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Taxonomic revision of the genus *Cladosporium* s. lat. 8. Reintroduction of *Graphiopsis* (= *Dichocladosporium*) with further reassessments of cladosporioid hyphomycetes

Uwe Braun[1], Pedro W. Crous[2] & Konstanze Schubert[3]

uwe.braun@botanik.uni-halle.de
[1]Martin-Luther-University, Institute of Biology, Geobotany and Botanical Garden Herbarium, Neuwerk 21, D-06099 Halle (Saale), Germany

p.crous@cbs.knaw.nl
[2]CBS, Fungal Biodiversity Centre P.O. Box 85167, 3508 AD Utrecht, The Netherlands

konstanze.schubert@gmx.de
[3]Botanische Staatssammlung München Menzinger Straße 67, D-80638 München, Germany

Abstract — *Graphiopsis* is shown to be an older, valid name for the recently introduced genus *Dichocladosporium*. The new name *Cladosporium vincicola* is introduced and the new combinations *Fusicladium britannicum* (≡ *Cladosporium britannicum*) and *F. psammicola* (≡ *Exosporium psammicola*, *Cladosporium psammicola*) are proposed. The fungus represented by the invalid name *Cladosporium indigoferae* is described and illustrated. Due to insufficient material, however, its generic affinity could not be resolved.

Key words — anamorphs, cladosporium-like

Introduction

Based on a new phylogenetic and morphological circumscription of the heterogeneous genus *Cladosporium* Link (David 1997, Braun et al. 2003, Schubert et al. 2007b), attempts to redescribe and reassess the numerous species previously assigned to this genus (Dugan et al. 2004) have recently been made (Braun & Schubert 2007, Heuchert et al. 2005, Schubert 2005a,b; Schubert & Braun 2004, 2005a,b, 2007; Schubert et al. 2006, 2007a,b). In a recently published issue of 'Studies in Mycology' dedicated to cladosporioid fungi (Crous et al. 2007b), all aspects and kinds of hyphomycetes previously assigned to *Cladosporium* s. lat. (Crous et al. 2007a) have been addressed using standardized cultures and molecular approaches. This volume provides an important basis for the preparation of a projected monograph of *Cladosporium*.

In the present paper, the nomenclature of a recently introduced cladosporioid genus is discussed and some species, which are only known from type material and other herbarium specimens, are redescribed and reassessed.

Materials and methods

The collections examined were described, mounted in distilled water, using oil immersion (bright field and phase contrast), but without any staining, by means of standard light microscopy (Olympus BX 50, Hamburg, Germany). The collections examined are deposited at the herbaria BPI, CUP, HAL, IMI, LE, PAD, PPMH and W (abbreviations according to Holmgren et al. 1990).

Nomenclature and taxonomy

1. *Graphiopsis* – an older valid name for *Dichocladosporium*

Cladosporium chlorocephalum (= *C. paeoniae*) is a common, widespread hyphomycete of peony, characterized by dimorphic fruiting, and causing distinct necrotic leaf-blotch symptoms on living leaves, and with a second type of conidiophore and conidia on rotten, overwintered stems. Based on detailed re-examinations of this fungus in vivo and in vitro, supplemented by sequence data of the ITS and LSU gene regions, Schubert et al. (2007a) clearly demonstrated that this fungus has to be excluded from *Cladosporium* s. str. It is retained in the *Davidiellaceae* (*Capnodiales*), but forms a clade separate from the *Davidiella* Crous & U. Braun cluster. The placement of this fungus in a separate genus, '*Dichocladosporium*' was supported by its phylogenetic position and morphological peculiarities of the conidiophores, conidiogenous loci and hila. Unfortunately it was overlooked that *D. chlorocephala* (≡ *Periconia chlorocephala*), the type species of the former genus, is also the type species of an older, forgotten genus, *Graphiopsis*. Trail (1889) probably misinterpreted the name *P. chlorocephala* since he assigned Scottish collections on *Carex* spp., *Juncus effusus* and *Phragmites australis* to this species, which is confined to *Paeonia* spp. But peony was not listed under the hosts cited. This is, however, nomenclaturally irrelevant since Trail (1889: 76) clearly cited *Periconia chlorocephala* as type species of *Graphiopsis*. Hence, the following nomenclatural reassessment and correction is necessary:

Graphiopsis Trail, Scott. Naturalist (Perth) 10: 75. 1889
[non *Graphiopsis* Bainier 1907].
Type species: *G. chlorocephala* (Fresen.) Trail.
≡ *Dichocladosporium* K. Schub., U. Braun & Crous, Stud. Mycol. 58: 96. 2007.

Graphiopsis chlorocephala (Fresen.) Trail, Scott. Naturalist (Perth) 10: 76. 1889.
Neotype: On dead stems of *Paeonia officinalis*, Germany, Sachsen-Anhalt, Halle (Saale), Botanical garden, 16 Mar. 2005, K. Schubert (HAL 1924 F). Isoneotype: CBS-H 19869. Culture ex neotype: CBS 121523 = CPC 11969.

≡ *Periconia chlorocephala* Fresen., Beitr. Mykol. 1: 21. 1850.
≡ *Haplographium chlorocephalum* (Fresen.) Grove, Hardwicke's Sci.-Gossip 21: 198. 1885.
≡ *Cladosporium chlorocephalum* (Fresen.) E.W. Mason & M.B. Ellis, Mycol. Pap. 56: 123. 1953.
≡ *Dichocladosporium chlorocephalum* (Fresen.) K. Schub., U. Braun & Crous, Stud. Mycol. 58: 96. 2007.
= *Cladosporium paeoniae* Pass., in Thümen, Herb. Mycol. Oecon., Fasc. IX, No. 416. 1876, and in Bot. Jahresber. (Just) 4: 235. 1876.
= *Periconia ellipsospora* Penz. & Sacc., Atti Reale Ist. Veneto Sci. Lett. Arti, Ser. 6, 2: 596. 1884.
= *Cladosporium paeoniae* var. *paeoniae-anomalae* Sacc., Syll. Fung. 4: 362. 1886.
= *Haplographium chlorocephalum* var. *ovalisporum* Ferraris, Fl. Ital. Cryptog., Hyphales: 875. 1914.

2. ***Cladosporium vincicola*** U. Braun & K. Schub., **nom. nov.** Fig. 1

MycoBank, MB 511302

≡ *Cladosporium vincae* Moesz, Bot. Közlem. 23: 123. 1926, nom. illeg., non *C. vincae* Fairm., 1911.

Material examined: HUNGARY. Near Budapest, on living leaves of *Vinca herbacea* (*Apocynaceae*) infected by *Puccinia vincae* (DC.) Plowr., 25 Apr. 1926, W. Moesz (W 10216: lectotype, selected here). RUSSIA. St. Petersburg, Botanical Garden of the Komarov Botanical Institute, on living leaves of *Vinca minor*, 7 May 2007, V.A. Mel´nik (HAL 2069 F).

Leaf spots usually initiated terminally or laterally, later spreading, covering large leaf segments, often more than 50 % of the leaf blade, finally entire leaves turning necrotic, shape and size of the lesions variable, dark brown to pale grayish brown, later dingy gray to grayish white, margin indefinite or with a narrow to moderately wide dark brown to blackish border or halo, sometimes with rather diffuse discolorations. Caespituli amphigenous, mainly hypophyllous, punctiform, scattered, dark brown. Mycelium internal, forming immersed stromatic aggregations, 10–80 µm diam., composed of swollen hyphal cells, pigmented, thick-walled, up to 12 µm diam. Conidiophores in small to moderately large fascicles, loose to moderately dense, occasionally solitary, arising from substomatal stromatic hyphal aggregations, emerging through stomata, erect, straight, subcylindrical to moderately geniculate-sinuous, rarely subnodulose, unbranched, 15–100 × 3–7.5 µm, at the very base sometimes up to 10 µm wide, 0–4(–6)-septate, pale to medium olivaceous or olivaceous-brown, wall 0.5–1 µm thick, one-layered, smooth to faintly rough-walled; conidiogenous cells integrated, terminal or intercalary, 10–35 µm long; conidiogenous loci distinctly coronate, somewhat protuberant, 1.5–2.5 µm wide and ca. 1 µm high. Conidia in simple or branched chains, ramoconidia lacking, secondary ramoconidia (sensu Schubert et al. 2007b) and conidia ellipsoid-ovoid, obovoid, fusiform, rarely subcylindrical, (4.5–)6–25(–33) × (3–)4–8(–9) µm, 0–3(–4)-septate, pale olivaceous to olivaceous-brown, wall thin, ca. 0.5 µm, sometimes distinctly two-layered and up to 1 µm thick, distinctly verruculose,

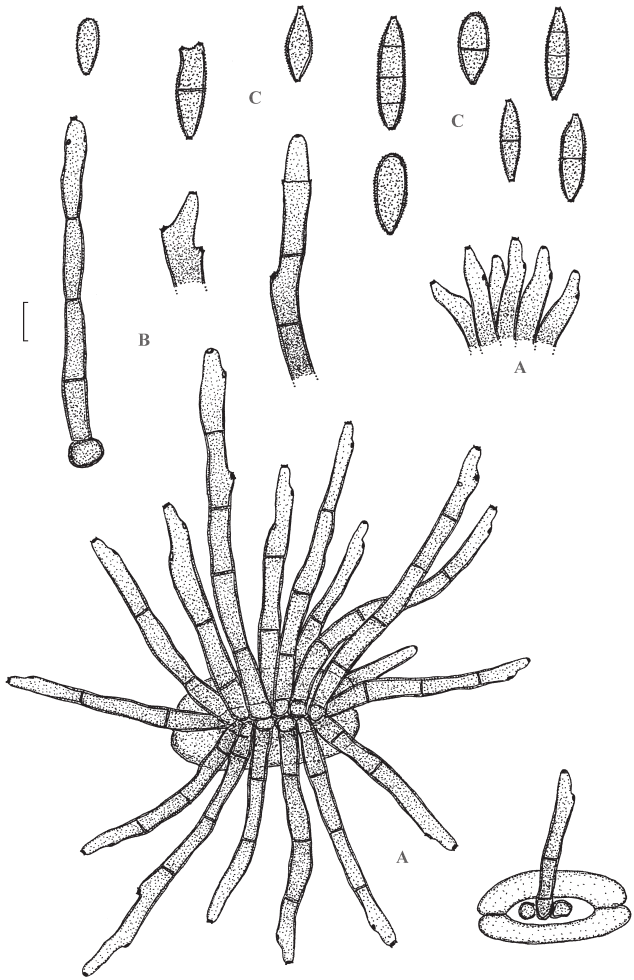

Fig. 1. *Cladosporium vincicola*.
A. Conidiophore fascicle. **B**. Conidiophores. **C**. Conidia.
Scale bar = 10 µm. U. Braun *del.*

apex rounded in conidia formed singly, attenuated in catenate conidia, base rounded, with an abruptly protuberant hilum or attenuated, 1–2 µm diam., occasionally with microcyclic conidiogenesis.

Comments: Morphologically this species resembles *Cladosporium aecidiicola* Thüm. However, *C. vincicola* is undoubtedly biotrophic, forming distinct leaf lesions, with fasciculate conidiophores emerging through stomata, and is not associated with rust aecia. The fascicles of conidiophores arise from

well-developed, large stromata. The conidia of *C. vincicola* agree well with those of *Cladosporium herbarum* (Pers.) Link s. str., but the conidiophores and the arrangement of the conidiogenous loci is different. The conidiophores in *C. vincicola* are non-nodulose, i.e., the conidiogenous loci are not confined to nodulose swellings as in *C. herbarum*. *Cladosporium vincae* Fairm. (material examined: on dead leaves of *Vinca minor*, USA, New York, Lyndonville, 6 May 1910, C.E. Fairman, CUP-F2873(24-68), holotype) is identical with *Cladosporium macrocarpum* Preuss, i.e., the conidiophores are distinctly nodulose with conidiogenous loci confined to swellings, and the conidia are rather broad, 5.5–11 µm, mostly 8–10 µm.

3. ***Fusicladium britannicum*** (M.B. Ellis) U. Braun & K. Schub., **comb. nov.** Fig. 2
MycoBank, MB 511303

≡ *Cladosporium britannicum* M.B. Ellis, More Dematiaceous Hyphomycetes: 328. 1976.

Illustrations: Ellis (1976: 327, Fig. 245 C), Ellis & Ellis (1985: Pl. 19, Fig. 190).

Material examined: UK. Wales, Pwee-y-Faeda Estate, on rotten wood of *Quercus* sp. (*Fagaceae*), 13 May 1973, collector unknown (IMI 175936: holotype).

Colonies on rotten wood, effuse, dark to blackish brown, villose. Mycelium usually immersed; hyphae sparingly branched, 1–3 µm wide, septate, brown, with solitary or aggregated swollen hyphal cells, 3–10 µm diam., subglobose, brown, wall up to 1 µm thick, but genuine stromata lacking. Conidiophores solitary to loosely aggregated, arising from immersed hyphae or swollen hyphal cells, erect, straight, subcylindrical to flexuous, sinuous, rarely slightly geniculate, unbranched, 80–350 × 3–6(–8) µm, pluriseptate throughout, medium to dark brown, tip somewhat paler, wall slightly thickened, up to 1 µm wide, smooth; conidiogenous cells integrated, terminal, 10–30 µm long; conidiogenous loci inconspicuous to subconspicuous by being subdenticulate, apex truncate to somewhat convex, 1–2.5 µm diam., unthickened or almost so, but somewhat darkened-refractive. Conidia in simple or branched chains, (9–)12–20 × (4–)5–8 µm, primary conidia obovoid, apex rounded, base short obconically truncate, secondary conidia ellipsoid-ovoid, fusiform, both ends attenuated, tips (hila) truncate, pale brown to medium brown, wall thin, 0.5–1 µm wide, smooth, hila (1–)1.5–2.5(–3) µm diam., unthickened or almost so, but often somewhat darkened-refractive.

Comments: Due to the non-coronate structure of the conidiogenous loci and conidial hila, this species has to be excluded from *Cladosporium* s. str. The subdenticulate, unthickened, but somewhat darkened-refractive loci and hila agree well with those of *Fusicladium* Bonord. (Schubert et al. 2003). Without cultures and molecular sequence analyses, it is rather difficult to distinguish *Fusicladium* anamorphs [*Venturiaceae*] from species of the genus *Cladophialophora* Borelli [*Herpotrichellaceae*] (Crous et al. 2007c). However,

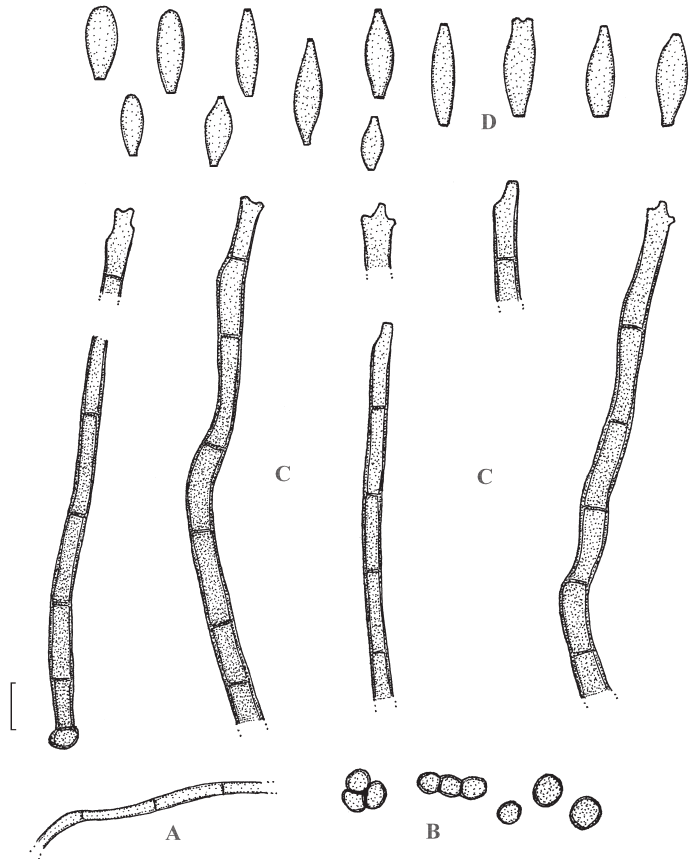

Fig. 2. *Fusicladium britannicum*.
A. Hyphae. **B**. Swollen hyphal cells. **C**. Conidiophores. **D**. Conidia.
Scale bar = 10 µm. U. Braun *del.*

based on the structure of the rather coarse, long and wide conidiophores, this species has been placed in *Fusicladium*.

4. ***Fusicladium psammicola*** (Sacc.) U. Braun & K. Schub., **comb. nov.** Fig. 3

MycoBank, MB 511304

≡ *Exosporium psammicola* Sacc., in Saccardo & Trotter, Ann. Mycol. 11: 420. 1913.

≡ *Cladosporium psammicola* (Sacc.) Morgan-Jones & W.B. Kendr., Canad. J. Bot. 50(9): 1817. 1972.

Illustration: Morgan-Jones & Kendrick (1972: 1818, Fig. 1).

Material examined: LIBYA. Ras Carrac, Magna Syrte, on dead leaves of *Psamma arenaria* [≡ *Ammophila arenaria*] (*Poaceae*), 18 May 1913, A. Trotter (PAD: holotype).

Colonies on dead leaves, punctiform to subeffuse, dark brown to blackish, scattered to dense. Mycelium immersed, occasionally partly superficial, branched, septate, subhyaline to brown, 2–5 µm wide, forming irregularly radiating strands and aggregations of swollen hyphal cells, 3–9 µm wide, brown, wall somewhat thickened, septate, usually constricted at the septa, often confluent, forming irregular plates or stromata, up to 50 µm diam., immersed to erumpent. Conidiophores solitary, in loose groups or loose to dense fascicles, arising from hyphal aggregations or stromata, erect, subcylindrical-conical, unbranched, 5–35 × 3–6 µm (according to the original description up to 70 µm long), aseptate or septate, pale brown, wall thin to slightly thickened, smooth to faintly rough-walled; conidiogenous cells integrated, terminal or conidiophores reduced to conidiogenous cells, often with a single conidiogenous locus, sometimes with sympodial proliferation and several loci, 1.5–2 µm diam., truncate to slightly convex, unthickened, but often distinctly darkened (pigmented). Conidia solitary, occasionally in short chains, ellipsoid-ovoid, fusiform, short subcylindrical, 10–25 × 4–7 µm, 0–3-septate [rarely with up to

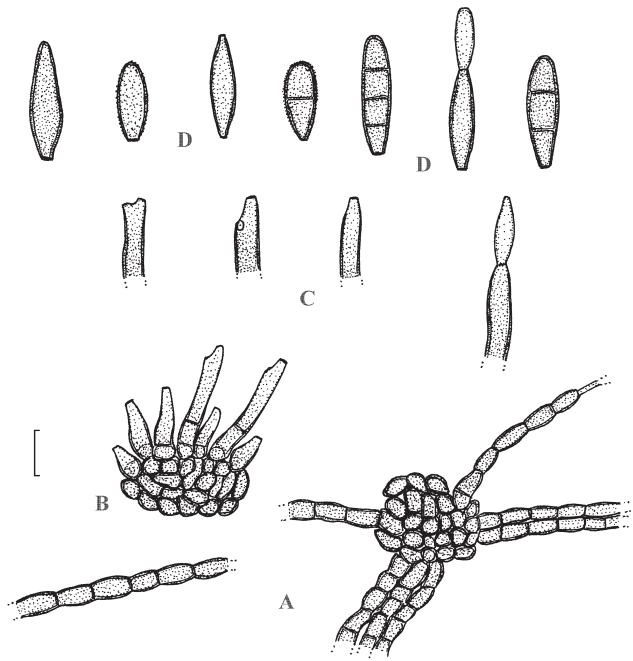

Fig. 3. *Fusicladium psammicola*.
A. Hyphae, hyphal aggregations and strands.
B. Fasciculate conidiophores. **C**. Conidiogenous cells. **D**. Conidia.
Scale bar = 10 µm. U. Braun *del*.

5 septa, according to Morgan-Jones & Kendrick (1972)], pale to medium brown or olivaceous-brown, wall thin to slightly thickened, smooth or almost so to faintly rough-walled, apex obtuse or somewhat attenuated, rarely subtruncate, base attenuated, with a truncate hilum, 1.5–2 µm diam., unthickened, but often distinctly darkened.

Comments: On account of clear differences between this species and the basic features of the genus *Exosporium* Link, Morgan-Jones & Kendrick (1972) reallocated *E. psammicola* to *Cladosporium* s. lat. However, due to the non-coronate conidiogenous loci and conidial hila, this species has to be excluded from *Cladosporium* s. str. The presence of subdenticulate, truncate, unthickened, but darkened-refractive scars suggests this species should be assigned to *Fusicladium* (Schubert et al. 2003), an assignment supported by the structure of the radiating hyphal strands and stromatic plates as well as the broad conidia, mostly formed singly. *Cladophialophora* is morphologically similar, but without cultures and molecular sequence analyses it is difficult to distinguish the two genera. However, characteristically radiating hyphal strands and stromatic plates are usually not formed in the latter genus, and the conidia are usually more slender and formed in long acropetal chains.

5. ***Cladosporium indigoferae*** Sawada,

Special Publ. Coll. Agric. Natl. Taiwan Univ. 8: 196. 1959, nom. inval. Fig. 4
= **fusicladium/cladophialophora-like**

Illustration: Sawada (1959: Pl. 3, Figs 8–9).

Material examined: TAIWAN. Pref. Taipei, Taipei, on dead stems of *Indigofera tinctoria* (*Fabaceae*), 18 Aug. 1909, K. Sawada (BPI 427230: type); Taiwan, 18 Aug. 1942, K. Sawada (PPMH: authentic material).

Colonies on dead stems, without any lesions (probably saprobic), punctiform, scattered or effuse, brown to blackish, somewhat velvety. Mycelium internal, forming one- to rarely multi-layered hyphal strands, composed of more or less globular, often somewhat inflated, 4–11 µm diam., smooth, thick-walled, olivaceous-brown cells, giving raise to conidiophores, but typical stromata lacking, additional hyphae smooth, 2–3 µm wide, paler. Conidiophores solitary or in small loose groups, arising from swollen hyphal cells or hyphal strands, erect, straight to somewhat curved, occasionally somewhat geniculate-sinuous, unbranched or rarely branched, 15–100(–146) × 3–4.5(–5) µm, septate, yellowish olivaceous-brown, wall smooth, slightly thickened; conidiogenous cells integrated, terminal or intercalary, 7–20 µm long, sympodial, with a single or few conidiogenous loci, truncate to slightly convex, 1–2 µm wide, barely thickened, but somewhat darkened-refractive. Conidia in branched chains, subglobose, ellipsoid-ovoid, cylindrical, straight, 4–26 × 3–5(–7) µm, 0–3-septate, not to somewhat constricted at the septa, pale olivaceous, wall

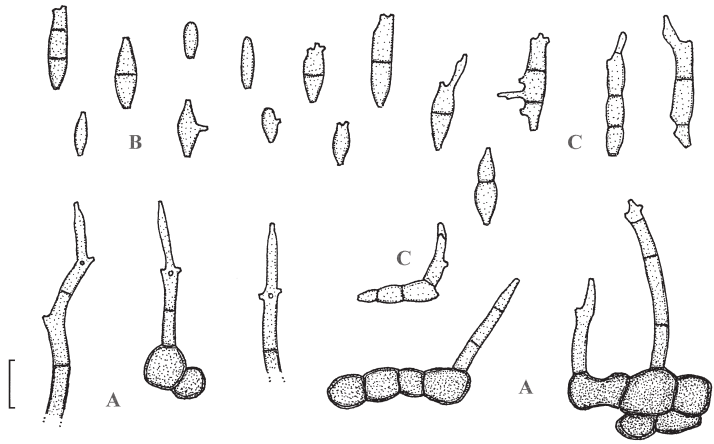

Fig. 4. *Cladosporium indigoferae*.
A. Conidiophores arising from swollen hyphal cells.
B. Conidia. **C**. Conidia (germination, with microcyclic conidiogenesis).
Scale bar = 10 µm. U. Braun *del*.

thin to slightly thickened, smooth, apex rounded to attenuated, base usually short obconically truncate, hila truncate, 1–2 µm diam., barely thickened, but somewhat darkened-refractive. Microcyclic conidiogenesis observed.

Comment: *Cladosporium indigoferae* is an invalid name, published without a Latin description. The type material examined is rather sparse, but some conidiophores and conidia, morphologically agreeing with the features of *Fusicladium* and *Cladophialophora*, has been found. However, the material examined is in too poor a condition for a final treatment and validation, which should be based on cultural characteristics and supported by molecular DNA sequence analyses.

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Literature cited

Braun U, Crous PW, Dugan F, Groenewald JZ, de Hoog GS. 2003. Phylogeny and taxonomy of *Cladosporium*-like hyphomycetes, including *Davidiella* gen. nov., the teleomorph of *Cladosporium* s. str. Mycological Progress 2: 3-18.

Braun U, Schubert K. 2007. Taxonomic revision of the genus *Cladosporium* s. lat. 7. Descriptions of new species, a new combination and further new data. Schlechtendalia 16: 61-76.

Crous PW, Braun U, Schubert K, Groenewald JZ. 2007a. Delimiting *Cladosporium* from morphologically similar genera. Studies in Mycology 58: 33-56.

Crous PW, Braun U, Schubert K, Groenewald JZ, eds. 2007b. The genus *Cladosporium* and similar dematiaceous hyphomycetes. Studies in Mycology 58: 1-253.

Crous PW, Schubert K, Braun U, de Hoog GS, Hocking AD, Shin H-D, Groenewald JZ. 2007c. Opportunistic, human-pathogenic species in the *Herpotrichiellaceae* are phenotypically similar to saprobes and phytopathogenic species in the *Venturiaceae*. Studies in Mycology 58: 185-217.

David J. 1997. A contribution to the systematics of *Cladosporium*. Revision of the fungi previously referred to *Heterosporium*. Mycological Papers 172: 1-157.

Dugan FM, Schubert K, Braun U. 2004. Check-list of *Cladosporium* names. Schlechtendalia 11: 1-103.

Ellis MB. 1976. More Dematiaceous Hyphomycetes. CMI, Kew.

Ellis MB, Ellis JP. 1985. Microfungi on Land Plants. An Identification Handbook. New Enlarged Edition. The Richmond Publishing Co., Ltd., Slough.

Holmgren PK, Holmgren NH, Barnett LC. 1990. Index herbariorum, Part. 1: The Herbaria of the World. 8th edn. Regnum vegetabile 120: 1-163.

Heuchert B, Braun U, Schubert K. 2005. Morphotaxonomic revision of fungicolous *Cladosporium* species (hyphomycetes). Schlechtendalia 13: 1-78.

Morgan-Jones G, Kendrick B. 1972. Notes on Hyphomycetes. III. Redisposition of six species of *Exosporium*. Canadian Journal of Botany 50: 1817-1824.

Sawada K. 1959. Descriptive catalogue of Taiwan (Formosan) fungi XI. Special Bulletin, College of Agriculture, National Taiwan University 10: 1-268.

Schubert K. 2005a. Taxonomic revision of the genus *Cladosporium* s. lat. 3. A revision of *Cladosporium* species described by J.J. Davis and H.C. Greene (WIS). Mycotaxon 92: 55-76.

Schubert K. 2005b. Morphotaxonomic revision of foliicolous *Cladosporium* species (hyphomycetes). Thesis, Martin-Luther-University Halle-Wittenberg.

Schubert K, Braun U. 2004. Taxonomic revision of the genus *Cladosporium* s. lat. 2. Morphotaxonomic examination of *Cladosporium* species occurring on hosts of the families *Bignoniaceae* and *Orchidaceae*. Sydowia 56: 296-317.

Schubert K, Braun U. 2005a. Taxonomic revision of the genus *Cladosporium* s. lat. 1. Species reallocated to *Fusicladium*, *Parastenella*, *Passalora*, *Pseudocercospora* and *Stenella*. Mycological Progress 4: 101-109.

Schubert K, Braun U. 2005b. Taxonomic revision of the genus *Cladosporium* s. lat. 4. Species reallocated to *Asperisporium*, *Dischloridium*, *Fusicladium*, *Passalora*, *Pseudoasperisporium* and *Stenella*. Fungal Diversity 20: 187-208.

Schubert K, Braun U. 2007. Taxonomic revision of the genus *Cladosporium* s. lat. 6. New species, reallocations to and synonyms of *Cercospora*, *Fusicladium*, *Passalora*, *Septonema* and *Stenella*. Nova Hedwigia 84: 189-208.

Schubert K, Braun U, Groenewald JZ, Crous PW. 2007a. *Cladosporium* leaf-blotch and stem rot of *Paeonia* spp. caused by *Dichocladosporium chlorocephalum* gen. nov. Studies in Mycology 58: 95-104.

Schubert K, Groenewald JZ, Braun U, Dijksterhuis J, Starink M, Hill CF, Zalar P, de Hoog GS, Crous PW. 2007b. Biodiversity in the *Cladosporium herbarum* complex (*Davidiellaceae*, *Capnodiales*), with standardisation of methods for *Cladosporium* taxonomy and diagnostics. Studies in Mycology 58: 105-156.

Schubert K, Braun U, Mułenko W. 2006. Taxonomic revision of the genus *Cladosporium* s. lat. 5. Validation and description of new species. Schlechtendalia 14: 55-83.

Schubert K, Ritschel A, Braun U. 2003. A monograph of *Fusicladium* s. lat. (hyphomycetes). Schlechtendalia 9: 1-132.

Trail JWH. 1889. Fungi of Inverary II. Micromycetes. Scottish Naturalist (Perth) 4: 57-76.