PREFACE

DEDICATION

This volume of the *Studies in Mycology* is dedicated to the memory of Gerardus Albertus de Vries (1919–2005), who spent his scientific career as mycologist at the CBS, where he was appointed as medical mycologist.

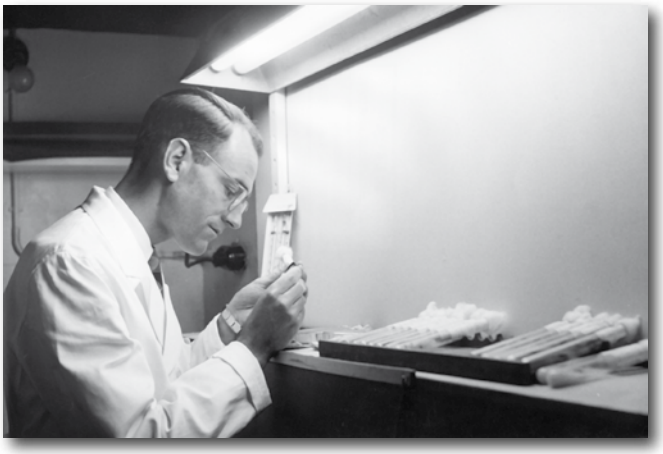

Fig. 1. Gerard de Vries studying *Cladosporium* spp. on different cultural growth media.

On the 10th of July 1952, Gerard de Vries graduated from the University of Utrecht, where he completed his Ph.D. on the topic "*Contribution to the knowledge of the genus Cladosporium Link ex Fr.*" under the guidance of the then director of the CBS, Prof. dr Johanna Westerdijk. At this time, his thesis (de Vries 1952) represented a benchmark and synthesis of our knowledge and understanding of *Cladosporium* spp. studied in culture (Fig. 1).

Gerard de Vries learned the basics of mycology by working during the 1930's with mushroom taxonomy under the guidance of Abraham van Luyk. Via van Luyk he was also introduced to the Dutch Mycological Society, who organised excursions, also around Baarn, which is where the de Vries family lived. For the rest of his career, Gerard would retain his love for studying and collecting mushrooms. In 1948 he was employed at CBS under Johanna Westerdijk, and given the task of establishing and heading a new division called Medical Mycology. This he did, right up to his retirement in 1984. For several years de Vries played an important role in this discipline, and attended numerous medical congresses and workshops, and also published extensively on the topic. De Vries loved the outdoors and traveling, and combined this with his other passion, which was ornithology (van der Aa 2005). In 1952 he graduated from the University of Utrecht, producing a revision of major species in the genus *Cladosporium* of importance to the medical, industrial and plant pathology disciplines. His book soon became highly popular, and with a strong demand for additional copies, resulting in it being reprinted by J. Cramer. His contribution to *Cladosporium* was also recently acknowledged with the introduction of the cladosporium-like heat-tolerant genus, *Devriesia* by Seifert *et al*. (2004). Additional books published by de Vries dealt with mushrooms for amateur mycologists (1955) and a treatment of *Hypogaea* and truffels published in 1971 as part 3 of the "Fungi of the Netherlands" (van der Aa 2005).

Gerard de Vries was a well tempered, softly spoken man, who avoided conflicts, except when it dealt with scientific issues. He never married, and died a bachelor, surrounded by a circle of loyal friends and fellow mycologists dating back to the "Baarn-era" of CBS. To the very end the CBS received a yearly Christmas card, which was always a water colour painting depicting some fascinating birds that he happened to be studying at the time. The *Cladosporium* notebooks, annotations and live cultures are still at the CBS. It is thus with great joy that we dedicate this volume to Gerard de Vries, and build on his *Cladosporium* legacy, most of which is still sporulating, and will be available for scientific debate for generations to come.

The genus *Cladosporium* and similar dematiaceous hyphomycetes

INTRODUCTION

Species of *Cladosporium* are common and widespread, and interact with humans in every phase of life, from growing behind your bed or bedroom cupboard and producing allergens, or growing on the bathroom ceiling, to the fruit decay happening in the fruit basket in the kitchen, to colonising the debris lying outside your house, and even the plant diseases observed on some of the shrubs, trees, or flowers cultivated in your garden. However, scientists generally shy away from trying to identify these similar looking organisms, and therefore the main aims of this volume were to:

1) Establish standardised conditions and protocols for studying cladosporioid species and their teleomorphs in culture;
2) Determine how they can morphologically be distinguished in culture, and highlight important diagnostic features;
3) Circumscribe the genus, and delineate it from morphologically similar dematiaceous hyphomycetes;
4) Determine which DNA gene loci are informative to accurately distinguish species of *Cladosporium*, and initiate a database of *Cladosporium* sequences that can in future be used to set up an online polyphasic identification key.

Although *Cladosporium* is one of the largest and most heterogeneous genera of hyphomycetes, currently comprising more than 772 names (Dugan *et al*. 2004), only a mere fraction of these species are known from culture, and thus the real number of taxa that exist remains unknown. Species of *Cladosporium* are commonly encountered on plant and other kinds of debris, frequently colonising lesions of plant pathogenic fungi, and are also isolated from air, soil, food, paint, textiles and other organic matters (Ellis 1971, 1976; Schubert 2005a), they are also common endophytes (Brown *et al*. 1998, El-Morsy 2000) as well as phylloplane fungi (Islam & Hasin 2000, de Jager *et al*. 2001, Inacio *et al*. 2002, Stohr & Dighton 2004, Levetin & Dorsey 2006). Some species of *Cladosporium* have a medical relevance in clinical laboratories, and also cause allergic lung mycoses (de Hoog *et al*. 2000). In spite of its obvious importance, species of *Cladosporium* are still poorly understood.

Taxonomy of the anamorph

The first binominal introduced for this group of fungi was that of *Dematium herbarum* Pers. (Persoon 1794) (Fig. 2). *Cladosporium herbarum* (Pers.) Link was subsequently selected to serve as

lectotype for the genus by Clements & Shear (1931), a proposal which was accepted by de Vries (1952), Hughes (1958), and others (Prasil & de Hoog 1988). In subsequent years the number of taxa described in the genus grew rapidly, though the generic concept was rather vague. As a consequence, numerous morphologically similar dematiaceous hyphomycetes with catenulate conidia were incorrectly assigned to *Cladosporium*, making this one of the largest genera of hyphomycetes.

In an attempt to circumscribe some of the more well-known taxa, de Vries (1952) published a revision of nine *Cladosporium* species *in vivo* and *in vitro*, and 13 additional taxa in an appendix. Ellis (1971, 1976) described and illustrated 43 species, while Morgan-Jones and McKemy dealt with selected species in the series "Studies in the genus *Cladosporium s. lat.*" (Morgan-Jones & McKemy 1990, McKemy & Morgan-Jones 1990, 1991a–c). Other significant works that also treated *Cladosporium* species include Ho *et al*. (1999), and Zhang *et al.* (2003), though these authors still followed a wider generic concept. David (1997) followed the taxonomy of de Vries (1952), who first considered *Heterosporium* as a synonym of *Cladosporium*, and introduced the combination *Cladosporium* subgen. *Heterosporium*. Subsequent to this publication, further monographic studies on the genus *Cladosporium s. lat*. were initiated by Braun and co-workers (Braun *et al*. 2003, 2006, Dugan *et al*. 2004, Schubert & Braun 2004, 2005a, b, 2006, 2007, Schubert 2005a, b, Heuchert *et al*. 2005).

Treatments of human pathogenic *Cladosporium* species (Masclaux *et al*. 1995, Untereiner 1997, Gerrits van den Ende & de Hoog 1999, Untereiner & Naveau 1999, Untereiner *et al*. 1999; de Hoog *et al*. 2000), concluded that they represent species belonging to the *Herpotrichiellaceae* (*Capronia* Sacc./*Cladophialophora* Borelli). Saprobic species, which appear morphologically similar, were found to belong to the *Venturiaceae* (*Caproventuria* U. Braun/ *Pseudocladosporium* U. Braun; Braun *et al.* 2003, Schubert *et al.* 2003, Beck *et al.* 2005) (see Crous *et al*. 2007 – this volume). Further genera that were separated from *Cladosporium* include *Sorocybe resinae* (Fr.) Fr. [≡ *Cladosporium resinae* (Lindau) G.A. de Vries, teleomorph: *Amorphotheca resinae* Parbery; Partridge & Morgan-Jones 2002] (see Seifert *et al*. 2007 – this volume), *Devriesia* Seifert & N.L. Nickerson, erected for heat tolerant species (Seifert *et al.* 2004), *Cladoriella* Crous, erected for saprobic species (Crous *et al*. 2006b), *Metulocladosporiella* Crous, Schroers, Groenewald, U. Braun & K. Schub., erected for the causal agent of banana speckle disease (Crous *et al*. 2006a), *Digitopodium* U. Braun, Heuchert & K. Schub. and *Parapericoniella* U. Braun, Heuchert & K. Schub., representing two genera of hyperparasitic hyphomycetes (Heuchert *et al*. 2005).

Fig. 2. Type specimen of *Dematium herbarum* Pers. (1794), preserved in the National Herbarium of the Netherlands in Leiden.

Taxonomy of the teleomorph

Teleomorphs of *Cladosporium* have traditionally been described in *Mycosphaerella* Johanson. The first indication that this may not be the case was the rDNA ITS sequence data presented by Crous *et al*. (2001), which revealed cladosporium-like taxa to cluster basal to *Mycosphaerella s. str.* This finding was further strengthened by adding 18S rDNA data, which clearly distinguished the *Cladosporium* clade from *Mycosphaerella* (Braun *et al.* 2003). These results lead to the erection of the genus *Davidiella* Crous & U. Braun for teleomorphs of *Cladosporium*, though it was largely established based on its unique anamorphs, rather than distinct teleomorph features. In a revision of the genus *Mycosphaerella*, Aptroot (2006) provided the first clear morphological characteristics to distinguish *Davidiella* from *Mycosphaerella*, referring to their sole-shaped ascospores, and angular lumina that are to be seen in *Davidiella* ascospores. Further phylogenetic evidence for the distinction was found by Schoch *et al*. (2006), which led to the erection of the family *Davidiellaceae* (*Capnodiales*). Detailed cultural studies of *Davidiella* teleomorphs, however, were still lacking (see Schubert *et al*. 2007 – this volume).

What is *Cladosporium*?

David (1997) provided the first modern concept of *Cladosporium* by conducting comprehensive scanning electron microscopic (SEM) examinations of the scar and hilum structure in *Cladosporium* and *Heterosporium*, thereby confirming the observations of Roquebert (1981). He introduced the term "coronate" for the *Cladosporium* scar type, which is characterised by having a central convex part (dome), surrounded by a raised periclinal rim (Fig. 3), and proved that these anamorphs are linked to teleomorphs now placed in *Davidiella* (see David 1997, fig. 12).

This new concept of *Cladosporium s. str*. and *Davidiella* (David 1997, Braun *et al*. 2003, Aptroot 2006), supported by morphological and molecular data, rendered it possible to initiate a comprehensive revision of the genus. The first step was the preparation of a general, annotated check-list of *Cladosporium* names (Dugan *et al*. 2004), followed by revisions of fungicolous (Heuchert *et al*. 2005) and foliicolous species of *Cladosporium s. lat*. (Schubert 2005b, Braun *et al.* 2006, Schubert & Braun 2004, 2005a, b, 2006, 2007). The present study is the first to integrate these concepts on cladosporioid species in culture, in an attempt to further elucidate species of *Cladosporium*, and delineate the genus from other, morphologically similar dematiaceous genera that have traditionally been confused with *Cladosporium s. str*.

How natural should anamorph genera be?

Article 59 of the International Code of Botanical Nomenclature was introduced to enable mycologists to name the asexual states of fungi that they encountered, and for which no teleomorph association was known. It was and remains a completely artificial system, complicated further by the evolution of the same anamorph morphology in different families, and even orders. In 1995 Gams discussed "How natural should anamorph genera be", concluding that paraphyletic genera should be an acceptable option, and that anamorphs cannot reflect natural relationships. In a special volume dedicated at integrating molecular data and morphology, Seifert *et al*. (2000) proposed using anamorph names as adjectives, e.g., acremonium-like, when they clustered in different clades, or were linked to different teleomorphs than the type species of the genus

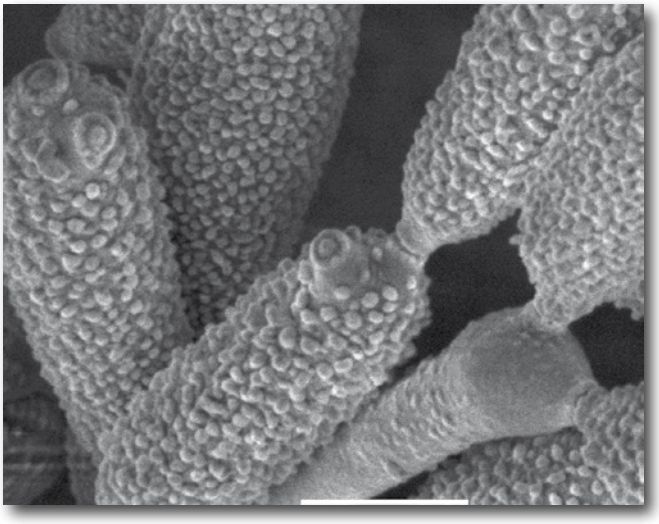

Fig. 3. Coronate scar structure of *Cladosporium herbaroides*, visible by means of Scanning Electron Microscopy. Scale bar = 5 μm (Photo: Jan Dijksterhuis).

Acremonium. In a phylogenetic study of the *Herpotrichiellaceae*, Haase *et al*. (1999) proposed to accept anamorphs as poly- and paraphyletic within the order *Chaetothyriales*, as their taxonomy was unsupported by phylogeny, and Cook *et al*. (1997) as well as Braun *et al.* (2002) followed this methodology in naming anamorphs of the *Erysiphaceae* (*Erysiphales*). After much debate, we have chosen to use the same approach in this volume, and will refrain from introducing different anamorph genera for the same phenotype clustering within different clades of the same order. It is hoped that this approach will stop the unnecessary proliferation of names, until we can move to a single nomenclature for ascomycetous fungi.

Anamorphs are just form taxa, established for the sole purpose of enabling mycologists to name asexual states that occur in the absence of their teleomorphs. Anamorph genera are simply phenotypic concepts that lack phylogenetic relevance within the order.

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The Editors *1 July 2007*

Propositions for this volume:

"Evolution gives rise to lineages, which we try to recognise as genera and species"

"The most interesting fungi are those isolated by accident"