

A powdery mildew (*Pseudoidium* sp.) found on *Chelidonium majus* in the Czech Republic and Slovakia

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The find of a powdery mildew (*Pseudoidium* sp.) on *Chelidonium majus* in the Czech Republic and Slovakia is reported. Disease symptoms and morphological characteristics of the anamorph are described. No teleomorph was observed. Morphology and distribution of other powdery mildew species on hosts of the *Papaveraceae* are discussed. We point out the need for phylogenetic analysis of three closely related species (*Erysiphe cruciferarum*, *E. hylomeci*, and *E. macleayae*) and determination of its relationship to the fungus on *C. majus*.

Key words: *Erysiphaceae*, *Erysiphe* s. str., morphology, *Papaveraceae*.

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V článku je publikovaný prvý nález múčnatkotvarej huby (*Pseudoidium* sp.) na *Chelidonium majus* v Českej republike a na Slovensku. Opisujeme symptómy ochorenia a morfológické znaky anamorfného štádia huby. Teleomorfné štádium huby nebolo zaznamenané. U ďalších druhov múčnatkotvarých húb na hostiteľoch čeľade *Papaveraceae* je diskutovaná ich morfológia a rozšírenie. Poukazujeme na nutnosť dodatočnej fylogenetickej analýzy troch blízko príbuzných druhov (*Erysiphe cruciferarum*, *E. hylomeci*, *E. macleayae*) a determinácie ich vzťahu k múčnatkotvarej hube na *C. majus*.

INTRODUCTION

Chelidonium majus L. (*Papaveraceae*), Greater Celandine, is native to Europe and the Mediterranean basin. Its area occupies the whole of Europe from the subarctic territories of Scandinavia down to the Mediterranean and also some temperate to subarctic territories of Asia. It is introduced in North America and New Zealand (Kubát 1988, Kadereit 2002). Although *Chelidonium* is considered to be a monotypical genus, Krahulcová (1982) divided it into two species with different chromosome numbers and different distribution areas: *C. majus* (2n=12)

distributed in Europe, Siberia and China, and *C. asiaticum* (H. Hara) Krahulc. (2n=10) distributed in East Asia and Japan.

In Europe, powdery mildew disease on *C. majus* caused by *Oidium* sp. had previously been reported from Italy (Ciferri & Camera 1962), France (Amano 1986), Lithuania (Grigaliunaite 1997), Spain (Amano 1986 – on *C. luteum* Gilib., considered to be a synonym of *C. majus*), Poland (Dynowska et al. 1999), and Hungary (Jankovics 2007). In Asian countries, Nomura (1997) recorded *Oidium* sp. on *C. asiaticum* [as *C. majus* var. *asiaticum* (H. Hara) Ohwi] from Japan; Shin (2000) described the fungus as the anamorph of *Erysiphe cruciferarum* Opiz ex L. Junell on the same host species in South Korea. Bunkina (1991) also identified *E. cruciferarum* on *C. majus* in the Russian Far East. The sexual stage of this powdery mildew on *C. majus* has not been detected so far.

Since 2006, severe powdery mildew infections were repeatedly observed on *C. majus* in Slovakia. Greater Celandine leaves infected by powdery mildew fungi were also collected in the Czech Republic in 2008. The powdery mildew fungus (*Pseudoidium* sp.) on *C. majus* was recorded for the first time in both countries. Morphological characteristics of its structures are described and illustrated below. We noted considerable resemblance in morphology of closely related powdery mildew species on hosts of the *Papaveraceae*.

MATERIAL AND METHODS

Powdery mildew specimens on leaves of *C. majus* were collected in urban areas of the Czech Republic and Slovakia. Fresh collections were examined for description by means of a standard compound microscope (Jenamed2, Carl Zeiss Jena, Germany) and measurements carried out in distilled water using oil immersion, but without any staining. The morphological structures of the fungus were photographically documented. To observe conidial germination, conidia were dusted onto dry glass slides, and incubated in a moist chamber for 24–48 h at room temperature (20–25 °C).

The specimens examined are deposited at the U.S. National Fungus Collections, USA (BPI), Martin Luther University, Institute of Biology, Geobotany and Botanical Garden, Herbarium, Halle/Saale, Germany (HAL), and in the herbarium of the Institute of Forest Ecology of SAS, Nitra, Slovakia (herb. Nitra).



Fig. 1. Leaves of *Chelidonium majus* with powdery mildew infection (Slovakia, Nitra, park around Nitra Castle, 25 Sep 2011). Photo by M. Pastirčák.

RESULTS

Field observation

The occurrence of powdery mildew on *C. majus* was first observed in Slovakia in October 2006. In 2008, the fungus was also found in the Czech Republic. White powdery mildew colonies were found on both surfaces of the leaves, but mainly on the upper surface (Fig. 1). Although Slovak localities with affected native Greater Celandine leaves were checked annually (since 2006) from late summer to winter, no teleomorph has developed up to present.

On the basis of its morphological characteristics (Fig. 2) the fungus was identified as a *Pseudoidium* sp., the anamorphic genus of *Erysiphe* sensu stricto.

Pseudoidium sp.

Description. Mycelium on leaves amphigenous, forming circular to irregular white patches, later confluent; vegetative hyphae branched, septate, hyaline,



Fig. 2. *Pseudoidium* sp.: **a** – conidiophores, **b** – hyphal appressoria, **c** – conidia (Slovakia, Nitra, Jesenského Street, park around Nitra Castle, 1 Oct 2006, BPI 877327). Scale bars = 20 μ m. Photo by M. Pastirčák.

smooth, thin-walled, 4–7 μ m wide; hyphal appressoria lobed to multilobed, solitary or opposite in pairs; conidiophores erect, simple, 85–170 μ m long, foot-cells straight or flexuous in the basal half, 35–50 \times 7.5–9.5 μ m, followed by 1–3 shorter cells (the basal septum being formed at the branching point of the mycelium, conidiophores arising mostly centrally from the top of the hyphal mother cell), producing single conidia; conidia cylindrical, doliiform, hyaline, 30–46 \times 12–18 μ m ($l/w = 2.0$ –3.6), sporadically in pseudo-chains, without fibrosin bodies; conidial germ tubes subterminal, short to moderately long, ending in a lobed appressorium. Chasmothecia not observed.

Habitat. On leaves of *Chelidonium majus* on waste ground, in hedges, and alongside walls.

Specimens examined

Czech Republic. Pardubice, Castle Park, 6 Nov 2008, leg. K. Pastirčáková (BPI 879305, HAL 2379F). – Brno, Kohoutova Street, dormitory of J.A. Komenský, 29 Aug 2009, leg. M. Pastirčák (BPI 879306). – Kroměříž, Náměstí Míru, 22 Nov 2012, leg. M. Pastirčák (herb. Nitra).

Slovakia. Nitra, Jesenského Street, park around Nitra Castle, 1 Oct 2006, leg. M. Pastirčák & K. Pastirčáková (BPI 877327, HAL 2377F). – Nitra, Zobor hill, near TB and Respiratory Diseases Institute, 8 Oct 2006, leg. M. Pastirčák (herb. Nitra). – Nitra, Pod Kalváriou, 5 Nov 2006, leg. M. Pastirčák (herb. Nitra). – Bratislava, Rusovce, 5 Dec 2006, leg. M. Pastirčák (herb. Nitra). – Veľčice, Zlaté Moravce District, 12 Dec 2006, leg. M. Pastirčák (BPI 879304, HAL 2378F). – Štitáre, Nitra District, 6 Dec 2007, leg. M. Pastirčák (herb. Nitra). – Podhorany, Nitra District, 16 Jun 2008, leg. M. Pastirčák (herb. Nitra).

DISCUSSION

Six species of powdery mildew fungi, i.e. *Erysiphe cruciferarum*, *Erysiphe hylomeci* H.D. Shin & Y.J. La, *Erysiphe macleayae* R.Y. Zheng & G.Q. Chen, *Golovinomyces orontii* (Castagne) V.P. Heluta (= *Erysiphe orontii* Castagne), *Leveillula taurica* (Lév.) G. Arnaud (= *Leveillula papaveracearum* Golovin), and *Podosphaera papaveris* (Simonyan) U. Braun & S. Takam. (= *Sphaerotheca papaveris* Simonyan) have been reported to occur on plants of about 10 genera of the family *Papaveraceae*, excluding *Fumariaceae* (Amano 1986, Braun 1987, Eliade 1990, Shin 2000, Bolay 2005). Three of them belong to *Erysiphe* s. str. and therefore have the *Pseudoidium* anamorph.

E. cruciferarum, as well as *L. taurica*, are the most common causal agents of powdery mildews on *Papaveraceae* in Asia and Europe. Although *Stylophorum diphylum* (Michx.) Nutt. and *Eschscholzia californica* Cham. are native to North America, *E. cruciferarum* infected these host plants in Switzerland (Bolay 2005) and Germany (Schmidt & Scholler 2011), respectively. Thus, records on hosts of the *Papaveraceae* mostly refer to anamorphs that morphologically coincide with *E. cruciferarum*. Bappammal et al. (1995) recorded *Oidium papaveracearum* Bappamm., Hosag. & Udaiyan (*Erysiphe* sp.) with conidiophores of the *Pseudoidium* type on *Argemone mexicana* L. in India. However, Braun & Cook (2012) consider *O. papaveracearum* to be a synonym of *Oidium matthirolae* Rayss with the teleomorph *E. cruciferarum*. Sharma & Khare (1992) also identified the powdery mildew anamorph on *A. mexicana* as *E. cruciferarum*. We are not able to verify the presence of a teleomorph in records of *Erysiphe communis* (Wallr.) Schltdl. on *C. asiaticum* from Japan (Amano 1986) and of *E. cruciferarum* on *C. majus* from the Russian Far East (Bunkina 1991, Karis 1995), so these should be considered doubtful records of *E. cruciferarum*. Likewise, based on merely anamorphic characteristics, Shin (2000) assigned powdery mildew on *C. asiaticum* (as *C. majus* var. *asiaticum*) collected in Korea to *E. cruciferarum*. His collection is morphologically close to our European specimens on *C. majus*.

E. macleayae is a unique species on account of its small chasmothecia with very long appendages and unusually large ascospores. Zheng & Chen (1981) recorded *E. macleayae* on *Macleaya cordata* (Willd.) R. Br. and *Papaver nudicaule* L. in China. Braun (1987) revised a Chinese sample of the fungus on *P. nudicaule* but failed to find any chasmothecia and considered it a doubtful record. Fakirova (1991) recorded *E. macleayae* on *Papaver somniferum* L. from Bulgaria. Fakirova's (1991: 54) description (in Bulgarian; asci 5–12 per ascoma, 2–4(6)-spored, ascospores 12.5–25 × 10–15 µm) agrees well with collections of *E. cruciferarum* on *Papaver*. Also Braun (1995) studied Bulgarian material and determined that it belongs to *E. cruciferarum*. So we cannot agree with Schmidt & Scholler (2011), who identified the Bulgarian collection as *E. macleayae*. Likewise, these authors indicated that a similar anamorph found on *C. majus* in Germany was also *E. macleayae*. Their description and illustration agree well with our observations. Furthermore, these authors found a confirmed *E. macleayae* (with mature chasmothecia) on *Meconopsis cambrica* (L.) Vig. in Germany.

E. hylomeci has been recorded only on *Hylomecon vernalis* Maxim. in Korea (Shin 2000). According to Braun & Cook (2012), this species is very close to *E. macleayae* and possibly represents just a variety of the latter species. Shin (2000) distinguished the latter species from *E. hylomeci* by having few asci per chasmothecium, with only 2–4 larger ascospores, 29–38 × 13–17 µm.

Morphological resemblance of the anamorphic stages of the closely related species *E. cruciferarum*, *E. hylomeci*, and *E. macleayae* (Tab. 1) makes it impossible to identify the mildew anamorph infecting *C. majus* using classical taxonomic methods. Therefore further molecular methods of investigation are needed to determine their relationships.

CONCLUSIONS

Based on morphological characteristics, the fungus found on leaves of *C. majus* clearly belongs to the mitosporic genus *Pseudoidium*, the anamorph of *Erysiphe* sensu stricto. It is characterised by large conidia, maturing singly (although mature conidia may hang together in pseudochains), lobed appressoria, and absence of chasmothecia. In the absence of a teleomorph, further phylogenetic analyses are necessary to identify the species of *Erysiphe* on *C. majus* and to determine its relationship to *E. cruciferarum*, *E. hylomeci*, and *E. macleayae*.

Our collections represent the first records of a *Pseudoidium* sp. on *Chelidonium majus* in the Czech Republic and Slovakia.

Tab. 1. Comparison of morphological characteristics of *Erysiphe* species on *Papaveraceae* (Braun & Cook 2012) with the Czech and Slovak material examined.

	<i>Erysiphe cruciferarum</i> <i>Argemone, Eschscholzia, Glaucium, Meconopsis, Papaver, Stylophorum</i>	<i>Erysiphe hylomeci</i> <i>Hylomecon</i>	<i>Erysiphe macleayae</i> <i>Macleaya, Meconopsis</i>	Examined material <i>Chelidonium</i>
Anamorph				
Host plant genus*				
Mycellium	amphigenous	amphigenous, mostly epiphyllous	amphigenous	amphigenous
Hypal cells (dimensions in µm)	40–75 × (2.5)3–7(10)	–	3–7 (width)	4–7 (width)
Hypal appressoria	unlobed to moderately lobed; solitary or in opposite pairs	multilobed; solitary or in opposite pairs	nipple-shaped or moderately to strongly lobed; solitary	lobed to multilobed; solitary or opposite in pairs
Conidiophores (type, length in µm)	<i>Pseudoidium</i> , 50–120	<i>Pseudoidium</i> , 75–100	<i>Pseudoidium</i> , 40–150	<i>Pseudoidium</i> , 85–170
Foot cells (dimensions in µm)	15–50 × 7–10	20–40 × 8–11	25–120 × 6–10.5	35–50 × 7.5–9.5
Conidia (shape, dimensions in µm)	cylindrical or ellipsoid-doliiform, (25)30–50(62.5) × 10–21	ellipsoid-ovoid, cylindrical, 28–40(48) × 15–18	ellipsoid-ovoid, doliiform-cylindrical, 25–50(60) × (10)11.5–20(29)	cylindrical, doliiform, 30–46 × 12–18
Teleomorph				
Chasmothecia (diameter in µm)	75–150	80–110	70–95(100)	absent
Appendages (number, shape, length)	numerous, mycelioid, rarely branched, 0.5–3.5 times the chasmothecial diam. (40–400 µm)	8–16, mycelioid, unbranched, (1)2–8(10) times the chasmothecial diam.	5–25, mycelioid, rarely branched, (0.5)1–7 times the chasmothecial diam. (up to 700 µm)	
Asci (number, dimensions in µm)	(3)4–10(12) per chasmothecium, (40)50–85 × 25–45(55)	5–12(16) per chasmothecium, 55–75 × 35–50	2–5 per chasmothecium, 40–75 × 25–60	
Ascospores (number, shape, dimensions in µm)	(2–)3–6(–8) per ascus, ellipsoid-ovoid, (15)18–30(35) × 10–18(20)	4–6 per ascus, ellipsoid-ovoid, 17–24 × 11–14	(2)3–4(5) per ascus, ellipsoid-ovoid, often with oil drops, 18–38 × 12–18	

*data sources for host range: Bolay (2005), Braun & Cook (2012), Sharma & Khare (1992)

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