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ORIGINAL ARTICLE

New data on the expansion of *Erysiphe platani* (Howe) U. Braun & S. Takam. (Erysiphales, Ascomycota) in Ukraine

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Purpose: Monitoring of phytopathology condition of plane trees (*Platanus* L.) in the cities of Kyiv and Zhytomyr. **Methods:** The samples for the investigation have been selected in the course of route investigation of plants in parks, public gardens, and street plantations of plane trees in Kyiv and Zhytomyr. Phytopathology analysis and morphometry of conidia and fruit bodies and asci of *Erysiphe platani* were carried out with the help of a light microscope and a smartphone with the software "Magnifier Cam". **Results:** For the first time, the affection of leaves of plants genus *Platanus* L. by powdery mildew *Erysiphe platani* has been detected in the most northern region of Ukraine (50°26'34 N; 30°32'56 E). The fungus went through the full development cycle, with the formation of mycelium, conidia, and cleistothecia. A comparative analysis of morphometric parameters of conidia and cleistothecia of *Erysiphe platani* sampled by other authors and researchers has been conducted. **Conclusions:** The affection of *Platanus* x acerifolia plants by powdery mildew *Erysiphe platani* has been observed only in certain localities in Kyiv, where the host plant grows. Several types of affection have been identified: complete coverage of the upper surface of a mature leaf which does not cause its deformation; the formation of a densely felted mold on young apical leaves and deformation of the leaf blade; damage to the Lammas leaves of plants (second half of August).
Keywords: Powdery mildew, *Erysiphe platani*, plane tree, *Platanus*, invasion.

Introduction

In recent years, powdery mildew fungi (*Fungi, Ascomycota, Leotiomycetes, Erysiphales, Erysiphaceae*) have attracted the attention of many mycologists around the world, which is due to the emerging trend towards high expansion, pathogenicity, and the growing number of new species of plants that feed them (Kliuchevych et al., 2020). For example, powdery mildew *Erysiphe platani* was found in Ukraine only up to 48 parallel (Bulhakov et al., 2019), and only species of the genus *Platanus* L. (*Platanaceae*) were feeding plants. However, recently, this fungus has been detected on Chinese sumach-*Ailanthus altissima* (Mill.) Swingle is a plant from a completely different family (Simarubaceae) (Beenken & Senn-Irlet, 2016; Marchica, et al. 2020). According to (Pastirčáková & Pastirčák, 2006, 2008), this North American pathogen (*E. platani*) is found throughout the world where climatic conditions are favorable for the host plant. The fungus has been brought to South America, Africa, Asia, Oceania, and many European countries (Takamatsu, 2012). The fungus was introduced to Europe in the early 1960s; it has become widespread in Europe today. In Ukraine, (Heluta et al., 2013), powdery mildew (*Erysiphe platani*) was detected in November 1986 on *Platanus orientalis* L. in the Nikitsky Botanical Garden (Yalta), and much later (2012) in Simferopol, Sevastopol, and Odessa (Heluta et al., 2013), in the village Agrarnoe (Crimea) (Valeeva, 2016) and the Donetsk Botanical Garden (Bulhakov & Bondarenko-Borysova, 2019).

The host plant *(Platanus orientalis* L. and P. *x acerifolia*) and *Platanus* L. species are widely used for greening in subtropical zone cities (approximately between 30 and 40 parallel). They are less widely used in the northern temperate zone (approximately between 40–45° north latitude) (Eramov, 1987) and are very little used between 45° and 55° N. Most cases of affection of plane trees by powdery mildew were observed in the subtropical zone, much less in the northern temperate zone and only recently, affection of plane trees by powdery mildew has been detected at latitude 53° N (Adamska, 2019). According to V.P. Heluta (Heluta et al., 2013), in Ukraine, powdery mildew (*Erysiphe platani*) until recently has been found approximately between 44° (Yalta, Simferopol) and 46° north latitude (Odessa). Five years later, the fungus was discovered in the Donetsk Botanical Garden (48° north latitude) (Bulhakov & Bondarenko-Borysova, 2019). Because *Erysiphe platani* tends to expand to more northern latitudes, into new ecotypes of artificial plantations of plane trees, monitoring the phytopathological condition of these plants under conditions that are extreme for them becomes urgent.

Our purpose was to study the phytopathological condition of plane tree species used for greening in Zhytomyr (Yu. Gagarin park) and Kyiv (collections of A.V. Fomin Botanical Garden and city streets).

Materials and Methods

Phytopathology condition of plane trees of the species *Platanus* L. was monitored in 2018-2020 using the method of route investigation of plants in Zhytomyr (50°26'49 N; 28°67'67 E) and in Kyiv (50°26' N; 30°32' E). The crowns were examined by visual detection of the fungus in the lower part of the crown (1.5-2 meters from the ground). Above the indicated level, a camera with a function of at least 10x zoom was used. Leaves affected by *Erysiphe platani* (up to 30 specimens from each plant) were photographed without separating them from the branch; the photos were processed in the laboratory.

In order to monitor the degree of affection of plants by the fungus and for light microscopy, a transparent adhesive tape was used (Heluta et al., 2013). Micropreparations of conidia and fungal fruit were prepared according to the recommendations (Lavitska & Kovtun, 1978; Heliuta, 1989) with some modifications. For instance, instead of lactic acid, a mixture of glycerin and a bleacher "Belizna" (ratio 1:10) was used to decolor fruit bodies. This mixture does not form air bubbles under the cover glass of the preparation, improves the clarification of the fruit bodies, the visibility of the asci and ascospores in them. The obtained preparations were examined under a microscope with a magnification of 200 × and 400 ×. Photos of fruit bodies, asci, and ascospores were taken with a smartphone Samsung S8 using the Magnifier Cam program.

Erysiphe platani powdery mildew was identified by recommendations of Braun, Takamatsu (2000), and Heluta et al. (2013).

The obtained digital data was processed with the help of the quantitative indicators accepted in statistics (the number of measurements was ≥ 30 for each separately investigated feature of the fungus).

The investigated materials of the fungus *Erysiphe platani* are stored at the Department of Plant Protection at Polissia National University.

Results

The examination of the phytopathologic condition of plane trees (American plane tree-*Platanus occidentalis* L.; London plane tree-*P. x acerifolia* (Ait.) Willd., Oriental plane tree-*P .orientalis* L.) showed that powdery mildew *Erysiphe platani* is highly pervasive on the London plane tree in Kyiv. However, the fungus was not detected in Zhytomyr (Yu. Gagarin Park and Botanical Garden of Polissia National University) (Table 1).

Tab. 1. Localities of the plants of genus *Platanus* L., on which powdery mildew *Erysiphe platani* has been detected (Howe) U. Braun & S. Takam. (Zhytomyr and Kyiv, 2018–2020).

Place Of Detection		Host Plant	Development Cycle Of The Fungus	
Locality	Location Of Plane Trees		Anamorpha	Telemorph Stage
Zhytomyr				
Yu. Gagarin park	50°24'52.1"N, 28°66'49.37"E	Platanus sp.	–	–
Botanical Garden of Polissia National University (=BGPNU)	50°25'19"N, 28°69'75"E	*Platanus x acerifolia* (Ait.) Willd.	–	–
Kyiv				
Metro station Vystavochnyi Tsentr	50°26'42.9"N, 30°32'01.5"E	*P. x acerifolia*	+	+
93 Goloseevskyi Prospekt	50°38'54.11"N, 30°48'74.23"E	*P. x acerifolia*	+	+
82 Goloseevskyi Prospekt	50°39'32.02"N, 30°50'56.02"E	*P. x acerifolia*	+	–

The data from Table 1 shows that in the period of examination of plane trees (*P. x acerifolia*) in Zhytomyr (BGPNU and Yu. Gagarin park), powdery mildew *Erysiphe platani* was not detected. Monitoring the phytopathologic condition of plane trees in Kyiv showed that these plants are affected by the fungus only in several localities (Metro station Vystavochnyi Tsentr; 93 Goloseevskyi Prospekt, 82 Goloseevskyi Prospekt). It should be highlighted that both anamorphic (agamic) and teleomorphic (ascogenous) stages were observed in the developmental cycle of the fungus.

Analyzing the data on changes in the manifestation of the mycelium and conidia of the fungus, the following features should be highlighted:

At first, the mycelium appears only on the adaxial mature and fully formed leaves in the form of individual spots and then completely covers the entire leaf surface (Fig.1a);

-The mycelium forms a thick felted mold on the upper surface of physiologically young leaves, which leads to their deformation (Fig. 1b);

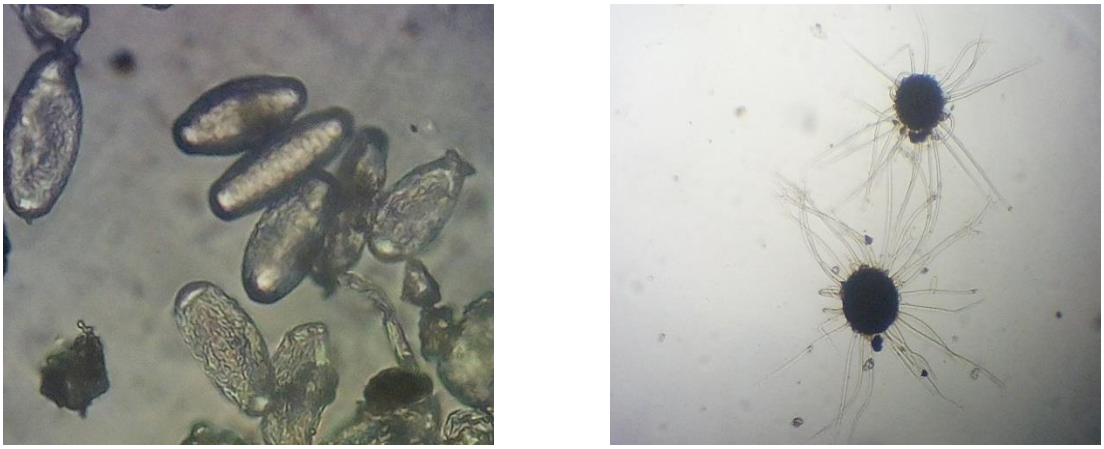
-The mycelium covers the apical part of the secondary shoots (August–September).

a b

Fig. 1. Powdery mildew *Erysiphe platani* (Howe) U. Braun & S. Takam. on leaves of *Platanus x acerifolia* (Ait.) Willd. Types of affection: a) individual spots and complete affection of a leaf, b) thick felted mold and deformation of Lammas leaves (*original photos*).

It has been found that the first type of leaf affection (individual spots or complete coverage of the upper surface of a mature leaf) does not cause the deformation of a leaf. The affection of the second type of young apical leaves by the fungus and the formation of a thick felted mold on them, as a rule, is characterized by a substantial deformation of the leaf blade. The affection of shoots by the fungus is observed only in the variants of the formation of Lammas leaves of plane trees (second half of August).

The fungus conidia we collected are colorless, ellipsoid-shaped, elongated-elliptical, cylindrical, with a smooth or wrinkled surface in a chain of 2–3 specimens. However, some researchers note that they observed glassy, cylindrical conidia (Pastircakova, Pastircak, 2008) or slightly rugous or reticulate (Glawe, 2003). In the latter case, we observed conidia of this kind from herbarium material (i.e., dried leaves). In freshly collected material, we have also come across conidia with a smooth surface and conidia with a shaded surface in the form of short, irregularly spaced dashes. There is only one visible direction in the chaotic arrangement of dashes on the surface of conidia; they all go not across but along the body of the conidia (Fig. 2).



a b

Fig. 2. Conidia with the smooth and shaded surface (a) and fruit bodies of *Erysiphe platani* (b) (Howe) U. Braun & S. Takam. (*original photos*).

The parameters of conidia have been measured; it has been found that their length varied from 31.0 to 35.0 μm, and their width from 14.0 to 16.0 μm.

It is known that when many invasive species of powdery mildew fungi enter new territory, as a rule, their feature is anamorphic reproduction (Palahecha & Chumak, 2011). When the fungus *Erysiphe platani* penetrated the European continent, it has developed for a long time without forming a teleomorph (Pastircakova et al., 2014). The population of *Erysiphe platani,* which we have investigated in Kyiv, goes through a complete development cycle with the formation of fruit bodies (Fig. 2b). The fruit bodies are

scattered on the leaves affected by the fungus; sometimes, they are located in groups. Cleistothecia is black, 75–98 μm in diameter. Comparing the parameters of the diameter of fruit bodies and asci in them with the parameters of similar features of this fungus identified by other researchers (Heluta et al., 2013) showed that they differ. Thus, the diameters of samples of the fungus collected in the southern regions of Ukraine (Yalta–Odessa) by V. P. Heluta et al. (Heluta et al., 2013) varied from 85 to 125 μm.
Consequently, the samples of fruit bodies that we have collected in Kyiv are much smaller than those of the fungus samples from the southern regions of Ukraine. Accordingly, there may be more asci in the fruit body of the fungus. For example, from 6 to 8 asci were found in cleistothecia investigated by (Heluta et al., 2013); we found no more than 6 specimens in cleistothecia.

Discussion

Monitoring of the phytopathological condition of plane trees *Platanus x acerifolia* in the cities of Kyiv and Zhytomyr showed that the plants are affected by powdery mildew *Erysiphe platani* only in Goloseevskyi district of Kyiv. The detection of the fungus in Kyiv indicates that it has expanded to the northern regions in Ukraine where the host plant grows (50°43'99.93" N, 30°51'83.93" E). Previously, the fungus was found in Yalta (44°29'71" N, 34°9'98" E) and in the village Agrarnoe (45°01'05" N, 30°03'15" E) (Valeeva, 2016). According to V. P. Heliuta (Heluta et al., 2013), it was found much closer to the south – in Odessa (46°29'08" N, 30°44'36" E) and the Donetsk Botanical Garden (Bulhakov & Bondarenko-Borysova, 2019) (48°00'32" N, 37°48'00" E). It is essential that *Erysiphe platani* was not detected on plants of the genus *Platanus* L. in A. V. Fomin Botanical Garden (Kyiv) and Yu. Gagarin park (Zhytomyr). At the sites of affection by powdery mildew, *Platanus x acerifolia* that we have found, the fungus went through a complete cycle of its development, with the formation of mycelium, conidia, and cleistothecia.

Measurements of the parameters of the conidia of the fungus showed that their size varied slightly less compared to the conidia of the fungal samples collected in the south of Ukraine (Heluta et al., 2013). Thus, the length and width of conidia in the sampled fungi varied within 31.0– 35.0 x 14.0–16.0 μm. The range of length and width of conidia in fungi sampled in the south of Ukraine was 32.5 – 37.0 x 15.0 – 17.5 μm (Heluta et al., 2013). The range of variability (norm of reaction) of the parameters of the length of conidia in the samples from the southern zone was 4.5 units and the width 2.5 units, and in the samples that we collected, they were 4.0 and 2.0 units, respectively. In general, the parameters of conidia that we have collected in the southern and northern zones of Ukraine differ from each other, but not as much as between these parameters of the fungus from its primary station. Thus, in the USA (Glawe, 2003), the parameters of conidia are 20.5–34.0 x 11.0–20.0 μm. The ranges of the variability of conidia length calculated by us are 13.5 units and for width nine units. Obviously, during the fungus invasion from the primary station (USA), a well-known pattern of formation of the island population of biota inevitably arises due to the fragmentation (not a significant part) of the primary invasive material from the general population of the pathogen.

It is known (Kliuchevych et al., 2020; Heluta et al., 2016; Kovalchuk et al., 2016; Palahecha & Chumak, 2011) that many invasive species of powdery mildew are characterized only by the anamorphic type of reproduction at the beginning of invasion when they appear in new ecological and climatic zones. This mushroom is no exception. For a long time, powdery mildew in Europe was detected only at the anamorphic stage (Oidium Link) (Pastircakova et al., 2014). However, until now, the development of powdery mildew was only anamorphic from year to year (the fungus formed only mycelium and conidia) in some ecological and geographical regions of the world: Korea (La et al., 2013; Lee, 2013), Japan (Marchica et al. 2020), the Caucasus (Sochi) (Isikov, 2014), Slovakia (Nitra) (Pastirčáková & Pastirčák, 2006). Many mycologists state this phenomenon as a fact, but, unfortunately, the reasons are not considered.

Along with that, some researchers (Hosford et al., 1975) believe that in addition to genes that control the type of connubium, fungi have other genes (genes of vegetative incompatibility) that are manifested under certain conditions and block the reproductive process. However, some researchers believe that the reproductive process and the formation of fruit bodies do not play a decisive role in the life cycle of some fungal species (Terekhova & Diakov, 1986; Zhong & Steffenson, 2001). Thus, P. V. Volvach (Volvach, 1986) noted that "the autogenous stage of the causative agent of powdery mildew that affects apple trees does not play a significant role in plant pathogenesis yet, but in the process of evolution, the pathogen may acquire the ability to infect apple leaves with ascospores primarily". Currently, some researchers (Kirschner, 2011; Scholler et al., 2012) suggest that the formation of cleistothecia of the fungus contributes to survival in the winter period, while global warming contributes to the spread beyond its primary station (Italy) into Europe from the United States at the beginning of 1960. Considering the rate of expansion of the fungus in Ukraine, it can be noted that penetration from the primary station (Nikitsky Botanical Garden) in the parks of Odessa happened 26 years later and from Odessa to Donetsk and Kyiv only 6 and 7 years later, respectively. We are observing a rapid spread of the fungus to new, more northern areas of Ukraine.

It should be noted that many mycologists, including us, have regularly carried out phytopathological monitoring of plane trees in Kyiv and Zhytomyr for many years, and this phytopathogen has not been observed before. The discovery of some sites of affection at street plantings of *Platanus x acerifolia* in Kyiv indicates its relatively recent appearance far beyond its primary affection site in Ukraine. Mass reproduction according to the epiphytotic type, which we observed in 2020 in the Goloseevo district (Kyiv), should be taken into account by specialists engaged in greening of metropolises not only in Ukraine but also wherever plane trees are used for greening or are grown in collections of botanical gardens located further the north of Kyiv.

Conclusions

The affection of *Platanus x acerifolia* plants by powdery mildew *Erysiphe platani* has been observed only in certain localities in Kyiv, where the host plant grows. Several types of affection have been identified: complete coverage of the upper surface of a mature leaf which does not cause its deformation; the formation of a densely felted mold on young apical leaves and deformation of the leaf blade; damage to the Lammas leaves of plants (second half of August).

References

Bulhakov, T.S., Bondarenko-Borysova, Y.V. (2019). Chuzherodnye muchnystorosianye hryby (Erysiphaceae) na drevesnykh rastenyiakh v Donetskom botanycheskom sadu (Donetskaia oblast, Ukrayna). Monytorynh y byolohycheskye metody kontrolia vredytelei y patohenov drevesnykh rastenyi: ot teoryy k praktyke : materyaly Vtoroi Vserossyiskoi konferentsyy s mezhdunarodnыm uchastyem.. Moskva-Krasnoiarsk: YL SO RAN.

Valeeva, N.H. (2016). Eryzyfovye hryby, porazhaiushchye drevesnye y kustarnykovye porody v poselke Ahrarnoe (Respublyka Krym). Yzvestyia selskokhoziaistvennoi nauky Tavrydy, 6:42-49.

Volvych, P.V. (1986). Muchnystaia rosa Yablony. Moskva : Ahropromyzdat.

Eramov, R.A. (1987). Praktykum po fyzycheskoi heohrafyy materykov : [Ucheb. posobye dlia ped. yn-tov po spets. N2107 "Heohrafyia"]. Moskva : Prosveshchenye.

Lavitska, Z.H., Kovtun V.A. (2001) Nyzhchi roslyny. Doslidy i sposterezhennia. Kyiv : Rad. Shkola (in Ukrainian).

Palagecha, R.M., Chumak, P.Y. (2011). Ekoloho-morfolohichna struktura subpopulatsii Microsphaera magnifica U. Braun (Erysiphales) ta invazijna spromozhnist tsioho hryba. Materialy XIII zjizdu Ukrainskoho botanichnoho tovarystva. Lviv, TzOV «Prostir M.

Terekhova, V.A., Diakov, Yu.T. (1986). Henetycheskaia nestabylnost hrybov. Mykol. y fytopatol. 20:233-240.

Adamska, I. (2019). Epidemic of Erysiphe platani in urban areas on the example of the Szczecin (NW Poland). Ecological Questions, 30:71–81.

Beenken, L., Senn-Irlet, B. (2016). Neomyceten in der Schweiz. Stand des Wissens und Abschätzung des Schadpotentials der mit Pflanzen assoziierten gebietsfremden Pilze. WSL Ber, 50:93.

Braun, U., Takamatsu, S. (2000). Phylogeny of Erysiphe, Microsphaera, Uncinula (Erysiphaceae) and Cystotheca, Podosphaera, Sphaerotheca (Cystotheceae) inferred from rDNA its se-quences-some taxonomic consequences. Schlechtendalia. 4:1-33.

Glawe, D.A. (2003) First report of powdery mildew of Platanus occidentalis caused by Microsphaera platani (Erysiphe platani) in Washington State. Plant Management Network.

Heluta, V.P., Korytnianska, V.G., Akata, I. (2013). Distribution of Erysiphe platani (Erysiphales) in Ukraine. Acta Mycologica, 48.

Heluta, V.P., Kovalchuk, V.P., Chumak, P.Y. (2016). First records of teleomorph of an invasive fungus *Erysiphe macleayae* (Erysiphales) in Ukraine. Ukrainian Botanical Journal, 73:269-272.

Hosford, R.M., GRM, S., RL, K. (1975). Inheritance in Cochliobolus sativus. Phytopathology. 65:699-703.

Zhong, S., Steffenson, B.J. (2001). Genetic and molecular characterisation of mating type genes in Cochliobolus sativus. Mycologia. 93:852-863.

Isikov, V.P. (2014). Annotated checklist of tree-inhabiting fungi of the Black Sea Coast of the Caucasus. Collection of scientific works of the State Nikitsky Botanical Garden. 139:149-158.

Kirschner, R. (2011). Observations on Erysiphe platani in Germany. Plant Pathology & Quarantine. 1:115-119.

Kliuchevych, M.M., Stoliar, S.H., Chumak, P.Ya., Retman, S.V., Strygun, O.O., Tkalenko, H.M., Vigera, S.M. (2020). Most recent detection of invasive species *Erysiphe palczewskii* (Jacz.) U Braun et S Takam on *Robinia pseudoacacia* L. in Ukraine. Modern Phytomorphology, 14:85-92.

La, Y.J., Cho, S.E., Shin, H.D. (2013). First report of powdery mildew of *Platanus occidentalis* caused by *Erysiphe platani* in Korea. Plant Disease, 97:843-844.

Kliuchevych, M.M. Stoliar, S.H., Chumak, P.Ya., Vigera, S.M. (2020) Most recent detection of invasive species *Erysiphe palczewskii* (Jacz.) u. Braun et s. Takam. on *Robinia pseudoacacia* L. in Ukraine. Modern Phytomorphology, 14:85-92.

Kliuchevych, M.M., Chumak, P.Ya., Vigera, S.M., Stolyar S.G. (2019) First detection of Colletotrichum gloesporioides (penz.) Pens. & sacc. on Liriodendron chinense (hemsl.) Sarg. in Ukraine. Modern Phytomorphology, 13:9-12.

Lee, H.B., Lee, H.W, Mun, H.Y. (2013) First report of Powdery Mildew Caused by Erysiphe platani on Sycamore (*Platanus occidentalis*) in South Korea. Plant Disease, 97:841.

Marchica, A., Pisuttu, C., Calzone, A. (2020). First report of powdery mildew caused by *Erysiphe platani* in *Ailanthus altissima*, the tree-of-heaven, in the Mediterranean basin, Italy. Journal of Genetic Plant Pathology, 86:428-431.

Pastirčáková, K., Pastirčák, M. (2006) The anamorph of Erysiphe platani on Platanus × hispanica in Slovakia. Mycotaxon. 97:189-194.

Pastirčáková, K., Pastirčák, M. (2008). Erysiphe platani causing powdery mildew of London plane in Hungary. Acta Phytopathology Entomology Hungary, 43:31-36.

Pastirčáková, K., Pastirčák, M., Adamčiková, K., Bouznad, Z., Kedad, A., El Guilli, M., ... & Hofte, M. (2014). Global distribution of Erysiphe platani: new records, teleomorph formation and re-examination of herbarium collections. Cryptogamie, Mycologie, 35:163-176.

Scholler, M., Hemm, V., Lutz, M. (2012). Erysiphe platani: monitoring of an epidemic spread in Germany and molecular characterization based on rDNA sequence data. Andrias, 19:263–272.
Takamatsu, S. (2012). Overview of revised systematics of the powdery mildews（Ascomycota: Erysiphales）in the new monograph published in 2012. Bulletin of Graduate School of Bioresource Sciences, Mie University, 38:1-73.
Zhong, S., Steffenson, B.J. (2001) Genetic and molecular characterisation of mating type genes in Cochliobolus sativus. Mycologia, 93:852–863.
Lesovoy, N., Fedorenko, V., Vigera, S., Chumak, P., Kliuchevych, M., Strygun, O., Stoliar, S., Retman, M., Vagaliuk, L. (2020). Biological, Trophological, Ecological and Control Features of Horse-Chestnut Leaf Miner (*Cameraria ohridella* Deschka & Dimic.). Ukrainian Journal of Ecology, 10:24-27.

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