Mycobiology 32(3): 105-109 (2004)

The Record of *Erysiphe azaleae* (Erysiphales) from Poland and Its Anamorph

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(Received June 1, 2004)

***Erysiphe azaleae*, a powdery mildew fungus on *Rhododendron* spp., was originally described from North America, and has only recently been recorded in Germany, England, Switzerland and Poland. The present paper records plentiful collections of this species from Poland, and provides additional information of its anamorphic state for taxonomic purposes.**

KEYWORDS: Biogeography, Erysiphaceae, Powdery mildew, Primary conidia, *Rhododendron*

An outbreak of powdery mildew was noticed on outdoor *Rhododendron* in the southern counties of the UK in 1981 (Brooks and Knights, 1984), but the identity of the fungus in Europe was not clear (Watling, 1985; Basden and Helfer, 1995; Ing, 2000; Inman *et al.*, 2000; Helfer, 2001). Inman *et al.* (2000) examined German collections of *Microsphaera azaleae* U. Braun (now *Erysiphe azaleae* (U. Braun) U. Braun & S. Takam.) (Braun and Takamatsu, 2000), and treated an earlier record of '*M. azaleae*' from Belgium as a new species, *M. digitata* A. J. Inman & U. Braun (now *Erysiphe digitata* (A. J. Inman & U. Braun) A. J. Inman & U. Braun).

Four species of '*Microsphaera*' (now *Erysiphe* DC. emend. U. Braun & S. Takam.) been recorded in the world (Inman *et al.*, 2000). *Erysiphe vaccinii* Schwein. is principally characterized by ascomatal appendages that are longer than those in the other three species (Braun, 1987; Inman *et al.*, 2000). Although the teleomorphic features of *Erysiphe izuensis* (Y. Nomura) U. Braun & S. Takam. and *E. digitata* are similar, they differ in appendage septation, pigmentation and branching. Furthermore, the conidia and conidiophores of *E. izuensis* are somewhat larger than those of *E. digitata* (Inman *et al.*, 2000). The former species is known only from the Far East, viz. Japan (Nomura, 1984), the Far East of Russia (Bunkina, 1979), and Korea (Shin, 2000). The latter species was recorded only in Belgium (Inman *et al.*, 2000). Finally, *E. azaleae* was first described from North America (Braun, 1982), and more recently Germany (Braun, 1997, 2003; Inman *et al.*, 2000), England (Ing, 2000), Switzerland (Inman *et al.*, 2000; Bolay, 2001) and Poland (Piatek, 2003).

In September 2001, the junior author collected several leaves of *Rhododendron luteum* bearing a powdery mildew from Poland. The causal fungus was tentatively identified as an anamorphic state of *E. azaleae*. In October 2001, the teleomorphic state of a powdery mildew was collected on leaves of *Rhododendron arborescens*. The collection contained a great number of mature ascomata on both sides of the leaves, together with a sparse conidial state. Morphological characteristics of the teleomorphic state in this specimen (LBLM 8168) were consistent with the previous description of *E. azaleae* (Table 1). These findings encouraged the authors to survey powdery mildews of *Rhododendron* throughout Poland, and 21 specimens of rhododendron powdery mildews were collected or obtained from various localities in 2002. They were deposited in the Herbarium at Maria Curie-Sklodowska University, LBLM.

Several collections, including LBLM 8185, contained both anamorph and teleomorph on the same colony of powdery mildew, which proved the teleomorph-anamorph connection of *E. azaleae*. The samples were examined with a modified Shin's lactic acid technique (Shin, 2000), with addition of some Acid Fuchsin to the lactic acid to increase the contrast of the hyaline structure of powdery mildew.

Inman *et al.* (2000) described the anamorphic features of *E. azaleae* in comparison with those of *E. digitata* on the basis of two collections from Germany and the USA. Recently, Bolay (2001) provided the anamorphic characteristics of this species. More recently, Braun *et al.* (2003) found the conidial form and ascomata of *E. azaleae* on *Erica gracilis* in Germany, and proved that *Oidium ericinum* Erikss. is the anamorph of the latter species. Furthermore, a powdery mildew found on *Rhododendron* in Britain, and possibly also in other European countries, produces conidial chains of various length; a character not normally associated with *Erysiphe* or its sections (sect. *Microsphaera*; sect. *Uncinula*; sect. *Erysiphe*). Nevertheless, more information on the conidial state of these two species is urgently needed for taxonomic purposes.

A microscopic examination of the conidial state of the

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Table 1. Comparative characters of the teleomorph of *Erysiphe azaleae* on *Rhododendron*

Character	Braun (1982)	Inman *et al.* (2001)	Present material
Ascoma			
diameter (μm)	100-130	113-139	110-140(-150)
Appendage			
form	stiff to flexuous	stiff to flexuous	stiff to flexuous
pigment	hyaline	hyaline, occ. very pale brown at base	hyaline throughout
septa	0(-1)-septate	0-1-septate at base	0(-1)-septate
wall	thin; thicker at base	thin; thicker at base	thin; thicker at base
branches	4-6	4-5(-6)	4-5(-6)
branching	regular, compact	regular, compact	regular, compact
tips	recurved	recurved	recurved
number	10-40	10-32	12-34(-42)
length*	× 1-1.5(-2)	× 0.5-1(-1.2)	× 0.8-1.3
width (μm)	6-10	8-10	6-10
Ascus			
number	4-10	5-9	5-10
length (μm)	35-60	52-74	50-68(-76)
width (μm)	35-50	34-50	35-45(-52)
Ascospore			
number	4-6(-7)	4-8	(5-)6-8
length (μm)	17-28	15-24	15-25
width (μm)	10-15	11-14	10-14

*times of ascomata diameter.

Polish collections reveals that they greatly resemble the previous description by Inman *et al.* (2000). The LBLM 8185 (*R. luteum*) is used to describe the anamorphic state of *E. azaleae*, and those features of taxonomic value that were not described previously are provided.

Conidial state of *Erysiphe azaleae* (U. Braun) U. Braun & S. Takam. Figs. 1, 2

Mycelium amphigenous, mostly epiphyllous, in some collections only hypophyllous, persistent to subpersistent, forming circular white patches on the upper leaf surface, evanescent to thinly effused on the lower leaf surface. **Hyphae** hyaline, substraight to wavy, geniculate, 35~70 (~95) × (3~)4~7 μm, mostly branching at right angles, usually with a septum near the branching point, secondary hyphae not observed. **Appressoria** well developed, multilobed to moderately lobed, in pairs or single. **Primary conidiophores** differentiated from the secondary ones by possessing an uppermost primary conidium, followed by 2 straight cells and a rather long foot-cell, thus mostly composed of 4 cells when mature. **Secondary conidiophores** single on a hyphal cell, arising from the upper or lateral part of mother cells, position mostly central, occasionally non-central, 32~80 × 5~7 μm in epiphyllous ones, (45~) 55~125 × 4~6 μm in hypophyllous ones, usually becoming broader upwards, neither constricted nor swollen at the branching point of the mycelium, producing conidia singly, followed by 1(~2) immature cells and a rather long foot-cell, thus mostly composed of 3 cells when mature, occasionally appearing as forming short chains by somewhat broadening or swelling of the second cell, twisted or kinked to flexuous at the base of foot-cells, with a basal septum at the branching point of the mycelium. **Primary conidia** differentiated from the secondary conidia by having rounded apex and subtruncate base, mostly smaller than the secondary ones, (20~)24~32 × 11~13 μm, broadest part non-median, obovoid with broad subtruncate base, producing germ tubes at the basal or terminal end. **Secondary conidia** oblong to cylindrical or somewhat doliiform, mostly symmetric at both ends, (18~)22~38 × 10~13 μm (length/width = 2.0~3.3), without conspicuous fibrosin bodies, occasionally guttulate, producing terminal germ tubes.

Materials examined: On ***Rhododendron arborescens*** (Pursh) Torr, LBLM 8168 (26 Oct 2001, Kotlina Sandomierska Basin, Bolestraszyce, Arboretum, Poland, leg. W. Mulenko). On ***Rhododendron japonicum*** (A. Gray) J.V. Suring, LBLM 8175 (5 Aug 2002, Silesia region, Wroclaw, Botanical Garden, Poland, leg. J. Mazurek). On ***Rhododendron luteum*** Sweet, LBLM 8185 and 8186 (20 Sep 2001, Sanatorium center, Kotlina Klodzka Basin, Ladek Zdroj, Poland, leg. W. Mulenko), LBLM 8187, 8188 and 8189 (20 Sep 2001, Arboretum, Kotlina Klodzka Basin, Ladek Zdroj, Poland, leg. W. Mulenko), LBLM 8169 and 8170 (20 Aug 2002, Pomerania, Darlowko near Darlowo, Poland, leg. W. Mulenko), and LBLM 8183 (5 Aug 2002, Silesia, Wroclaw, Botanical Garden, Poland, leg. J. Mazurek). On ***Rhododendron occidentale*** Torr. & A. Gray, LBLM 2971 (5 Aug 2002,

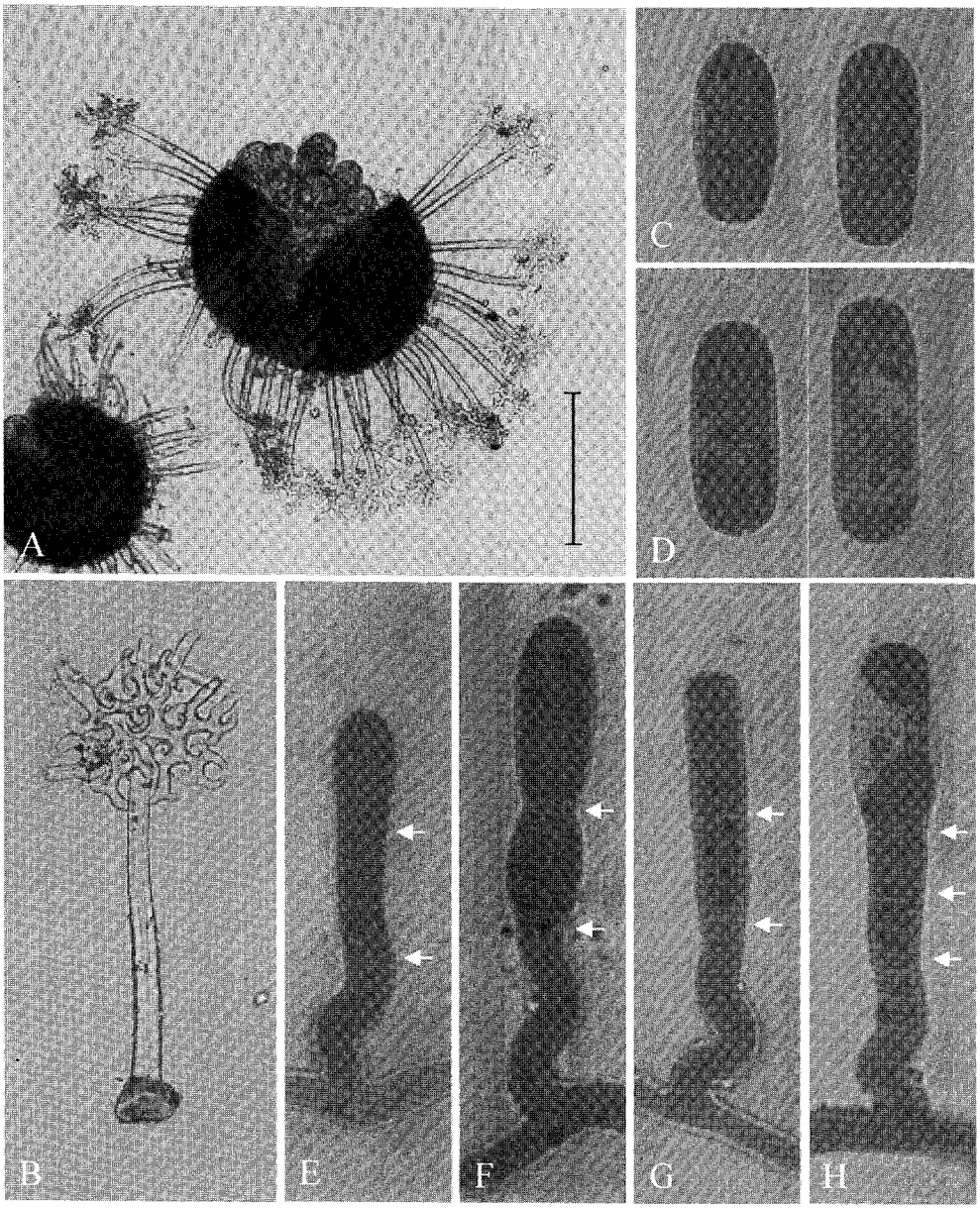

Fig. 1. *Erysiphe azaleae*. (**A**) Ascoma showing short, stiff to mildly flexuous appendages and several asci. (**B**) An appendage thick-walled at the base and thinner upwards; branching is regular, close, and compact with recurved apex. (**C**) Primary conidia having subtruncate base and rounded apex. (**D**) Secondary conidia having symmetric ends. (**E, F**) Primary conidiophores composed of four cells; the apex of the terminal primary conidium is rounded. (**G**) Secondary conidiophore composed of three cells; the apex remains truncate just after producing a conidium. (**H**) Secondary conidiophore composed of four cells; the terminal cell (conidium) is swollen with a subtruncate apex. The conidia and conidiophores (C-H) are originally hyaline. The dark color of these structures is due to biological staining with lactofuchsin. Arrows indicate the position of septum. Bar = 30 μm.

Silesia, Wroclaw, Botanical Garden, Poland, leg. J. Mazurek). On **hybrid *Rhododendron*** (5 Aug 2002, Silesia, Wroclaw, Botanical Garden, Poland, leg. J. Mazurek), LBLM 8172 (cv. Golden Sunset), 8174 (cv. Hostpur Bed), 8178 (cv. Hostpur Bed), 8181 (cv. Berryrose), 8177 (cv. Speks Brilliant), 8176 (cv. Mollis von Gneist), 8184 (cv. Conte de Quincy), 8179 (cv. Christophen Wren), 8180 (cv. Saturnus), 8182 (cv. Kosters Brilliant Bed), and 8171 (cv. Killan).

Note: The most distinctive feature of this anamorph is the kinking of the basal part of the conidiophore foot-cells. This feature is shared by *E. izuensis*, whose larger conidia and conidiophores differentiate it from the present species (Nomura, 1984; Inman *et al.*, 2000). The kinking or twisting at the base of the conidiophores seems to be more prominent in *E. azaleae* than in *E. izuensis*. Our measurements of conidiophores and conidia are not deviated from those of Bolay (2001).

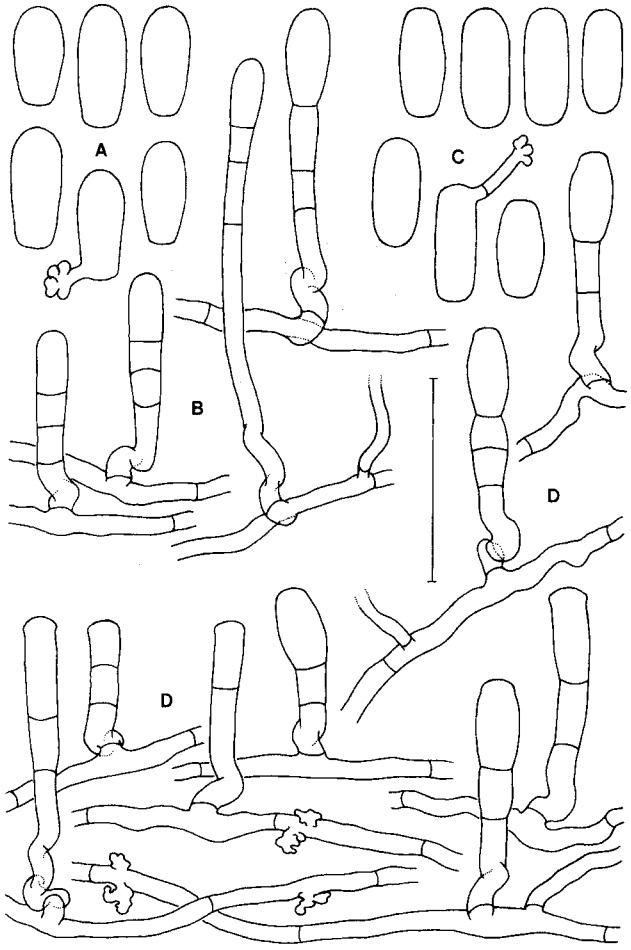

Fig. 2. Anamorphic characteristics of *Erysiphe azaleae*. (**A**) Primary conidia. (**B**) Primary conidiophores. (**C**) Secondary conidia. (**D**) Secondary conidiophores. Bar = 50 μm.

The conidia in our collections were positively consistent with those in Inman *et al.* (2000) and Bolay (2001). The present observation provides the first description of primary conidia of this species, characterized by a rounded apex and a subtruncate base (Figs. 1C, 2A). A similar shape of primary conidia was described and illustrated for *Erysiphe weigelae* Z.X. Chen & S.B. Luo (Shin and Choi, 2003) and the majority of powdery mildew fungi (Shin, 2003, unpublished data). On the other hand, the secondary conidia of this species are characterized by having symmetric ends (Figs. 1D, 2C).

Conidiophores of *E. azaleae* are composed of 2~4(~5) cells. The primary conidiophore bearing a primary conidium at the apex is usually 4-celled, rarely 3-celled, at maturity (Figs. 1E, 1F, 2B). The subtruncate apex of the apical cell characterizes the secondary conidiophore (Figs. 1G, 1H, 2D), which is usually 3-celled, but occasionally 2- or 4-celled.

The length of conidiophores of this species varies by 32~125 μm, mostly on account of the length of foot-cells. Although the conidiophores on the lower leaf surface are characteristically longer and narrower than those on the upper leaf surface, there was no difference in the number of their constituent cells. A similar phenomenon was previously noticed in *Uncinula necator* (Schwein.) Burrill (now *E. necator* Schwein.) (Yarwood and Gardner, 1970) and *Microsphaera alphitoides* Griffon & Maubl. (now *E. alphitoides* (Griffon & Naulbl.) U. Braun and S. Takam.) (Shin, 2000).

Inman *et al.* (2000) recorded that conidia of this species were formed singly, but sometimes remained attached in short chains when mature. We also found a short chain of conidia on conidiophores from Polish material (Fig. 1F). The formation of short chains of mature conidia on conidiophores is not uncommon in powdery mildews belonging to section *Pseudoidium*, as previously described or illustrated for several species, viz. *E. alphitoides* (Shin, 2000), *Oidium neolycopersici* Kiss *et al.* (Jones *et al.*, 2001), and *Erysiphe* sp. on *Glycine* spp. (Takamatsu *et al.*, 2002).

It is hoped that the present observation on the anamorphic feature of *E. azaleae* will stimulate further comparative investigation about the conidial characteristics of rhododendron powdery mildews species for taxonomic purposes.

Acknowledgements

We are indebted to Dr. A. J. Inman, Central Science Laboratory, UK, for critical comments and suggestions on the manuscript. Many thanks are due to Dr. J. Mazurek (Wroclaw Botanical Garden) and Dr. N. Piorecki (Bolestraszyce Arboretum) of Poland for collecting and providing access to their *Rhododendron* specimens infected by powdery mildew.

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