

## The current systematics and taxonomy of the powdery mildews (Erysiphales): an overview

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**Abstract** A brief survey of the current systematics and taxonomy of powdery mildews (Erysiphales) is given with special focus on new characters used for taxonomic purposes as well as new approaches, methods and techniques. The structure of the family Erysiphaceae based on phylogenetic results is summarized, and the current, strongly increased number of powdery mildew taxa in a planned new monographic treatment of this fungal group is given and compared with the old monograph from 1987.

**Keywords** Erysiphaceae · Progress · Survey · Taxonomic structure

The powdery mildews represent an important, large group of pathogenic ascomycetes of almost cosmopolitan distribution encompassing numerous diseases of economic plants. Thus, it is not surprising that these fungi have attracted the attention of biologists, mycologists and phytopathologists for a long time, actually since the very beginning of scientific mycology at the end of the eighteenth century. *Mucor erysiphe*, published by Linnaeus (1753), was the first binomial referring to a powdery mildew (now known as *Phyllactinia guttata*). The first monograph of the powdery mildews was published by Salmon (1900). The second comprehensive taxonomic treatment of this important group of plant pathogenic fungi appeared more than 20 years ago as the “Monograph of the Erysiphales” (Braun 1987). Since that time, knowledge of the biology, host range and

distribution, phylogeny and taxonomy of anamorphic as well as teleomorphic powdery mildews have rapidly increased. New, hitherto neglected morphological characters have been introduced, e.g., the position of conidiophores on the mother cell (Shin and Zheng 1998), differences in the outline of conidial chains (Shin and La 1993), shape and size of the penicillate cells in the upper half of chasmothecia of *Phyllactinia* (Shin and Lee 2002), structure and size of the thin terminal portion of asci (= oculus) (Braun et al. 2001), differences in the conidial surface when viewed by SEM (Cook et al. 1997) and details of the patterns of conidial germination (Cook and Braun 2009). Furthermore, numerous new species and hitherto unknown anamorphs of known teleomorphs have been described. A large number of regional monographs and checklists have been published. But, above all, the introduction of molecular methods in the taxonomy of the Erysiphales provided better insight into the phylogenetic context and structure of this fungal group and led to significant changes in the circumscriptions of the genera concerned (e.g., Saenz and Taylor 1999; Takamatsu et al. 1999, 2000, 2008, 2010; Mori et al. 2000; Takamatsu 2004; Matsuda and Takamatsu 2003; Hirose et al. 2005; Ito and Takamatsu 2010). The whole structure of the family Erysiphaceae has been altered and adapted in order to reflect the new anamorphic and phylogenetic knowledge. Taking its phylogeny into account, Braun et al. (2002) provided a summary of the new taxonomy of the Erysiphales. To cut a long story short, the 1987 monograph needs updating urgently as it is now badly out of date, and out of print. Therefore, the decision to prepare a new updated version of the monograph came into being in 2008. From the first idea this ambitious project has been strongly and continuously supported by the Director of the CBS in Utrecht, The Netherlands, and the whole staff of this institute. It is

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planned to finish the manuscript of the new book by the end of this year and to publish it under the following authorship and title: Braun, U. & Cook, R.T.A., Taxonomic Manual of the *Erysiphales* (Powdery Mildews).

The new generic structure of the family, consistent with its phylogeny as described in the new book, can be summarized as follows:

### **ERYSIPHACEAE** Tul. & C. Tul.

Tribe **Erysipheae** [One genus: *Erysiphe emend.* (incl. the former genera *Bulbomicrosphaera*, *Bulbouncinula*, *Furcouncinula*, *Medusosphaera*, *Microsphaera*, *Setoerysiphe*, *Typhulochaeta*, *Uncinula*, *Uncinuliella*)]

Tribe **Golovinomyceteeae** (U. Braun) U. Braun & S. Takam. (Braun & Takamatsu 2000)

Subtribe **Neoerysiphinae** (U. Braun) U. Braun & S. Takam. (Braun & Takamatsu 2000) [One genus: *Neoerysiphe*]

Subtribe **Golovinomycetinae** [One genus: *Golovinomyces*]

Subtribe **Arthrocladiellinae** (R.T.A. Cook et al.) U. Braun & S. Takam. (Braun & Takamatsu 2000) [One genus: *Arthrocladiella*]

Tribe **Cystothecaeae** (Katumoto) U. Braun (Braun 1987)

Subtribe **Cystothecinae** [Two genera: *Cystotheca*, *Podosphaera emend.* (incl. *Sphaerotheca*)]

Subtribe **Sawadaeinae** (U. Braun) U. Braun & S. Takam. (Braun & Takamatsu 2000) [One genus: *Sawadaea*]

Tribe **Phyllactiniaee** (Palla) R.T.A. Cook et al. (in Braun 1999) [Four genera: *Leveillula*, *Phyllactinia*, *Pleochaeta*, *Queirozia*]

Tribe **Blumerieae** R.T.A. Cook et al. (Cook et al. 1997) [One genus: *Blumeria*]

Tribe **Unnamed** [to accommodate the anamorph of *Oidium* subgen. *Microidium* (To-anun et al. 2005)]

It has to be mentioned that the genera *Caesporotheca* (Takamatsu et al. 2005b) and *Parauncinula* (Takamatsu et al. 2005a), situated at the very base of the large *Erysiphales* clade, are not included in this classification. Also *Brasiliomyces* is not placed in the present system of tribes, because its phylogenetic position is not yet clear. *B. malachrae* (= *B. malvastris*), the type species, and *B. Chiangmaiensis* seem to form a separate lineage that is either sister to the *Erysiphe* clade or clusters distantly (S. Takamatsu, *in litt.*). Sequences of additional species of this heterogeneous genus are needed for a final conclusion. Currently *Takamatsuella* (*ined.*) is a new genus close to *Sawadaea*, forming a sister group in molecular sequence analyses.

Several compound species have been re-examined and revised during the updating of the monograph, resulting in the splitting of these complexes, e.g., in *Phyllactinia* species, *Golovinomyces cichoracearum*, the *Podosphaera fuliginea* complex, *P. clandestina* and *P. tridactyla*, and

descriptions of several new species have been included. Thus, the number of recognised powdery mildew species has increased from 515 (including 435 teleomorphs/holomorphs) in Braun (1987) up to about 820 species (including about 685 teleomorphs/holomorphs) in the manuscript of the new book planned to be published in 2011.

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