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

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Abstract: Zimmermannová-Pastirčáková, K., Adamska, I., Błaszkowski, J., Bolay, A. & Braun, U. 2002: Epidemic spread of *Erysiphe flexuosa* (North American powdery mildew of horse-chestnut) in Europe. Schlechtendalia **8**: 39-45.
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 Republik, 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.

Zusammenfassung: Zimmermannová-Pastirčáková, K., Adamska, I., Błaszkowski, J., Bolay, A. & Braun, U. 2002: Epidemische Ausbreitung von *Erysiphe flexuosa* (Nordamerikanischer Rosskastanienmehltau) in Europa. Schlechtendalia **8**: 39-45.
Die epidemische Ausbreitung von *Erysiphe* (*Uncinula*) *flexuosa*, dem Nordamerikanischen Rosskastanienmehltaupilz, in Europe wird diskutiert. Neue Funde dieser Pflanzenkrankheit der Jahre 2000 und 2001 aus Österreich, Kroatien, Frankreich, Polen, der Slowakei, Schweiz und Tschechischen Republik auf Blättern und gelegentlich Zweigen von *Aesculus* × *carnea*, *A. chinensis*, *A. hippocastanum*, *A. indica*, *A. neglecta* und *A.* × *plantierensis* werden beschrieben. Die Taxonomie dieses Pilzes wird diskutiert und Befallssymptome sowie mikroskopische Merkmale, einschließlich einiger neuer Beobachtungen, werden beschrieben und illustriert.

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

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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, Chambésy/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*:

Erysiphe flexuosa (Peck) U. Braun & S. Takamatsu, Schlechtendalia 4: 19 (2000)
≡ *Uncinula flexuosa* Peck, Trans. Albany Inst. 7: 215 (1872)
≡ *Uncinuliella flexuosa* (Peck) U. Braun, Nova Hedwigia 34: 712 (1981).

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,

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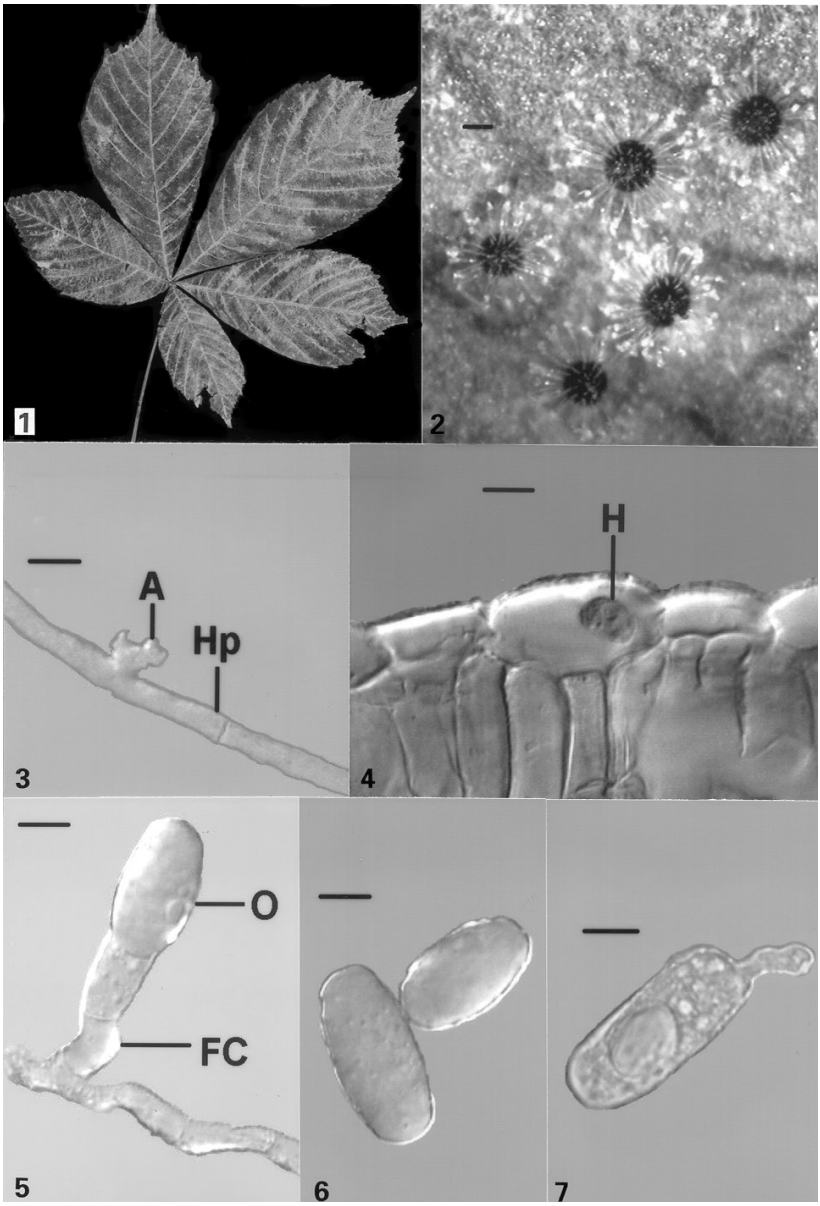

Figs 1-7: *Erysiphe flexuosa* from leaves of *Aesculus hippocastanum*. 1, white powdery colonies on a leaf; 2, ascoma; 3, hypha (Hp) and appressorium (A); 4, haustorium (H) in an epidermal cell mounted in lactic acid stained with aniline blue; 5, conidium (O) and foot-cell (FC); 6, conidia; 7, germinated conidium [2: light microscopy; 3-7: differential interference contrast]. Bars: 2 = 160 µm; 3-7 = 10 µm (figures by I. Adamska and J. Błaszkowski).

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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-helicoid, 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).

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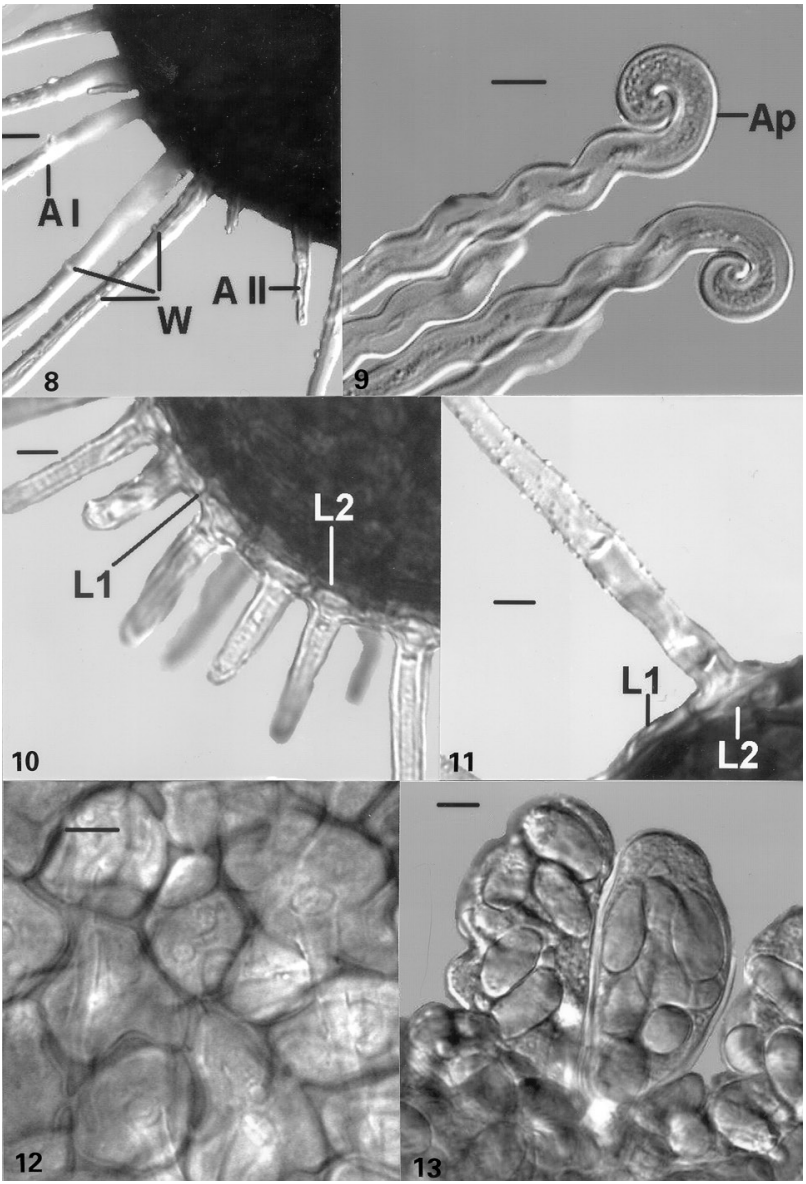

Figs 8-13: *Erysiphe flexuosa* from leaves of *Aesculum hippocastanum*. 8, appendages of types I (AI) and II (AII); note the warts (W) in the lower part of appendages of type I. 9, circinate apices (Ap) of appendages of type I. 10, wall layers 1 (L1) and 2 (L2) of a young ascoma. 11, wall layers 1 (L1) 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).

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New collections: On *Aesculus* × *carnea*, Austria: Vienna, center of the city, 30 Sept. 2001 and Tulln, front of river Danube, 22 Sept. 2001, M. Pastirčák; Czech Republ.: Prague, Mala Strana, 9 Sept. 2002, Zimmermannová-Pastirčáková; France: Haute-Savoi, along the lake of Genève, Yvoire, Aug. 2000, A. Bolay, Alsace, Colmar, Aug. 2000, A. Bolay, Gard, Anduze, Bamboo plantation of Prafrance, Sept. 2000, A. Bolay; Slovakia: Bratislava, Nove Mesto, 24 Sept. 2001, K. Zimmermannová-Pastirčáková; Switzerland: Berne, Matte, Jul. 2001, A. Bolay, Genève, Botanical Garden, Oct. 1999-2001, A. Bolay, Vaud, Morges, Quai and Lutry, Quai, Oct. 1999, A. Bolay, along the lake of Genève (Villeneuve, Chillon, Montreux, Cully, Lutry, Lausanne, Morges, Nyon), Oct. 2000, A. Bolay and Yverdon-les-Bains, Oct. 2000, A. Bolay. On *A. chinensis*, Switzerland: Vaud, Aubonne, Arboretum, Sept. and Oct. 2000, A. Bolay. On *A. hippocastanum*, Austria: Vienna, centre of the city, 30 Sept. 2001, K. Zimmermannová-Pastirčáková, Tulln, front of river Danube, 22 Sept. 2001, M. Pastirčák; Croatia: Zagreb, Cmrok, park, 20 Sept. 2001, D. Diminić; Czech Republ.: Olomouce, park, 5 Sept. 2002, Zimmermannová-Pastirčáková, Prague, Mala Strana, 9 Sept. 2002, Zimmermannová-Pastirčáková; Poland: Szczecin, [Agricultural University, 5 Oct. 2000, I. Adamska, DPP 2356, 2357, at Chopin and Wszystkich Świętych streets, 3-4 Oct. 2001, I. Adamska, DPP 2360, 30 Oct. 2001, I. Adamska, DPP 2362, at Cyryl and Metody street, 3-4 Oct. 2001, I. Adamska, DPP 2363], Kluki, Słowiński National Park, Skansen museum, 22 Aug. 2001, I. Adamska, DPP 2358 and 18 Sept. 2001, I. Adamska, DPP 2361; Slovakia: Bratislava, military hospital, 28 Sept. 2001, K. Zimmermannová-Pastirčáková, Pezinok, castle park, 27 Sept. 2001, G. Juhasova and Zilina, town park, 15 Aug. 2001, K. Zimmermannová-Pastirčáková; Switzerland: everywhere in the lake of Genève region since 2000, A. Bolay. On *A. indica*, Switzerland: Genève, Botanical Garden, Oct. 2001, A. Bolay. On *A. neglecta* and *A.* × *plantierensis*, Switzerland: Vaud, Aubonne, Arboretum, Oct. 2000, A. Bolay.
[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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