878)
Figs. 1–4. Asci and ascospores of Mycosphaerella spp. Figs. 1–3. *Mycosphaerella albocrustata*. Fig. 1. Type of *M. albocrustata* (BPI 798998). Fig. 2. Type of *M. plataniolius* (BPI 609234). Fig. 3. Ascospores from material deposited by Wolf (BPI 602240). Fig. 4. Type of *M. stigmia-platani* (BPI 602240). Scale bar = 10 μm.

Fig. 5. Conidiophores and conidia of *Pseudocercospora platanicola* (FH). Scale bar = 10 μm.

**HOST:** *Platanus occidentalis* L.

**GEOGRAPHIC DISTRIBUTION:** Italy.

**SPECIMEN EXAMINED:** ITALY: Padova, leaf litter of *P. occidentalis*, C. Spegazzini, Feb. 1878 (PAD).

The type specimen consists of a few leaf pieces, colonized by several fungi. On two on these, black, crumplent, mostly empty pseudothecia were visible on the hypophyllous leaf surface. A few cylindrical, aperaphysate, bitunicate asci were found. However, there was insufficient material to fully redescribe this taxon. Ascospores were broadly ellipsoidal, mostly straight, swollen in the middle, 10–15 × 3–4 μm, asceptate, becoming light brown with age. Although the generic placement of *S. veneta* remains uncertain from the examination of this specimen, the asceptate ascospores clearly exclude it from *Mycosphaerella*.


**HOST:** *Platanus* sp.

**GEOGRAPHIC DISTRIBUTION:** Italy.

Passerini (1876) described this species from *Platanus* leaves collected in Italy. Other than the epiphyllous pseudothecia, no details were given of its ascospore shape or dimensions, and the type specimen could not be located in PARMA where Passerini’s specimens are housed.


=*Sphaerella platani* Ellis & G. Martin, Am. Nat. 19: 77 (1885)

**ANAMORPH:** Unknown, but Ellis and Martin (1885) reported a *Phyllosticta* sp. to be present on lesions.

**HOST:** *Platanus occidentialis*.

**GEOGRAPHIC DISTRIBUTION:** U.S.A.

Ellis and Martin (1885) characterized this species by its epiphyllous, black pseudothecia. Ascospores were reported to be ovate-oblong, 1-septate, constricted at the septum, 14–16 × 4–6 μm, and distinct from those of *M. albocrustata* (as *Sphaeria plataniolius*). The type specimen of this species was not located in BPI, FH, or NY.

*Mycosphaerella albocrustata* (Schwein.) Crous & Corlett comb. nov.

Figs. 1–3 and 8–10.


=*Sphaeria albocrustata* (Schwein.) Cooke, J. Bot. 21: 68 (1883)
Fig. 6. Vertical section through a pseudothecium of *Mycosphaerella stigmata-platani* (BPI 602240). Scale bar = 10 μm.

= *Mycosphaerella platani-folia* (Cooke) F.A. Wolf, Mycologia, 30: 62 (1938)

=Sphaerella platani-folia* Cooke, J. Bot. 21: 106 (1883).

**ANAMORPH:** Unknown, not *Pseudocercospore platanicoila* (Ellis & Everh) U. Braun (1997).

Pseudothecia on the type specimen are hypophyllous, black, immersed, becoming erumpent, separate, or aggregated in clusters. The frequent aggregation of pseudothecia is also visible on the material collected by Wolf and lodged at several herbaria (in association with *M. stigmata-platani*). The asci of the type specimen, as well as of the other collections, are narrowly cylindrical, 25–30 × 5–6 μm. Ascospores are multiseriate in asci, hyaline to slightly olivaceous, straight, constricted at the median septum, obovoid, widest near the obtuse apex, tapering more prominently towards the lower end, 6–8 × 2–4 μm.

**HOSTS:** *Platanus occidentalis, Platanus sp.*

**GEOGRAPHIC DISTRIBUTION:** U.S.A.


Based on its ascus and ascospore morphology, as well as pseudothecial anatomy and arrangement, *M. platani-folia* should be reduced to synonymy under the older epithet, *Sphaeria albo-crustata*, for which a new combination is proposed in *Mycosphaerella* above.

Two species of *Mycosphaerella, M. albo-crustata* (Fig. 3), and *M. stigmata-platani* (Fig. 4), are present on the material collected and studied by Wolf (1938). Wolf collected discharged ascospores of what he considered to be representatives of these two species, and obtained single conidial and single ascospore cultures. Based on the similarity of the colonies in culture, he linked what he considered to be *Cercospora platanicoila* to *M. albo-crustata* (*as* *M. platani-folia*), and what he referred to as *Stigmata platani* to *M. stigmata-platani*. Smith and Smith (1941) commented, however, that what Wolf regarded to be *M. platani-folia* could possibly be *M. stigmata-platani*. Wolf (1938) cited ascospores of *M. platani-folia* as being 8–10 × 4–4.5 μm. Based on a re-examination of the type specimens of *M. platani-folia, M. albo-crustata*, and the material collected by Wolf, we found ascospores of this species to be considerably smaller, namely 6–8 × 2–4 μm. Furthermore, Smith and Smith (1941) considered the acceptable variation of ascospore size within *M. stigmata-platani* to be 8–19 × 4–7 μm. This suggests, therefore, that Wolf was in fact working with *M. stigmata-platani*. The fact that both species occur mixed throughout the type material studied by Wolf further confuse the issue. Wolf’s illustrations of the telemorphs of
the two species show them to be morphologically similar and also to have a similar mode of ascospore germination. If the cultures described by Wolf (1938) as *M. plataniolata* were in fact *M. stigmina-platani*, the question arises as to how these two species could have distinct anamorphs. A subsequent re-examination of the type of *Cercospora platanicola* revealed it to be distinct from the material identified as such by Wolf, with the conidia being shorter, narrower and lighter in pigmentation than those on the material collected by Wolf. Our opinion is that the material of *Cercospora platanicola* sensu Wolf actually represents the synanamorph of what he incorrectly called *Stigmina platani* (see below). In summary, *Cercospora platanicola* is a different organism. Wolf apparently studied and cultured only a single species, *M. stigmina-platani*, an organism that produces two previously undescribed synanamorphs.


TELMOMORPH: unknown, not *M. plataniolata* (Cooke) F.A. Wolf.
Leaf spots irregular, amphigenous, red-brown, 1–6 mm diam. Mycelium internal and external, olivaceous, smooth, branched, septate, 2.5–3 μm wide. Caesipulvi amphigenous, fasciculate, pale brown, arising through stomaata from inconspicuous to well developed, pale brown, substomatal or erumpent stromata, 10–50 μm. Conidiophores arising from the upper cells on inconspicuous stromata in dense to loose fascicles, or occurring separately on superficial mycelium, smooth, pale olivaceous, straight to variously curved or geniculate, unbranched, 0- or 1-septate, 5–25 × 2–4 μm. Conidiogenous cells, terminal, pale olivaceous, smooth, tapering to flat tipped apical loci, proliferating sympodially, 5–15 × 2–3 μm.

Conidia solitary, smooth, pale olivaceous, narrowly obclavate to cylindrical, straight to curved, apex subobtuse, base truncate to long obconically truncate, 1–5-septate, (15–)30–40(–60) × 2–2.5 μm.

HOST: Platanus occidentalis.

GEOGRAPHIC DISTRIBUTION: Transcaucasia (Azerbaijan and Georgia), U.S.A. (Braun and Melnik 1997).

specimen examined: U.S.A.: Louisiana, Pointe à la Hache, on P. occidentalis, A.B. Langlois No 557, 2 Oct. 1886, FH, isoelectotype; lectotype deposited at NY.

The conidial measurements of the type correspond well with those given by Ellis and Everhart (30–40 × 2–2.5 μm).
Pseudocercospora platani (J.M. Yen) J.M. Yen, which was described from leaves of Platanus occidentalis collected in Taiwan (Yen 1977), is in many ways very similar to Pseudocercospora plataniolica. Braun and Melnik (1997) tentatively retained Pseudocercospora platani as a separate species based on the absence of superficial mycelium, larger conidiophores and longer conidia, 36–90 x 2–3 μm. If these two are eventually shown to be synonymous, the older name, Pseudocercospora plataniolica would have priority.

When Wolf (1938) incorrectly linked Cercospora plataniolica to Mycosphaerella plataniolofia, he reported the conidia as 30–60 x 3–4 μm. Ellis and Everhart (1903) referred to another specimen with conidia 30–55 x 4–5 μm. Chupp (1954) therefore felt that the type was either immature, or that Wolf (1938) had collected a species other than Cercospora plataniolica. Our opinion is that the material examined by Ellis and Everhart (1903) in fact represent the same organism studied by Wolf (1938). The material deposited by Wolf at BPI confirms that he was in fact not working with C. plataniolica, but with the synonym morph of what he incorrectly referred to as Stigmina platani.

**Mycosphaerella stigmata-platani**

F.A. Wolf, Mycologia 30: 60 (1938).  
Figs. 4, 6, 7, and 11–17.  
=Myosphaerella polymorpha D.J. Sm. & C.O. Sm., Hilar. 14: 206 (1941).

**ANAMORPH:** Xenostigma wolfii Crous & Corlett sp.nov. (non Stigmina platani (Fukkel) Sacc.  
**SYNANAMORPH:** Cercostigma sp.

Xenostigma wolfii ab Stigmina platani (Fukkel) Sacc. differt conidiophoros symphialtiter et percurrente proliferentibus, conidiis longioribus et angustioribus, (15–)23–30–(45) x (6–)8–9–(10) μm, transversaliter 3–6 et ex parte longitudinaliter vel oblique 1–4-septatis.

Leaf spots amphigenous, discrete, irregular, initially 1–3 mm diam., chlorotic, enlarging up to 6 mm diam., coalescing with age, appearing red-brown on upper leaf surface, and black (due to profuse sporulation) on the lower surface. Pseudothecia hypophysal, separate, black, subepidermal, becoming erumpent, globose, 60–100 μm wide, 60–90 μm high; apical ostiole up to 15 μm in diam.; wall consisting of three or four layers of medium brown texture angularis, hymenium layer at base consisting of two or three layers of elongated, flattened cells. Ascii apomorphous, fasciculate, bitunicate, subsectile, obvoid to broadly ellipsoid, straight or incurved, 8-spored, 35–50 x 7.5–13 μm. Ascospores bi- to tri-seriate, overlapping, hyaline, non-guttulate, thick-walled, slightly curved, rarely straight, fusoid-ellipsoid with obtuse ends, widest above the median septum, 1-septate, constricted at septum, tapering towards both apices, (12.5–)14–16 x 3.5–4–(5) μm. Mycelium internal, hyphae light brown, smooth, septate, branched, 2–3 μm diam.

**Xenostigma wolfii** anamorph: Conidiomata sporodochial, hypophysal, black on leaves, up to 60 μm diam. Conidiophores arising from the upper cells of a supramostatoma brown stroma; conidiophores verruculose, medium brown, 1–10-septate, frequently constricted at septa, subcyllindrical, variously curved, branched, 10–80 x 5–8 μm. Conidiogenous cells terminal and intercalary, light brown, verruculose, subcyllindrical, 10–15 x 5–6 μm; proliferating sympodially and one to seven times enteroblastically and percurrently.

Conidia solitary, verruculose, straight to curved, broadly ellipsoidal to obclavate or subcyllindrical, apex oboste, base truncate to obconically truncate, muriform, with three to six horizontal and one to four longitudinal or oblique distosepta, (15–)23–30–(45) x (6–)8–9–(10) μm; marginal basal frill present.

**Cercostigma** synanamorph: As observed for the Xenostigma state, conidiophores either in small, dense fascicles with conidiophores 0- or 1-septate, 15–20 x 6–7 μm, or in larger, loose fascicles with conidiophores extensively branched, 1–6-septate, 15–60 x 5–8 μm; fascicles giving rise to the Cercostigma state lighter in color, and only finely verruculose. This is not always the case, as both states could also occur on conidiophores in the same fascicle. Conidiogenous cells terminal and intercalary, light brown, finely verruculose to verruculose, subcyllindrical, 10–15 x 5–6 μm; proliferating one to seven times enteroblastically and percurrently, but in some cases also sympodially. Conidia solitary, light brown (although darker brown scelosporous conidia also occur), finely verruculose to verruculose, narrowly obclavate to subcyllindrical, apex obtuse, rarely obtuse, base obconically truncate, curved, 3–7–euseptate, rather thin walled, (35–)45–60–(100) x (4–)5.5–(6–6.5) μm; hila inconspicuous, marginal frill minute to absent.

**HOSTS:** Platanus acerifolia (Aiton) Willd., Platanus occidentalis, Platanus racemosa Nutt., Platanus wrightii S. Watson.

**GEOGRAPHIC DISTRIBUTION:** U.S.A.

**SPECIMEN EXAMINED:** Of Mycosphaerella stigmata-platani.  

Ascospores of *M. stigmata-platani* were measured as (12.5–)14–16 x 3.5–4–(5) μm, and are thus smaller than
Figs. 13–23. Conidiophores and conidia of *Xenostigma* and *Stigmina* spp. Figs. 13–17. *Xenostigma wolffii* and its synanamorph (type at FH). Fig. 13. Sporodochium with two conidial types. Fig. 14. Conidiogenous cells proliferating percurrently (arrow), and sympodially (double arrow). Fig. 15. *Xenostigma* conidium. Figs. 16 and 17. Conidia of *Cercostigma* synanamorph. Figs. 18–20. *Stigmina platani* (PAD). Fig. 18. Sporodochium with percurrently proliferating conidiogenous cells (arrow). Figs. 19 and 20. Distoseptate conidia. Figs. 21–23. *Stigmina platani-racemosae* (type, FH 8889). Fig. 21. Percurrently proliferating conidiogenous cells. Figs. 22 and 23. Muriformly septate conidia. Scale bars = 10 μm.
Smith and Smith (1941) also induced the anamorph from single ascospore cultures. Although Wolf (1938) incorrectly identified the anamorph as Stigmina platani, the teleomorph description is valid, and supersedes M. polymorpha, which should now be treated as an obligate synonym. However, Smith and Smith (1941) were also correct in stating that the anamorph is too variable to be *Stigmina platani*. A similar observation was made earlier by Bubá (1914), when he reduced *Stigmina visianica* Sacc. to synonymy with *Stigmina platani*. Re-examination of the type specimens of these two species further supports them as synonyms, and distinct from the anamorph of *M. stigmata-platani* (Figs. 7, 13–17). In the same paper, Bubá (1914) also described *Ceuthospora platani* Bubá from two specimens from Greece (Thúnen's Mycothea Univ. 889; Baenitz's Herb. Eur. No. 2469), the locality where *Stigmina platani* was collected. We found these two specimens to be representative of a spongornial state (*Asteromella* Pass. & Thüm.) of a *Mycosphaerella* sp. Scleromycoria were hypophyllous, aggregated, black, subepidermal, becoming crumulent, with ampulliform, hyaline conidiogenous cells, 2.5–5 × 2.5–4 μm, and bacilliform, straight to slightly curved, hyaline conidia, 3–4 × 1.5–2 μm.

*Stigmina platani*, which occurs on *P. orientalis* (Smith and Smith 1941) has conidia that are 1–3-distoseptate, occasionally with one oblique septum, 15–23 × 7.5–11 μm (Figs. 18–20, 25). In contrast, *Stigmina platani-racemosa* occurs on *P. racemosa* and *P. wrightii*, and has conidia that are 1–3-distoseptate, prominently muriformly septate, and 14–22 × 8.5–14 μm (Smith and Smith 1941; Hughes 1952) (Figs. 21–24). The anamorph of *M. stigmata-platani*, which can infect *P. acerifolia*, *P. occidentalis*, *P. racemosa*, and *P. wrightii* (Smith and Smith 1941), is easily distinguished from these two *Stigmina* species based on its longer and slightly narrower conidia (15–23–30–45) × (6–)8–9–(10) μm, and three to six horizontal and one to four longitudinal or oblique septa. The presence of its *Cercostigmata* syzanamorph was first commented on by Smith and Smith (1941; Fig. 2), who managed to induce both conidial types in culture from single ascospore cultures. They referred to the syzanamorph as the *Cercospora*-type conidial form, and described these conidia as 17–70–(120) × 3–6 μm in size.

The generic placement of this anamorph is somewhat problematic. Although conidiogenous cells proliferate percurrently and enteroblastically, branched conidiophores with lateral and terminal loci, sympodial and percurrent proliferation also occur. These features exclude the species from *Stigmina sensu stricto*, and leaves two other genera to be considered, namely *Cercostigmata* and *Xenostigmata*. Braun (1993) considered *Cercostigmata* close to *Pseudocercospora* Speg. in having species with scelecosporous, euseptate conidia with horizontal septa. *Xenostigmata* species on the other hand, have lateral and terminal conidiogenous loci and muriformly septate conidia. Although the conidia of *X. zilleri* have a mixture of distosepta and eusepta, the anamorph of *M. stigmata-platani* is best accommodated in *Xenostigmata* as *X. wolfii*.

By clarifying that the anamorph of *M. stigmata-platani* does not belong in *Stigmina*, no species of *Stigmina sensu stricto* are presently known as anamorphs of *Mycosphaerella*. The three reported “*Stigmina*” anamorphs listed by Corlett (1991), are now accommodated in *Cercostigmata* (Braun 1993) and *Xenostigmata* (Crous 1998).

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