

Assessment of plane trees health status in urban green areas of Sofia, Bulgaria

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Abstract. Health status of plane trees (*Platanus* spp.) was observed in twenty urban green localities on the territory of Sofia city. Field inventories were conducted in June-October 2022. In the studied localities *Platanus × acerifolia* was the dominant species, comprising 90.5% of all trees, and the rest ones were *Platanus orientalis* L. According to the age, the largest share (63.2%) was occupied by mature trees at the age >60-100 years. The vitality of trees was assessed by estimating the degree of defoliation, presence of dieback and dry branches in the crowns. The average defoliation varied between 5% and 71.7%, but the majority of trees were in defoliation range between 30% and 50%. In good health conditions (0-25% defoliation) were the trees in five localities (City Garden, Slaveykov Square, National Palace of Culture, Vazrazhdane Park, Earth and People National Museum Park), where no drying in the top of the crowns was observed. The results reported in this study show that damages caused by biotic agents were associated with relatively different impact of identified pests and diseases. The relatively greater negative effect on the health status of trees was determined in attacks caused by the sycamore lace bug (*Corythucha ciliata*) and anthracnose disease (caused by the fungal pathogen *Apiognomonia veneta*). In two localities the fungal pathogens *Armillaria mellea* and *Cytospora platani* caused severe damages on studied trees. The decorative qualities and tree vitality of solitary plane trees in Sofia are threatened by negative impact of the biotic factors.

Key words: *Platanus* spp., urban green areas, health status, biotic agents, Sofia, Bulgaria.

Introduction

The urban forest is a green infrastructure system that deliver multiple environmental, economic, social and health services, and functions in cities (Wolf et al., 2020). Plane trees have been widely planted in urban and ornamental environments in Europe. Although the species prefer riparian and wetland habitats, in urban green areas they are drought-tolerant. *Platanus* species are often used in Bulgaria for landscaping of urban areas as ornamental plants in parks, gardens, streets and alleys due to their high deco-

orative value and resistance to air pollution. The oriental plane (*Platanus orientalis* L.) is a fast-growing and long-living tree species with high decorative value. Its natural distribution spread from eastern Sicily through the southern Balkan Peninsula, the islands of the Aegean and Anatolia to the Caucasus, north Iran and further east to central Asia and Afghanistan (Mandžukovski et al., 2021).

The species is the only naturally spread representative of *Platanus* genus in Bulgaria. The hybrid *Platanus × acerifolia* (Aiton) Willd, com-

monly known as London plane tree, is the most widely used *Platanus* species in the urban areas in Bulgaria as a street tree, and in large yards or parks as a shade tree. London plane tree is one of the most tolerant to atmospheric pollution, high temperature amplitudes, drought, diseases and root compaction.

In recent years the health condition of plane trees both in natural populations and in the urban environment has deteriorated significantly. The most serious problems include canker stain, anthracnose, powdery mildew, various wood-rotting fungi and the sycamore lace bug, *Corythuca ciliata* (Diminić et al., 2003; Diminić & Hrasovec, 2000; Intini et al., 2000; Intini & Tello, 2003; Juhasova & Hamsikova, 1996; Kehr et al., 2003; Panconesi, 1999; Pilotti et al., 2002; Strouts, 1991; Vigouroux, 1986).

Sofia is the capital and most populous city of Bulgaria. The green spaces are with very diverse landscaping. The most widely planted species are *Acer platanoides* L., *Aesculus hippocastanum* L., representatives of *Fraxinus*, *Tilia*,

Populus, *Platanus*, *Betula*, *Quercus* and many other genera. In the aggravated environmental city conditions, such as shading, noise, pollution, diseases and pests, many of the trees are in poor physiological and health condition.

The aim of this study was to assess the health status of *Platanus* solitary trees in Sofia, to identify the main insect pests and fungal pathogens, and to clarify their impact on the host plants.

Materials and methods

A total number of 106 plane trees were observed on the territory of Sofia in twenty urban green localities (twelve parks, five gardens and three streets) (Fig.1, Table 1). *Platanus × acerifolia* was the dominant species, comprising 90.5% of all trees, and the rest ones were *P. orientalis*. Selected trees were grouped according to their age into three classes: 1 - young (up to 20 years); 2 - middle aged (>20 and 60 years); 3 - mature (>60 years), according to the year of afforestation of the selected green areas.

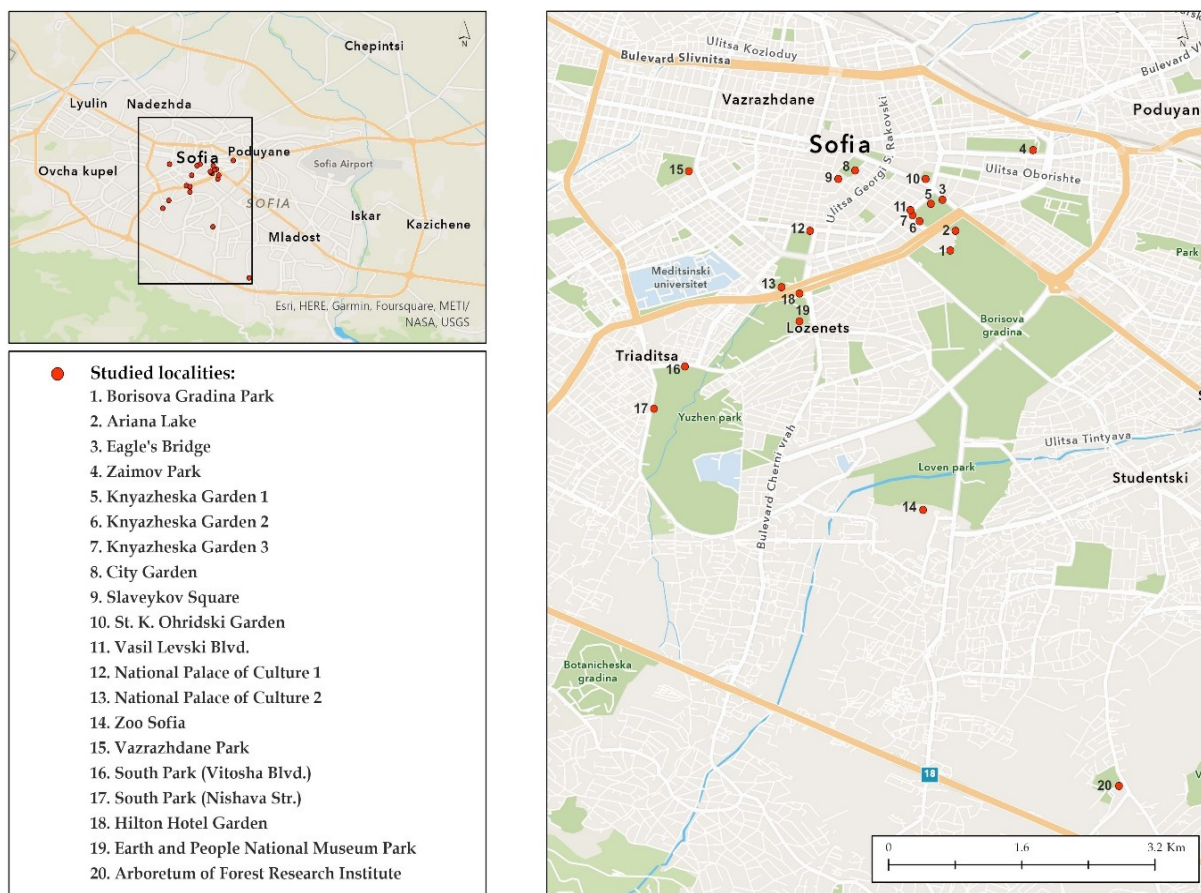


Fig. 1. Studied localities of *Platanus* trees in Sofia.

Table 1. Main characteristics of the studied localities.

N	Locality	Tree species	Number of trees	Geographical coordinates		Altitude, m	Class of tree age
				Longitude	Latitude		
1	Borisova Gradina Park	<i>Platanus acerifolia</i>	7	42.686588	23.336250	558	1
2	Ariana Lake	<i>Platanus orientalis</i>	6	42.688613	23.336250	554	3
3	Eagle's Bridge	<i>Platanus acerifolia</i>	5	42.691813	23.335436	555	3
4	Zaimov Park	<i>Platanus acerifolia</i>	5	42.696908	23.345191	551	3
5	Knyazheska Garden 1	<i>Platanus acerifolia</i>	5	42.691394	23.334163	563	3
6	Knyazheska Garden 2	<i>Platanus acerifolia</i>	2 3	42.689619	23.332938	552	1 3
7	Knyazheska Garden 3	<i>Platanus acerifolia</i>	5	42.690219	23.332172	558	3
8	City Garden	<i>Platanus acerifolia</i>	5	42.694819	23.326000	567	3
9	Slaveykov Square	<i>Platanus acerifolia</i>	5	42.693944	23.324166	560	1
10	St. K. Ohridski Garden	<i>Platanus acerifolia</i>	5	42.693944	23.333611	557	3
11	Vasil Levski Blvd.	<i>Platanus acerifolia</i>	5	42.690730	23.331952	557	1
12	National Palace of Culture 1	<i>Platanus acerifolia</i>	5	42.688611	23.321102	568	3
13	National Palace of Culture 2	<i>Platanus acerifolia</i>	2 3	42.682855	23.318025	565	1 3
14	Zoo Sofia	<i>Platanus orientalis</i> <i>Platanus acerifolia</i>	3 6	42.660002	23.333338	600	3
15	Vazrazhdane Park	<i>Platanus acerifolia</i>	5	42.694755	23.308033	552	1
16	South Park (Vitosha Blvd.)	<i>Platanus acerifolia</i>	5	42.674686	23.307611	580	3
17	South Park (Nishava Str.)	<i>Platanus acerifolia</i>	5	42.670366	23.304269	589	2
18	Hilton Hotel Garden	<i>Platanus acerifolia</i>	5	42.682208	23.319997	560	2
19	Earth and People National Museum Park	<i>Platanus acerifolia</i>	3	42.679333	23.319997	567	2
20	Arboretum of Forest Research Institute	<i>Platanus acerifolia</i>	6	42.631641	23.354475	634	3

Field inventory and health status assessments were conducted in June–October 2022. The condition of trees in studied localities was assessed by estimating the degree of defoliation compared to the amount of foliage on a standard reference tree (Eichhorn et al., 2020). Defoliation was associated with other morphological and physiological indicators of reduced tree vitality. The frequency of symptoms of damage recorded on foliage, branches, stem, and collar was reported related to damage caused by pests and fungal pathogens.

Individual trees were allocated to mild, moderate or severe categories of damage caused by pests and diseases according to the scores of defoliations and presence of dry branches in the crown, as follows: mild (damage cover \leq 25% of tree crown); moderate (damage cover between 25 and 60% of tree crown); severe (damage cover \geq 60% of tree crown).

Results

According to age, the largest share (63.2%) was occupied by mature trees from class 3 (60–100 years old). The trees from the other classes were distributed from 12.3% (middle aged) to 24.5% (young trees) (Table 1).

The impact of defoliation on the examined tree vitality depended on the distribution along the entire 0–100% defoliation range. The average defoliation varied between 5% (9 – Slaveykov Square) and 71.7% (2 – Ariana Lake), but the majority of trees examined in this study were in a defoliation range between 30% and 50% (Fig. 2).

In good health conditions (0–25% defoliation) were the trees in five localities (8 – City Garden, 9 – Slaveykov Square, 13 – National Palace of Culture 2, 15 – Vazrazhdane Park, 19 – Earth and People National Museum Park), where no drying in the top of the crowns was observed.

Significant differences existed in the damage effect across diseases when measured the health status of trees. Damage caused by the fungus *Apiognomonia veneta* (Sacc. et Speg.) Höhnel. – a causal agent of plane tree anthracnose, were observed in 95% of studied localities. The patho-gen caused damage on the leaves and branches withering of *Platanus* spp., which worsen tree ornamental qualities and their health status (Table 2). The strongest damages were observed in two localities - Ariana Lake (2) and National Palace of Culture 1 (12) (Fig. 3A). The highest concentration of trees was detected in the moderate category at 55% of the studied localities.

In other identified pathogens (*Armillaria mellea* (Vahl) Kumm., *Cytospora platani* Fuckel, *Erysiphe platani* (Howe) Braun & Takam., *Phomopsis* sp. and *Phytophthora* sp.), numbers

of affected trees differed by the disease type. The trees damaged by the root rot pathogen *A. mellea* (10 - Sofia University and Eagle's Bridge) (Fig. 3B) and necrotic disease caused by *C. platani* (15 - Vazrazhdane Park) were categorized as severe (Table 2). At mild to moderate categories were assessed trees damaged by *E. platani*, *Phomopsis* sp. and *Phytophthora* sp. in six studied localities.

Phytophthora bleeding canker was found on the bark of trees in the locality Knyazheska Garden 3. The most prominent symptom of the disease was dark-colored sap oozing from bark cankers. Infected bark was water soaked and stained in brown color (Fig. 4A). The structures of *Phytophthora* species were found: withy mycelium structure (Fig. 4B) and semipapilate sporangia with ovoid shape (Fig. 4C).

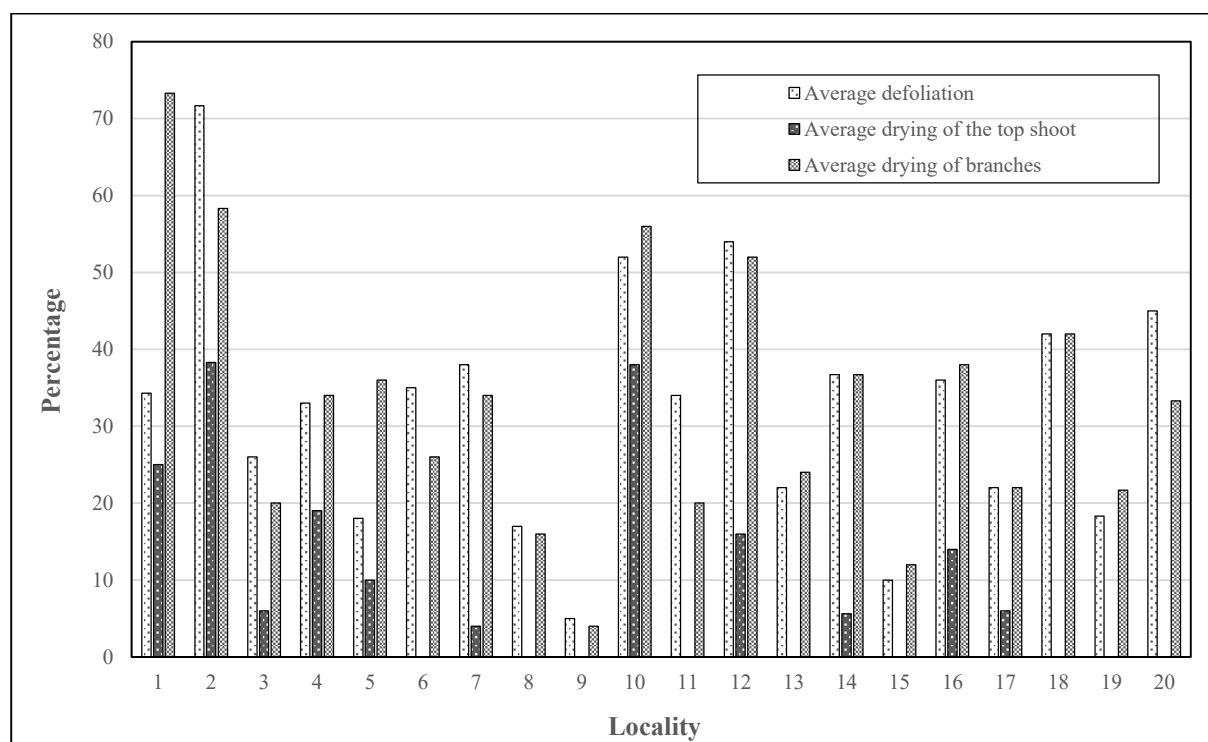
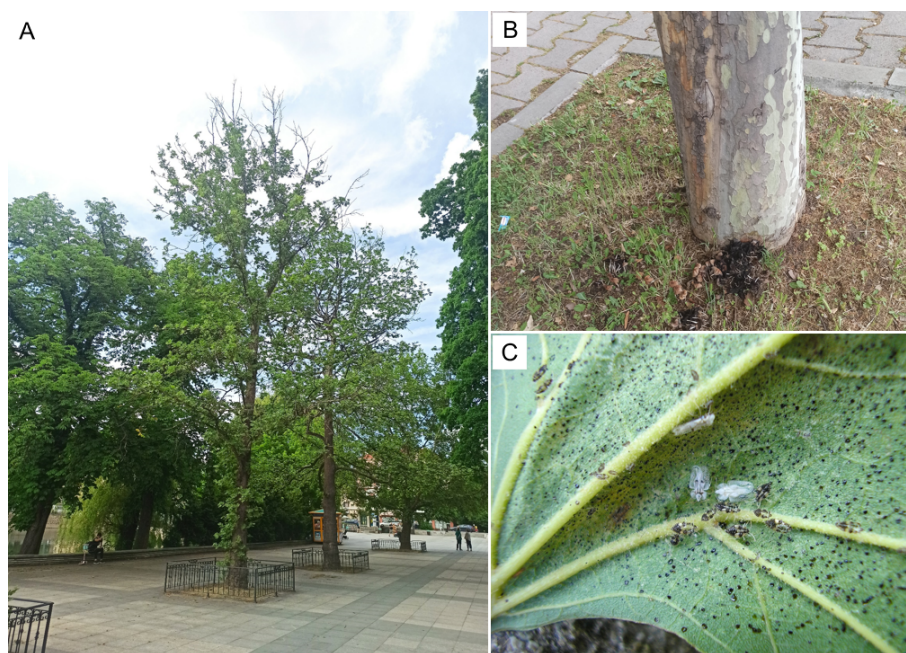


Fig. 2. Average defoliation and drying of crown of *Platanus* trees in different localities: 1 – Borisova Gradina Park; 2 – Ariana Lake; 3 – Eagle's Bridge; 4 – Zaimov Park; 5 – Knyazheska Garden 1; 6 – Knyazheska Garden 2; 7 – Knyazheska Garden 3; 8 – City Garden; 9 – Slaveykov Square; 10 – St. K. Ohridski Garden; 11 – Vasil Levski Blvd.; 12 – National Palace of Culture 1; 13 – National Palace of Culture 2; 14 – Zoo; 15 – Vazrazhdane Park; 16 – South Park (Vitosha Blvd.); 17 – South Park (Nishava Str.); 18 – Hilton Hotel Garden; 19 – Earth and people National Museum Park; 20 – Arboretum of Forest Research Institute.

Table 2. Damage caused by biotic factors on *Platanus* trees in studied localities.

N	Locality	Degree of damage on plane trees*							
		Fungal pathogens						Insect pests	
		A. <i>veneta</i>	A. <i>mellea</i>	C. <i>platani</i>	E. <i>platani</i>	<i>Phomopsis</i> sp.	<i>Phytophthora</i> sp.	C. <i>ciliata</i>	P. <i>platani</i>
1	Borisova Gradina Park	++	-	-	-	-	-	++	+
2	Ariana Lake	+++	-	-	-	-	-	++	-
3	Eagle's Bridge	++	+++	-	-	-	-	++	-
4	Zaimov Park	++	-	-	-	-	-	++	-
5	Knyazheska Garden 1	+	-	-	-	-	-	++	-
6	Knyazheska Garden 2	++	-	-	-	-	-	++	-
7	Knyazheska Garden 3	++	-	-	-	-	+++	++	-
8	City Garden	+	-	-	-	-	-	++	+
9	Slaveykov Square	-	-	-	-	-	-	+	-
10	St. K. Ohridski Garden	++	+++	-	++	-	-	++	-
11	Vasil Levski Blvd.	++	-	-	-	-	-	++	-
12	National Palace of Culture 1	+++	-	-	++	-	-	++	-
13	National Palace of Culture 2	+	-	-	-	++	-	+++	+
14	Zoo Sofia	++	-	-	-	-	-	+	+
15	Vazrazhdane Park	+	-	+++	-	++	-	++	-
16	South Park (Vitosha Blvd.)	++	-	-	-	-	-	++	+
17	South Park (Nishava Str.)	+	-	-	-	-	-	++	-
18	Hilton Hotel Garden	++	-	-	-	-	-	++	+
19	Earth and People National Museum Park	+	-	-	+	-	-	++	+
20	Arboretum of Forest Research Institute	++	-	-	-	-	-	++	+++

*Degree of damage: + mild; ++ moderate; +++ severe.

**Fig. 3.** Biotic damage on solitary *Platanus* trees: A – drying of crown caused by *Apiognomonia veneta* (Ariana Lake); B – *Armillaria mellea* (Eagle's Bridge); C – *Corythucha ciliata* (Arboretum of Forest Research Institute).

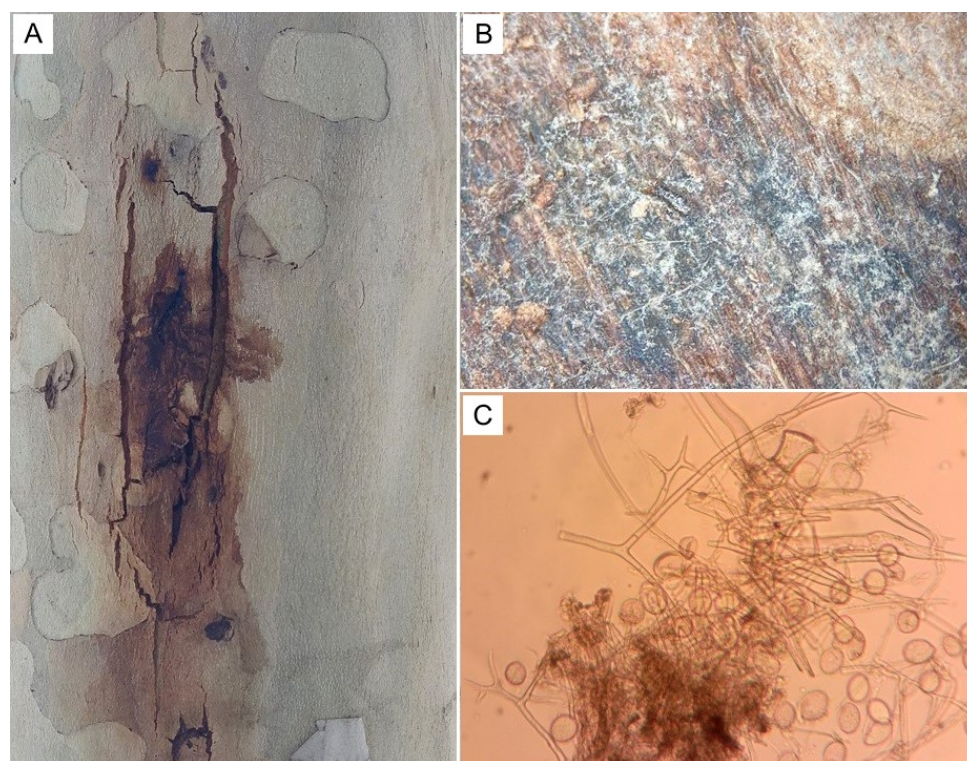


Fig. 4. Symptoms of damage caused by *Phytophthora* sp. (Knyazheska Garden 3): A – brown-coloured sap oozing from bark canker; B – mycelium of fungus; C – sporangia.

Colonies of a sycamore lace bug, *Corythucha ciliata* (Say, 1832) (Hemiptera: Tingidae) were noticed on the undersides of the leaves of London plane trees (*Platanus × acerifolia*) and *P. orientalis* in all studied localities (Table 2). Infected leaves were easily identified by their characteristic chlorophyll depigmentation (Fig. 2C). Most trees were moderately affected. Severe attack was only observed at the park of National Palace of Culture (13) and low attack - on plane trees in Zoo Sofia (14).

Mild attacks by the leaf-miner pest *Phyllonorycter platani* (Staudinger, 1870) (Lepidoptera: Gracillariidae) were detected in seven studied localities in the city (Table 2). Severe damages by the pest were detected on leaves of *Platanus* trees in the Arboretum of Forest Research Institute.

Discussion

The results reported in this study show that damage caused by biotic agents on *Platanus* trees in Sofia city were associated with relatively different impact of identified pests and diseases. The relatively greater negative effect on the health status of trees was determined in attacks

caused by the fungal pathogens *Apiognomonia veneta*, *Armillaria mellea*, *Phytophthora* sp. and the sycamore lace bug (*Corythucha ciliata*). In three localities the fungal pathogens *A. mellea* and *Cytospora platani* caused severe damages on studied trees.

Sycamore lace bug (*C. ciliata*) is naturally distributed in USA and south parts of Canada. In Europe the species was found for first time in Italy in 1964 and later in other countries (France, Switzerland, Croatia, Greece, etc.). In Bulgaria the pest was found for first time in Sofia (Josifov, 1990). Currently, the pest has distributed all over the country. The species is trophically related to plane trees (*Platanus* spp.). In urban environment in Bulgaria, the pest mostly attacks *Platanus × acerifolia* trees. It has penetrated into all natural localities of *P. orientalis* in the country.

Apiognomonia veneta is distributed in several countries from Europe (Tello et al., 2000), as well as in Australia (Milne & Hudson, 1987), New Zealand (Brien, 1939), South Africa (Swart et al., 1990) and South America (Sinclair et al., 1987). In Bulgaria serious damage and drying of species from genus *Platanus* was reported in 1981

(Rossnev, 1981), and later – on dry leaves from *P. orientalis*, growing in Struma River valley (Stoykov & Assyov, 2006).

Insignificant damage with mild and moderate effect of the pest *Phyllonorycter platani* and fungal pathogens (*Erysiphe platani*, *Phomopsis* sp., and *Phytophthora* sp.) were detected on *Platanus* trees in studied localities. In Europe, the pathogen *E. platani* was observed for the first time in Italy (Sprenger, 1916) and now occurs in most European countries (Fakirova, 1991; Pastirčáková et al., 2014). Recently, *Cytospora platani* has been found to cause damages on *Platanus × acerifolia* trees planted in urban green areas in Karlovo (Dimitrov et al., 2018). Symptoms of diseases caused by the fungal pathogens *Phomopsis* sp. and *Phytophthora* sp. on plane trees were observed for the first time in Bulgaria.

In present study, canker stain caused by the fungus *Ceratocystis platani* (Walter) Engelbr. & Harr was not identified. The pathogen was introduced from North America to Southern Europe, distributed on species from genus *Platanus*, causing destructive tracheomicotic disease (Pilotti et al., 2009). The most dramatic impact of the disease was reported in Greece in natural stands of oriental plane (Tsopelas & Angelopoulos, 2004; Tsopelas et al., 2017). *Platanus* species are the only hosts for pathogen, often used for planting in urban environments in the countries with moderate climate. The disease causes staining of the xylem, disruption of water movement, cankers and usually death of the tree (CABI Compendium, 2001). *C. platani* was detected at several locations in Istanbul causing severe dieback and mortality mainly on *Platanus × acerifolia* and *Platanus orientalis* (Lehtijärvi et al., 2017).

Conclusions

In conclusion, it should be noted that the decorative qualities of solitary plane trees in Sofia are threatened by negative impact of biotic factors. Among the insect pests, the most important are attacks caused by the invasive sycamore lace bug (*Corythucha ciliata*), and among the fungal pathogens - infections caused by *Apiognomonina veneta*, *Armillaria mellea*, *Phytophthora* sp. It is important to note that the pathogen *Ceratocystis platani* caused severe damage in natural stands and solitary plane trees in urban green areas in the neighboring countries,

Greece and Turkey. If the pathogen entry Bulgaria, the disease would be destructive, causing widespread mortality of thousand natural and planted trees.

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