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FIRST RECORDS OF TELEOMORPH OF AN INVASIVE FUNGUS *ERYSIPHE MACLEAYAE* (*ERYSIPHALES*) IN UKRAINE

Heluta V.P., Kovalchuk V.P., Chumak P.Ya. **First records of teleomorph of an invasive fungus *Erysiphe macleayae* (*Erysiphales*) in Ukraine.** Ukr. Bot. J., 2016, 73(3): 268–272.

Abstract. It is reported that in 2015 an invasive powdery mildew fungus, *Erysiphe macleayae* (*Erysiphales*, *Ascomycota*), formerly known in Ukraine only in its anamorph stage, began to form mature fruiting bodies on *Chelidonium majus* and *Macleaya microcarpa* (*Papaveraceae*). Morphologically, they are almost identical to the chasmothecia of Slovak specimens. Ukrainian materials are also similar to *E. macleayae* samples described from China although having slightly larger chasmothecia and slightly smaller asci and ascospores. Teleomorph of the fungus was found in three localities in the city of Kiev and Kiev Region. Another species of *Macleaya*, *M. cordata*, was infected only by the anamorph of *E. macleayae*. The specimens studied are stored in the National Herbarium of M.G. Kholodny Institute of Botany, National Academy of Sciences of Ukraine (*KW*). The authors assume that formation of fruiting bodies of *E. macleayae* may be caused by an extremely hot summer in 2015. Another possible explanation is that a new biotype of *E. macleayae* has migrated from South Asia into Ukraine and subsequently formed mature chasmothecia through the sexual process with the indigenous European populations of the fungus.

Key words: Europe, invasion, powdery mildews, chasmothecium, *Pseudoidium*, *Chelidonium*, *Macleaya*, *Papaveraceae*.

Introduction

A powdery mildew fungus *Erysiphe macleayae* R.Y. Zheng & G.Q. Chen (*Erysiphales*, *Ascomycota*) was described (Zheng, Chen, 1981) from China as a parasite of *Macleaya cordata* (Willd.) R. Br. (*Papaveraceae*). Recently, it has been reported (Jiang et al., 2015) that in China the fungus also infected *Chelidonium majus* L., another representative of *Papaveraceae*, forming fruiting bodies (chasmothecia). At the same time, there are many reports of anamorphic powdery mildew on *C. majus*, *M. cordata* and *M. microcarpa* Fedde in Eu-

rope. This fungus was reported under different names, such as *Oidium* sp., *Pseudoidium* sp., *E. cruciferarum* Opiz ex L. Junell, and *E. macleayae* (Blumer, 1967; Amano, 1986; Grigaliunaite, 1990; Dynowska et al., 1999; Jankovics, 2007; Ale-Agha et al., 2008; Jankovics et al., 2008; Schmidt, Scholler, 2011; Park et al., 2012; Pastirčáková, Pastirčák, 2013). Molecular studies showed that this fungus, in any case collected in recent years, belongs to *E. macleayae* (Park et al., 2012; Jiang et al., 2015; Pastirčáková et al., 2016). Since 2007, it occurs every year in Ukraine (Heluta, Kravchuk, 2015). However, until 2015, fruiting bodies of the fungus were not observed here.

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Materials and methods

In the autumn of 2015, powdery mildew samples on *Chelidonium majus* and *Macleaya microcarpa*, which contained not only mycelium, conidia and conidiophores, but also fruiting bodies, were collected in Kyiv and Kyiv Region. At the same time, on *M. cordata* only anamorphic stage of this fungus was found. The studied materials are listed below, following the characteristics of *E. macleayae* anamorph and teleomorph. The specimens are stored in the National Herbarium of M.G. Kholodny Institute of Botany, National Academy of Sciences of Ukraine (KW). The fungus was studied and photographed under a light microscope «Primo Star» (Carl Zeiss, Germany) with the camera «Canon A 300» and the software «AxioVision 4.7». Only herbarium specimens were used. The mycelium, conidiophores and conidia removed from the surface of infected leaves by a transparent adhesive tape. To restore shape and size, a piece of tape with these fungus structures was put in a droplet of 40 % lactic acid solution on a microscope slide (sticky side up), covered with a cover glass, gently heated to boiling point, then examined under the light microscope. Chasmothecia were prepared and studied in a drop of distilled water. Digital data were treated statistically when $n \geq 30$ for each character.

Results and discussion

As noted by R. Cook and U. Braun (2012), *E. macleayae* is characterized by very small fruiting bodies with long appendages and large ascospores. Morphologically, Ukrainian materials are almost identical to Slovak specimens of this fungus, which have recently been reported by Pastirčáková et al. (2016). Our samples are also close to the specimens of *E. macleayae* described from China (Zheng, Chen, 1981) although having slightly larger chasmothecia and smaller asci and ascospores. Below are description of the holomorph of the fungus and corresponding illustrations (Figure).

Erysiphe macleayae R.Y. Zheng & G.Q. Chen, Sydowia 34: 290. 1981

Mycelium at first greyish, very thin, not conspicuous, mostly on the upper side of the leaf, on the underside almost absent, then forming circular to irregular white patches, later confluent, also on stems and infructescences. *Hyphae* branched, septate, hyaline, thin-walled. *Hyphal appressoria* two times lobed to nipple-shaped, solitary or opposite doubled. *Conidiophores* erect, 80–145 μm , mainly 3- or 4-cell, foot-cells some

flexuous, 20–30 \times 6–8 μm , producing conidia singly, Pseudoidium type. Conidia elongated ellipsoid, almost cylindrical or cylindrical, hyaline, without fibrosin bodies, 32–53 \times 8.5–16 μm , length to width ratio 2.2–4.8, with the mesh surface. *Chasmothecia* mostly gregarious or of a continuous layer on the upper side of the leaf, less often scattered on the lower side of the leaf, petioles and sometimes stalks (on *C. majus*), or mainly on the lower side of the leaf in diffuse groups (on *M. microcarpa*), hemispherical, depressed below, 80–109 μm diam. *Peridium* black, shiny in reflected light, *peridial cells* not very distinct, irregularly polygonal. *Appendages* numerous, basal, mycelium-like, mainly simple, often twisted, long, up to 700 μm , brown or light brown, paler towards the hyaline apex. *Asci* 2–5(–9) per chasmothecium, ellipsoid, ovoid, mainly stipitate, (2–)3–5(–7)-spored, 44–63 \times 32–49 μm . *Ascospores* very variable in form and size, from short-ellipsoid to elongated ellipsoid, frequently ovate, oblong-ovate, often asymmetric, recurved, slightly constricted, up to foot-like, with granular contents, sometimes with large oil drop, 21–32 \times 11–16 μm .

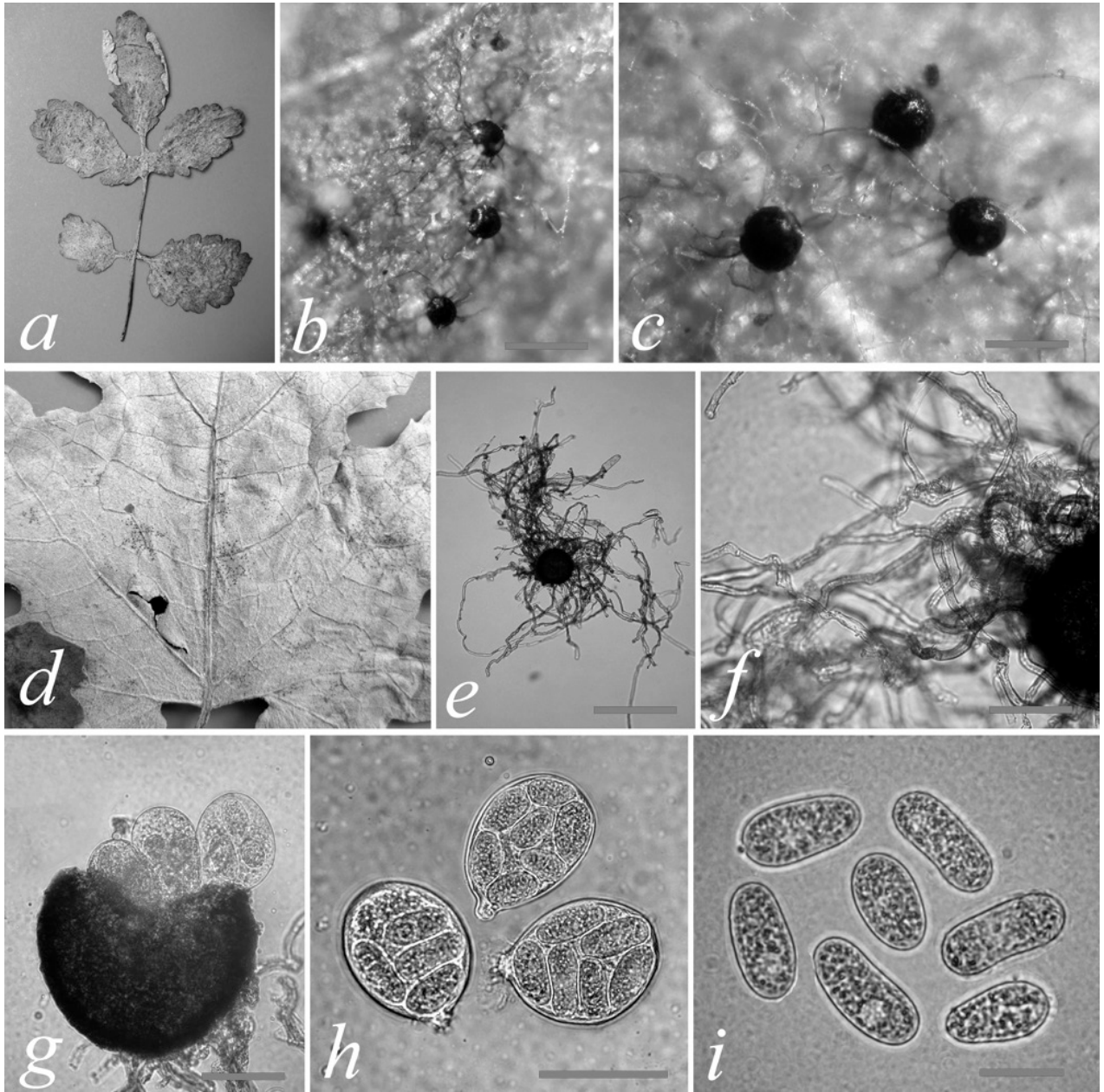
Specimens examined

On *Chelidonium majus* – Kyiv, centre, O.V. Fomin Botanical Garden, 02.10.2015, V.P. Kovalchuk (KW 60953F); Kyiv Region, Boryspil District, village Hlyboke, 03.10.2015, V.P. Kovalchuk (KW 60954F; Figure, a–c).

On *Macleaya cordata* – Kyiv, centre, O.V. Fomin Botanical Garden, 02.10.2015, V.P. Kovalchuk (anamorph; KW 70033).

On *Macleaya microcarpa* – Kyiv, M.M. Hryshko National Botanical Garden of the National Academy of Sciences of Ukraine, 04.09.2015, S.L. Mosyakin (anamorph; KW 60956); *ibid.*, 18.09.2015, S.L. Mosyakin (KW 60957); *ibid.*, 08.10.2015, V.P. Kovalchuk, P.Ya. Chumak (KW 60959; Figure, d–i).

In 2015, we made a comparative study of *E. macleayae* on *C. majus* and *M. cordata*. As a result, it was determined that dynamics of the affection of these hosts was somewhat different. Thus, on the former host the mycelium of the fungus appears much earlier than on the latter. Symptoms of powdery mildew lesions were observed on *C. majus* in early July, while on *M. cordata* only in early September. First, the fungus infected mostly the upper side of leaves of *C. majus*, then in the period of seed formation it spread to the stem. Fruit bodies formed in early September on both sides of the lower, older leaves of plants. They first appeared on leaflets,



Erysiphe macleayae on *Chelidonium majus* (a–c) and *Macleaya microcarpa* (d–i): a, d – infected leaves of host plants; b, c, e – chasmothecia (b, c – in reflected light); f – appendages; g – cracked chasmothecium with outgoing asci; h – 4-, 6- and 7-spored asci; i – ascospores (bars: b, e – 200 μ m, c – 100 μ m, f–h – 50 μ m, i – 20 μ m)

located closer to the base of the petioles and much less on the base of leafstalks. Typically, on the upper leaflets fruiting bodies are missing. On *M. cordata*, the fungus first developed mainly on the upper side of the leaves of the lower tier, then also on the flowering part of the stem. Chasmothecia were not formed. In addition, a slight difference in the shape of conidia of the fungus on these hosts was noticed. Thus, the ratio of length to

width for *C. majus* averaged 2.5, whereas for *M. cordata* 2.2. However, these indicators fit well within the scope of this feature variation (2.2–4.8) shown previously for Ukrainian material (Heluta, Kravchuk, 2015).

There were some differences in the formation of fruiting bodies on *C. majus* and *M. microcarpa*. On the former host, they developed mainly on the upper side of the leaf as a continuous layer (Figure, a), while on the

latter mainly on the lower side, in the form of diffuse spots (Figure, *d*).

The authors can not reliably explain why *E. macleayae*, which for many years developed only anamorphic stage in Europe, with one exception on *Meconopsis cambrica* (L.) Vig., began to form fruiting bodies. We have already noted similar cases for other powdery mildews. For example, the anamorph of East Asian *E. arcuata* U. Braun, V.P. Heluta & S. Takam. was recorded by one of the authors of this article in 1977 (Heluta, 1989). However, the fungus began intensively to form fruiting bodies, simultaneously in different parts of Europe, only in 2005 (Braun et al., 2006). We can propose two hypotheses concerning the cause of the development of *E. macleayae* teleomorph. Presumably formation of fruiting bodies of this fungus was provoked by the extremely hot summer in 2015. If this assumption is correct, then obviously in cooler seasons the fungus will again develop exclusively anamorph. Another possible explanation is that a new biotype of *E. macleayae* has migrated from South Asia into Ukraine and subsequently formed complete chasmothecia through the sexual process with the indigenous European populations of the fungus. In this case, fruiting bodies in the future will be observed annually.

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REFERENCES

- Ale-Agha N., Boyle H., Braun U., Butin H., Jage H., Kummer V., Shin H.D. Taxonomy, host range and distribution of some powdery mildew fungi (*Erysiphales*), *Schlechtendalia*, 2008, **17**: 39–54.
- Amano K. *Host range and geographical distribution of the powdery mildew fungi*, Tokyo: Japan Scientific Societies Press, 1986, 741 p.
- Blumer S. *Echte Mehltauipilze (Erysiphaceae). Ein Bestimmungsbuch für die in Europa vorkommenden Arten*, Jena: VEB Gustav Fisher, 1967, 436 S.
- Braun U., Cook R.T.A. Taxonomic manual of the *Erysiphales* (powdery mildews), *CBS Biodiversity Series*, 2012(11): 1–707.
- Braun U., Takamatsu S., Heluta V., Limkaisang S., Divarangkoon R., Cook R., Boyle H. Phylogeny and taxonomy of powdery mildew fungi of *Erysiphe* sect. *Uncinula* on *Carpinus* species, *Mycological Progress*, 2006, **5**(3): 139–153.

- Dynowska M., Fiedorowicz G., Kubiak D. Contributions to the distribution of *Erysiphales* in Poland, *Acta Mycologica*, 1999, **34**: 79–88.
- Grigaliunaite V. *Muchnistoro-syanye gryby Litvy*, Vilnius: Mokslas, 1990, 88 pp. [Григальюнайте Б. *Мучнисторосяные грибы Литвы*. – Вильнюс: Мокслас, 1990. – 88 с.].
- Heluta V.P., *Muchnistoro-syanye gryby*, Kiev: Naukova Dumka, 1989, 256 pp. [Гелюта В.П. *Флора грибов Украины. Мучнисторосяные грибы*. – Киев: Наук. думка, 1989. – 256 с.].
- Heluta V.P., Kravchuk O.O., *Ukr. Bot. J.*, 2015, **72**(1): 39–45. doi.org/10.15407/ukrbotj72.01.039 [Гелюта В.П., Кравчук О.О. Перші знахідки в Україні нового інвазійного гриба *Erysiphe macleayae* (*Erysiphales*) // *Укр. ботан. журн.* – 2015. – **72**(1). – С. 39–45].
- Jankovics T. First report of powdery mildew (*Oidium* sp.) on great celandine (*Chelidonium majus*), *Plant Pathology*, 2007, **56**, p. 353.
- Jankovics T., Bai Y., Kovács G.M., Bardin M., Nicot P.C., Toyoda H., Matsuda Y., Niks R.E., Kiss L. *Oidium neolycopersici*: intraspecific variability inferred from amplified fragment length polymorphism analysis and relationship with closely related powdery mildew fungi infecting various plant species, *Phytopathology*, 2008, **98**(5): 529–540.
- Jiang W., Liu Sh., An B., Wang L., Li Y., Takamatsu S., Braun U. Chasmothecia of *Erysiphe macleayae* on *Chelidonium majus* confirm species identification, *Mycoscience*, 2015, **56**(2): 132–135. doi: 10.1016/j.myc.2014.04.008
- Park M.J., Cho S.E., Piatek M., Shin H.D. First report of powdery mildew caused by *Erysiphe macleayae* on *Macleaya microcarpa* in Poland, *Plant Dis.*, 2012, **96**(9): 1376.
- Pastirčáková K., Jankovics T., Komáromi J., Pintye A., Pastirčák M. Genetic diversity and host range of powdery mildews on Papaveraceae, *Mycol. Progress*, 2016, **15**: 36. doi: 10.1007/s11557-016-1178-8
- Pastirčáková K., Pastirčák M. A powdery mildew (*Pseudoidium* sp.) found on *Chelidonium majus* in the Czech Republic and Slovakia, *Czech Mycology*, 2013, **65**(1): 125–132.
- Schmidt A., Scholler M. Studies in *Erysiphales* anamorphs (4): species on *Hydrangeaceae* and *Papaveraceae*, *Mycotaxon*, 2011, **115**: 287–301.
- Zheng R., Chen G. The genus *Erysiphe* in China, *Sydowia*, 1981, **34**: 214–327.

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Повідомляється, що в 2015 р. інвазійний борошнисторосяний гриб *Erysiphe macleayae* (*Erysiphales*, *Ascomycota*), який раніше був відомий в Україні лише на стадії анаморфи на *Chelidonium majus* і *Macleaya microcarpa* (*Papaveraceae*), почав утворювати тут повноцінні плодові тіла. За морфологічними ознаками вони близькі до хазмотеціїв зразків із Словаччини. Українські матеріали також доволі близькі до зразків *E. macleayae*, описаних з Китаю, однак мають трохи більші за розміром хазмотеції, які містять дещо менші сумки та сумкоспори. Телеоморфу цього гриба знайдено в трьох локалітетах у м. Києві та Київській обл. Ще на одному виді, *Macleaya cordata*, реєструвалася лише анаморфа *E. macleayae*. Досліджені зразки передані до Національного гербарію Інституту ботаніки імені М.Г. Холодного НАН України (КН). Автори припускають, що утворення плодових тіл *E. macleayae*, можливо, спричинене надзвичайно спекотним літом 2015 р. Однак не виключено, що в Україну з Південно-Східної Азії мігрував новий біотип цього гриба, який може з європейською популяцією *E. macleayae* вступати в статевий процес й утворювати повноцінні хазмотеції.

Ключові слова: Європа, інвазія, борошнисторосяні гриби, хазмотецій, *Pseudoidium*, *Chelidonium*, *Macleaya*, *Papaveraceae*.

Гелюта В.П.¹, Ковальчук В.П.², Чумак П.Я.² **Первые находки в Украине инвазионного гриба *Erysiphe macleayae* (*Erysiphales*) на стадии телеоморфы.** — Укр. ботан. журн. — 2016. — 73(3): 268—272.

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Сообщается, что в 2015 г. инвазионный мучнисторосяной гриб *Erysiphe macleayae* (*Erysiphales*, *Ascomycota*), ранее известный в Украине только на стадии анаморфы на *Chelidonium majus* и *Macleaya microcarpa* (*Papaveraceae*), начал образовывать здесь полноценные плодовые тела. По морфологическим признакам они практически идентичны хазмотециям образцов из Словакии. Украинские материалы также довольно близки к образцам *E. macleayae*, описанным из Китая, однако имеют несколько крупнее хазмотеции, слегка более мелкие сумки и сумкоспори. Телеоморфа этого гриба найдена в трёх локалитетах в г. Киеве и Киевской обл. Еще на одном виде, *Macleaya cordata*, регистрировалась только анаморфа *E. macleayae*. Исследованные образцы переданы в Национальный гербарий Института ботаники имени Н.Г. Холодного НАН Украины (КН). Авторы допускают, что образование плодовых тел *E. macleayae*, возможно, вызвано чрезвычайно жарким летом 2015 г. Однако не исключено, что в Украину из Юго-Восточной Азии мигрировал новый биотип этого гриба, который может с европейской популяцией *E. macleayae* вступать в половой процесс и образовывать полноценные хазмотеции.

Ключевые слова: Европа, инвазия, мучнисторосяные грибы, хазмотеций, *Pseudoidium*, *Chelidonium*, *Macleaya*, *Papaveraceae*.