

Distribution, Incidence and Severity of the *Catalpa* Powdery Mildew Caused by *Erysiphe elevata* in North-Eastern Romania

Vasilică C. CHINAN*, Ciprian C. MÂNZU

Alexandru Ioan Cuza University, Faculty of Biology, Bd. Carol I, No. 20A, 700505, Iași, Romania; vasilechinan@yahoo.com (*corresponding author); ciprian.manzu@uaic.ro

Abstract

Erysiphe elevata is a North American fungus that causes the powdery mildew of *Catalpa* species. The present study brings new data on the spread of this species in Romania, and given its invasiveness in Europe, the study evaluates the incidence and intensity of the powdery mildew caused to *Catalpa bignonioides* (Southern catalpa). In 2017, 12 North-Eastern Romanian cities where *C. bignonioides* had been planted in green spaces were investigated. The results have shown that the pathogen is widespread in the North-Eastern part of Romania, accompanying the host plant in all of the localities investigated. In addition, the high frequency of the disease, confirms the invasiveness of *E. elevata*, most affected being the trees that were planted along streets and in public squares. A specimen of *E. elevata* was sequenced and the BLAST results revealed that it is identical to samples from France and Korea.

Keywords: alien fungi; epiphytotic disease; Erysiphaceae; ornamental plant; urban environment

Introduction

The importance of urban green spaces is well known, especially regarding their role within air pollution removal, carbon sequestration and air temperature reductions (Nowak *et al.*, 2018), but also in terms of social and psychological benefits to human societies (Chiesura, 2004). In the context of predicted climate change, upkeep of green spaces remains a permanent concern and therefore one must take into account the recent range expansion of some phytopathogenic fungi (Tubby and Webber, 2010), which includes powdery mildew species (Kiss, 2005). One of these virulent species is *Erysiphe elevata* (Burrill) U. Braun & S. Takam., a North American pathogen causing the powdery mildew of catalpa trees, which recently expanded its geographic range in Europe and is considered to be invasive (Kiss, 2005).

In Europe, five species of powdery mildew fungi are known to parasitize catalpa trees (Cook *et al.*, 2006; Braun and Cook, 2012), of which three were reported in Romania on *Catalpa bignonioides*: *Erysiphe catalpae* Simonyan (Pricop *et al.*, 2002; Negrean and Anastasiu, 2006), *Fibroidium hiratae* (U. Braun) U. Braun & R. T. A. Takamatsu, as *Oidium hiratae* U. Braun (Eliade, 1990; Negrean and Anastasiu, 2006) and *E. elevata* (Fodor and Vlad, 2013).

In Europe, *C. bignonioides* (Southern catalpa) was introduced for its ornamental value in the 18th century

(Olsen and Kirkbride, 2017). *E. elevata* was reported for the first time in 2002 in Hungary (Vajna *et al.*, 2004). Since then, this species has rapidly expanded its area to Bulgaria, Czech Republic, France, Germany, Poland, Slovakia, Switzerland, UK (Braun and Cook, 2012), Slovenia (Milevoj, 2004), Ukraine (Heluta *et al.*, 2009) and Romania (Fodor and Vlad, 2013). Recently, it was also reported in Asia, specifically Korea (Cho *et al.*, 2014) and Turkey (Erper *et al.*, 2018), parasitizing *C. bignonioides*, whereas in Thailand was noted on *Eucalyptus camaldulensis* Dehnh. (Meeboon and Takamatsu, 2017).

Even from the first reports on the presence of this fungus in Europe, it is stated that trees in Hungary were heavily infected (Vajna *et al.*, 2004), while the foliage of a mature tree in the UK was disfigured (Cook *et al.*, 2006). In Korea, Cho *et al.* (2014) considered *E. elevata* to be a serious threat due to hundreds of Southern catalpa trees being found heavily damaged by this powdery mildew pathogen.

In Europe, *E. elevata* has spread rapidly from one country to another, but its invasive nature has not been highlighted (Kiss, 2005). In Romania, Fodor and Vlad (2013) previously reported this species only in two localities: Oradea and Cluj-Napoca (North-Western Romania) and therefore additional research is needed.

The present study provides new data on the distribution of *E. elevata* in Romania and assesses the incidence and severity of this powdery mildew in the context of its invasiveness.

Materials and Methods

Study sites and sampling

Field investigations were performed in 12 cities in North-Eastern Romania (Fig. 1), where *Catalpa bignonioides* Walter had been planted in green spaces (parks, tree lined streets, landscapes around buildings and public squares). Leaves with powdery mildew symptoms were collected from each diseased tree. Voucher specimens from each city were preserved and deposited in the Herbarium of Alexandru Ioan Cuza University of Iasi, Romania (Index Herbariorum abbreviation: I).

Assessment of disease severity and incidence

The disease severity (intensity) was evaluated visually by estimating the percentage of the diseased crown foliage of each tree, using a numerical scale consisting of five grades, as follows: 1 - foliage injured up to 10%, 2 - from 11% to 30%, 3 - from 31% to 60%, 4 - from 61% to 80% and 5 - from 81% to 100% (Stravinskiene *et al.*, 2014).

The average of disease severity was calculated using the following formula:

$$V = \sum(n \times b) / N$$

where V is the average of disease severity, b is the grade of disease severity, n is the number of trees assigned to the same grade of disease severity and N is number of checked plants (Ziogas *et al.*, 2007).

The disease incidence (DI) was calculated using the following formula:

$$DI = n \times 100 / N$$

where n is the number of infected plants and N is the total number of plants observed in each study site (Pârnu, 2000).

Species identification

To identify the fungus, the teleomorph structures (chasmothecia, asci and ascospores) were examined using a standard light microscope (Novex, Holland) and compared with descriptions published by Ale-Agha *et al.* (2004), Vajna *et al.* (2004), Heluta *et al.* (2009) and Braun and Cook (2012).

To confirm the identification of the first specimen of *E. elevata* collected in Iasi, North-Eastern Romania in 2014 (voucher specimen number I 184187), DNA was extracted from the chasmothecia and the nuclear ribosomal internal transcribed spacer (ITS) region was amplified using primers ITS1F 5'-CTTGGTCATTTAGAGGAAGTAA-3' (Gardes and Bruns, 1993) and ITS4, 5'-TCCTCCGCTTATTGATATGC-3' (White *et al.*, 1990) and sequenced at Alvalab (Spain). The newly obtained sequence was deposited in GenBank (accession number MH638203) and compared with sequences of *E. elevata* and *E. catalpae* available in GenBank.

The *Catalpa* trees were identified using the methods of Zanoschi *et al.* (2004) and Olsen and Kirkbride (2017).

Results

In North-Eastern Romania, this powdery mildew species was first detected in the autumn of 2014, when some severely diseased *C. bignonioides* trees were found in Iasi City. At that time, a few infected leaves were collected from different trees. Based on morphological characteristics, *E. elevata* was found in all of the samples analysed. One of the specimens (I 184187) was sequenced and the BLAST result revealed that it was 100% identical to others from France (Cook *et al.*, 2006, GenBank Accession No. AY808059) and Korea (Cho *et al.*, 2014, GenBank Accession No. KF840721).

In the investigated cities, 795 trees of *C. bignonioides* were analyzed. Their number varied from one city to another, most of them being located in Iasi (Fig. 1) which is the largest city in North-Eastern Romania. Out of these, 456 trees (57.35%) displayed symptoms of powdery mildew (Fig. 2), all of which were infected by *E. elevata*. This fungus was found in all the investigated localities (Fig. 1), reaching epiphytotic proportions. The high frequency of this disease in North-Eastern Romania confirms the invasiveness of *E. elevata*.

The incidence of the disease varies substantially between the types of the green spaces. The highest percentage of damaged trees was recorded in tree lined streets (DI =

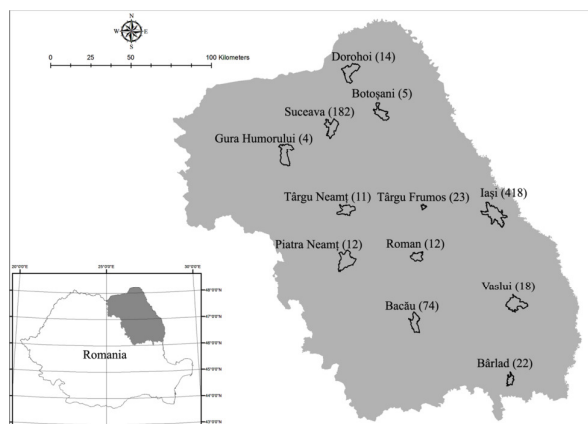


Fig. 1. Location of study area (the number of *C. bignonioides* trees investigated in each city is mentioned within brackets)



Fig. 2. *Catalpa bignonioides*, powdery mildew symptoms on leaves

Table 1. Disease incidence and the average of disease severity within green spaces types investigated

Types of green space	Cities	Number of assessed trees	Disease incidence (%)	Average of disease severity (V)
Tree lined streets	Suceava, Gura Humorului, Târgu Neamț, Piatra Neamț, Roman, Iași, Târgu Frumos, Bacău, Vaslui, Bârlad	283	71.37	1.3
Parks	Suceava, Botoșani, Piatra Neamț, Iași, Târgu Frumos, Bacău, Vaslui	268	53.73	1.1
Landscapes around buildings	Dorohoi, Piatra Neamț, Iași, Bacău, Vaslui	192	42.18	0.83
Squares	Roman, Iași	52	61.53	1.23

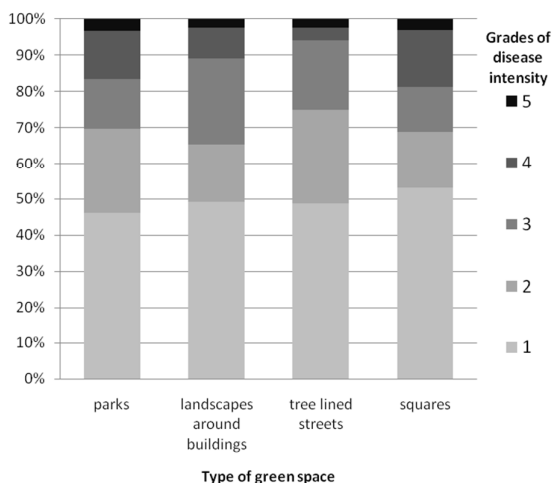


Fig. 3. Percentage distribution of the Southern catalpa trees according to disease intensity

71.37%), while in landscapes around buildings the incidence was lower (DI = 42.18%). Overall, the average of disease severity was 1.11, but the most injured trees were observed along streets, where $V = 1.3$. Also, as shown in Table 1, in all types of green spaces investigated, the average of disease severity increased along with its frequency.

Most of the infected trees (71.11%) showed a low to medium intensity of the disease (grades 1 and 2). However, strongly damaged trees were found in each type of green space, only in a smaller percentage (Fig. 3).

In two cities within the study area, *Catalpa ovata* G. Don was also located, respectively 20 trees in Piatra Neamț and two in Iași, but without any powdery mildew symptoms, even though nearby trees of *C. bignonioides* were observed to be infected by *E. elevata*.

Discussion

Although *E. elevata* has been known in Europe since 2002 when it was reported in Hungary (Vajna *et al.*, 2004), it was detected seven years later in Romania by Palovčková *et al.* (2009), without being specified the locality or the host plant. Subsequently, additional data on its presence in Romania has been provided by Fodor and Vlad (2013), who found this species on *C. bignonioides* in two cities in the North-West of the country. Currently, the obtained data shows that *E. elevata* is widespread in North-Eastern

Romania, following the host in all the localities where it is cultivated.

Trees grown along streets and in public squares are the most affected by this powdery mildew pathogen. It is likely that repetitive and severe infections will weaken the plants. These trees could be also affected by winter road salt contamination. In this regard, it is known that the salts used for winter road maintenance damage trees in urban environments (Equiza *et al.*, 2017).

For the present study, 456 Southern catalpa trees affected by powdery mildew were examined, but the other two species reported on this host in Romania, *E. catalpae* (Pricop *et al.*, 2002) and *Fibroidium hiratae* (Eliade, 1990) were not found. The presence of these species in North-Eastern Romania cannot be excluded, because it is impossible to check all the leaves of the diseased trees. According to Heluta *et al.* (2009), in Ukraine, *E. catalpae* may be supplanted in the future by *E. elevata*, which is likely to happen also in Romania.

E. elevata was probably imported into Romania along with plant material, given that Fodor and Vlad (2013) found this powdery mildew on potted catalpa trees for sale. In one of the investigated cities (Suceava), 182 recently planted trees of *C. bignonioides* f. *nana* were found, of which 175 displayed powdery mildew symptoms. There, it is most likely that *E. elevata* was brought along with the host plants, which is assumed to be the most probable pathway of powdery mildew fungi introduction (Paap *et al.*, 2017).

Worthy to mention, no powdery mildew species on *Catalpa ovata* were found in the hereby study. This taxon is included in the hosts list of *E. elevata* (Braun and Cook, 2012), but it is not mentioned in any published data from Europe, where the most frequent host plant is *C. bignonioides* (Ale-Agha *et al.*, 2004; Cook *et al.*, 2004; Milevoj, 2004; Cook *et al.*, 2006; Pastirčáková *et al.*, 2006; Stoykov, 2008; Heluta *et al.*, 2009). Moreover, this powdery mildew was not detected on *C. ovata* in the UK (Cook *et al.*, 2006). Also, in a study on susceptibility of *Catalpa* to powdery mildew (Olsen *et al.*, 2006), *C. ovata* was resistant to *E. elevata*.

Conclusions

Erysiphe elevata is an invasive species in Romania, affecting the ornamental value of *C. bignonioides*. The results indicate a high incidence of this powdery mildew along streets, in contrast to landscapes around buildings

where the disease occurred less frequently. The present study fills a gap on the distribution map of *E. elevata* in Romania, highlighting that the species is widespread in the urban environment within North-Eastern Romania. In this context, it is necessary to evaluate the spread of this species throughout Romania, as well as the long-term effects on the host plant, so that strategic solutions can be recommended.

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