Epidemic spread of *Erysiphe flexuosa* (North American powdery mildew of horse-chestnut) in Europe

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The European epidemic spread of *Erysiphe* (*Uncinula*) *flexuosa*, the North American horse-chestnut powdery mildew fungus, is discussed. New collections of this plant disease from Austria, Croatia, Czech Republic, France, Poland, Slovakia and Switzerland on leaves and occasionally stems of *Aesculus × carnea*, *A. chinensis*, *A. hippocastanum*, *A. indica*, *A. neglecta* and *A. × plantierensis* from 2000 and 2001 are reported. The taxonomy of this fungus is discussed and disease symptoms and microscopic features, including some new observations, are described and illustrated.


**Introduction**

Powdery mildews (Ascomycota, Erysiphales) are common plant pathogenic fungi of almost worldwide distribution (BRAUN 1987). Introductions of these pathogens in remote territories outside their natural distribution areas, followed by epidemic spreads, are not uncommon (GORLENKO 1983; WELTZIEN 1978; BRAUN 1987, 1995). *Erysiphe flexuosa* (Peck) U. Braun & S. Takamatsu (≡ *Uncinula flexuosa* Peck), a common North American horse-chestnut powdery mildew fungus, is a new case of a recent introduction of an exotic powdery mildew disease in Europe. ALE AGHA et al. (2000) and BOLAY (2000) published first records of this fungus from Germany and Switzerland, respectively. First records from Poland, Slovakia and Great Britain have recently been published by PIATEK (2002), ZIMMERMANNOVÁ-PASTIRČÁKOVÁ & PASTIRČÁK (2002) and ING & SPOONER (2002), respectively. Recently, an epidemic spread of *E. flexuosa* in Europe is to be observed, which is described in this paper. Furthermore, new morphological-anatomical data of the anamorph and teleomorph of this species are described and illustrated.

**Materials and methods**

Fresh leaves of *Aesculus* spp. with powdery mildew infections were used for identification purposes and for morphological examinations of the anamorphic and teleomorphic states
of the fungus by means of standard light microscopy. Mycelium, conidiophores, conidia and ascomata were mounted in distilled water, pure lactic acid, lactic acid stained with aniline blue and polyvinyl alcohol-lactic acid-glycerol (PVLG, Koske & Tessier 1983) and a mixture of PLVG and Melzer’s reagent (1:1, v/v). Descriptions of colours follow Kornerup & Wanscher (1983).

Voucher specimens of the collections from Poland are deposited at DPP (University of Agriculture, Department of Plant Pathology, Szczecin, Poland), collections from Austria (Tulln) and Slovakia (Bratislava) are at BRA (Slovak National Museum, Mycological Herbarium, Bratislava, Slovakia) and samples from France and Switzerland are at G (Conservatoire et Jardin botaniques de la Ville Genève, Herbarium, Chambéry/Genève, Switzerland). Specimens from Croatia and other places in Austria and Slovakia are deposited in the private herbarium of K. Zimmermannová-Pastirčáková.

**Results and Discussion**

**Taxonomy**

Braun (1987) described and illustrated ascomata of *Uncinula flexuosa*, the North American horse-chestnut powdery mildew, in detail, but the description of the anamorph was very brief and incomplete since fresh material of this fungus was not available to the author in that time. Based on short bristle-like appendages in the upper part of the ascomata in addition to ‘normal’ *Uncinula*-like long equatorial appendages, Braun (1981) assigned *Uncinula flexuosa* to *Uncinuliella* R.Y. Zheng & G.Q. Chen. Braun (1995) discussed the taxonomic value of these short bristle-like appendages and reduced *Uncinuliella* to synonym with *Uncinula* Lév. Comprehensive molecular examinations of powdery mildew fungi (Takamatsu et al. 1999; Mori et al. 2000) showed that the features of the teleomorphs (ascomata) have generally been overrated in this fungal group and that the anamorphs (appressoria, conidiophores and conidia) are more important for phylogenetic and taxonomic considerations. Based on these results and new SEM investigations of powdery mildew anamorphs (Cook et al. 1997), Braun & Takamatsu (2000) proposed a reassessment of *Uncinula* and allied genera with anamorphs of *Oidium* subgen. *Pseudoidium* Jacz. (appressoria lobed, conidia formed singly) and introduced *Erysiphe* DC. emend. (incl. *Erysiphe* sect. *Erysiphe*, *Microsphaera* Lév. and *Uncinula*, incl. *Uncinuliella*) as well as the new combination *Erysiphe flexuosa*:

≡ *Uncinula flexuosa* Peck, Trans. Albany Inst. 7: 215 (1872)

**Morphology**

Symptoms: Powdery mildew disease, amphigenous, often epiphyllous, forming thin superficial whitish or greyish white mycelial patches or effuse, arachnoid mycelial growth, evanescent to subpersistent (Fig. 1). Ascomata scattered to gregarious, minute, blackish.

Microscopic features: Mycelium superficial; hyphae creeping, sparingly branched, septate, hyaline, smooth, 2-6(-7.5) µm wide; haustoria globose-ellipsoid, pear-shaped to irregular,
Figs 1-7: *Erysiphe flexuosa* from leaves of *Aesculus hippocastanum*. 1, white powdery colonies on a leaf; 2, ascoma; 3, hypha (Hp) and appressorium (A); 4, haustorium (H) in an epidermal cell mounted in lactic acid stained with aniline blue; 5, conidium (O) and foot-cell (FC); 6, conidia; 7, germinated conidium [2: light microscopy; 3-7: differential interference contrast]. Bars: 2 = 160 µm; 3-7 = 10 µm (figures by I. Adamska and J. Błaszkowski).
5.0-10.0 x 7.5-12 µm (Fig. 4); appressoria lobed, solitary or in pairs, opposite, 3-8 µm diam. (Fig. 3). Conidiophores arising from creeping hyphae, lateral, erect, foot-cells straight, cylindrical to curved or flexuous-sinuous, 15-45 x 5-11.5 µm, followed by (0-1)-2(-3) shorter cells, occasionally followed by a single cell of about the same length or somewhat longer; conidia solitary, cylindrical (- ellipsoid-doliiform), 25-40(-46) x 9-17 µm, conidial germination agreeing with the ‘Polygoni type’ (Figs 5-7). Ascomata subglobose (Fig. 2), (65-)80-150(-170) µm diam., colour burn Sienna (7D8) to English red (8D8), peridium composed of two layers (Figs 10-12), outer layer, which gives raise to appendages, solid, hyaline to orange white (4A2), followed by a second layer of polygonal cells, 5-27 µm diam., burn Sienna (7D8) to English red (8D8), long appendages (type I) more or less equatorial, 20-60, 0.5-1.5 times as long as the ascomatal diameter (ca. 100-180 µm long), 4.5-8.5 µm wide at the base, aseptate, hyaline or sometimes brownish at the very base, and somewhat increasing towards the apex, 7-12 µm wide above, wall somewhat thickened below, ca. 1.5-2.2 µm, and thin above, ca. 0.5-1.0 µm, smooth to rough-walled below, apical part undulate-heliodic, tips closely circinate, hardly enlarged (Figs 8-9); short bristle-like appendages (type II) scattered in the upper half, simple, 10-50 x 3-7.5 µm, somewhat attenuated towards the apex, hyaline, aseptate, rough-walled (Fig. 8); asci 5-12(-19), saccate, sessile or short-stalked, 40-70 x 25-40 µm, (5-)6-8-spored (Fig. 13); ascospores ellipsoid-ovoid, one-celled, hyaline, (10-)15-28 x 9-13 µm.

The first observation of the conidial germination belonging to the ‘Polygoni type’ was based on material from Poland. In the ascomata of this material, it was also observed for the first time that the outer layer of the peridium in E. flexuosa is a solid, pale, colourless to light layer, followed by an inner layer of dark polygonal cells, although the peridial structure of ascomata in the Erysiphales was generally described to be composed of an outer layer of dark, thick-walled cells followed by an inner layer of pale, thin-walled cells (BRAUN 1987, 1995). In E. flexuosa, the short (type II) and long (type I) appendages arise from the outer pale layer. Similar two-layered wall structures with a pale outer layer have also been observed in Erysiphe necator Schwein., the grape powdery mildew, and Sawadaea bicornis (Wallr.: Fr.) Homma, a maple powdery mildew (GADOURY & PEARSON 1990, Adamska, Błaszkowski and Madej, pers. observ.). Ontogenetic investigations of GADOURY & PEARSON (1990) showed that the solid, pale outer layer in E. necator originates by a gradual sealing up and, thereby, decaying of two or three outer layers with age.

**Host range and distribution**

This species is widespread in North America (Canada, USA; on Aesculus × carnea, A. glabra, A. hippocastanum, A. neglecta, A. octandra, A. parviflora, A. pavia and A. sylvatica; ANONYMOUS 1960; CONNERS 1967; FARR et al. 1989; GINNS 1986; GRAND 1985; HEPTING 1971; PIRONE et al. 1960) and has been recorded from the Far East of Russia (on A. hippocastanum, in a botanical garden; BUNKINA 1991). Since 1999, this species has been observed in Europe (on A. × carnea, A. chinensis, A. hippocastanum, A. indica, A. neglecta and A. × plantierensis; Austria, Croatia, France, Germany, Poland, Slovakia, Switzerland, UK; ALE-AGHA et al. 2000, BOLAY 2000, Ing & Spooner 2002, ZIMMERMANNOVÁ-PASTIRČÁKOVÁ & PASTIRČÁK 2002, new collections in this paper).
Figs 8-13: *Erysiphe flexuosa* from leaves of *Aesculus hippocastanum*. 8, appendages of types I (AI) and II (AII); note the warts (W) in the lower part of appendages of type I. 9, circinate apices (Ap) of appendages of type I. 10, wall layers 1 (L1) and 2 (L2) of a young ascoma. 11, wall layers 1 (L1) and 2 (L2) and verruculose appendage of type I of a mature ascoma. 12, polygonal cells of the ascomatal wall layer 2 in plan view. 13, asci with ascospores in PVLG+Melzer’s reagent. 8-13: differential interference contrast. Bars: 8-13 = 10 µm (figures by I. Adamska and J. Błaszkowski).

[The specimens from Austria, Croatia and Slovakia were identified by K. Zimmermannová-Pastirčáková, those from Poland by I. Adamska and J. Błaszkowski and those from France and Switzerland by A. Bolay]. Furthermore, U. Heiniger (in litt.) collected this fungus in September and October 2001 in and around Basel, Wädenswil and Zürich (a specimen from Wädenswil is deposited at HAL, Herbarium of the Martin-Luther-University, Halle, Germany).

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**Literature:**


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