Received: 15.05.2025; Revised: 20.08.2025; Accepted: 23.09.2025

UKRAINIAN JOURNAL OF FOREST AND WOOD SCIENCE

UKRAINIAN JOURNAL OF FOREST AND WOOD SCIENCE

Journal homepage: https://forestscience.com.ua/en
Ukrainian Journal of Forest and Wood Science, 16(3)

UDC 630*436:630*17
DOI: 10.31548/forest/3.2025.75

Bacterioses of woody plants in the local urban phytocenoses of Kyiv: Symptoms, etiology, and distribution

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Abstract. Urban ecosystems of modern cities are characterised by a high level of anthropogenic load, which negatively affects the state of green spaces. Woody plants are particularly vulnerable to negative impacts, which occupy a key role in ensuring the ecological stability of the urban environment. The phytosanitary condition of trees is an important indicator of the health of the city ecosystem; therefore, its monitoring and analysis are urgent tasks in modern ecology. The aim of the study was a comprehensive study of the bacteriosis of woody plants in local urban phytocenoses of Kyiv, including the analysis of the characteristics of symptoms, identification of pathogens, and patterns of disease spread. The research was conducted during the 2024 growing

Suggested Citation:
Kulbanska, I., Kolesnichenko, O., Goychuk, A., & Shvets, M. (2025). Bacterioses of woody plants in the local urban phytocenoses of Kyiv: Symptoms, etiology, and distribution. *Ukrainian Journal of Forest and Wood Science*, 16(3), 75-92. doi: 10.31548/forest/3.2025.75.

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season in the green areas of the “Respublika Park” and “Retroville” shopping and entertainment complexes. The work used modern microbiological methods for identifying pathogens of bacteriosis, as well as classical methods of phytosanitary inspection. To clarify the current systematic position and current name of taxa, information from the interactive databases “Index Fungorum” and “International Committee on Systematics of Prokaryotes” was used. It was investigated that the sanitary condition of the urbophytocenoses of the “Respublika Park” and “Retroville” shopping centers is characterised by a high degree of weakening of *Acer saccharinum* L. trees and a medium degree for *Ulmus laevis* Pall. It was established that the main cause of weakening of the trees is bacteriosis, the causative agent of which is the bacterium *Lelliottia nimipressurallis* (Carter 1945) Brady *et al*. 2013, which was confirmed by the polymerase chain reaction method. It is noted that the primary signs of damage to the bacteriosis of *Acer saccharinum* and *Ulmus laevis* urbophytocenoses are superficial peeling cracks, swelling of the bark, and the release of exudate. Secondary signs of damage were deep ulcers, necroti sation of wounds, and settlement of wood-destroying fungi. It was shown that the degree of development of bacteriosis on *Acer saccharinum* trees is 2 points and is characterised as rapid, and for *Ulmus laevis* trees – 1 point and is characterised as gradual. Thus, this study allowed to obtain a comprehensive picture of the spread and impact of bacteriosis on woody plants of urban phytocenoses of Kyiv, and also, based on the described features of symptoms – key diagnostic elements to develop measures for timely phytosanitary management of the condition of green spaces of cities to improve the ecological state and improve the quality of life of residents

Keywords: *Acer saccharinum*; *Ulmus laevis*; microbiota; phytopathogens; bacteria; urban plantings

Introduction

The functioning of urbanised phytocenoses occurs under the complex influence of environmental factors (especially anthropogenic and abiotic), such as air and soil pollution due to transport and industrial emissions, radiation and electromagnetic radiation, noise pollution, vandalism, the emergence of “heat islands”, insufficient or excessive moisture, temperature fluctuations, disregard for environmental aspects in urban planning, etc. These factors weaken trees, making them vulnerable to the effects of various phytopathogens, which can cause diseases of various etiologies, including bacterial, viral, and fungal infections. Trees weakened by anthropogenic and abiotic stresses lose their natural resistance, contributing to the active spread of pathogenic microorganisms, including bacteria.

Studies of the sanitary condition by M. Matic *et al.* (2023), as well as the causes of weakening of trees that are part of urban phytocenoses, mainly concern factors of abiotic origin, and to a lesser extent – biotic, some gaps are especially noticeable in the identification of the species composition of phytopathogenic organisms, in particular bacteria. However, the availability of literature sources allows us to conduct a comparative analysis of previously obtained results to identify key trends and patterns of the influence of biotic factors, in particular bacterial infections, on the condition of trees in urban conditions. According to M.S. Kolenkina (2020) it was known that urban phytocenoses, especially those that are part of large cities, are constantly exposed to direct or indirect negative impacts of environmental factors, resulting in impaired tree viability.

V.L. Meshkova (2017) emphasised in her works that over the past decades the species composition of pathogens and insects of urban phytocenoses has significantly changed due to aboriginal species that have adapted to exist against the background of technogenic environmental pollution, and adventitious species that, with increasing temperature in cities, have better conditions for increasing the number of generations in the summer to survive in the winter. These studies emphasised the need for an integrated approach to the management of urban green spaces. It is important not only to take into account the resistance of plants to diseases and pests but also to understand how the species composition of potential phytopathogens changes under the influence of urbani sation and climate change. G.P. Nighswander *et al.* (2021) noted that the resistance of woody plants to pathogens and pests is an important ecosystem characteristic of urban stands that should be taken into account since the aggressiveness of phytopathogenic organisms limits the ecosystem services that plants provide in urban ecosystems. According to the authors, to ensure the sustainability of urban stands and maintain their ecosystem services, it is necessary to select resistant species, ensure their proper care, monitor them, and use an integrated approach to combat pests and pathogens, which combines different methods, such as biological control, agrotechnical measures, and chemical treatments. Taking into account all these aspects, it is possible to create more resilient and healthy urban stands that will effectively fulfill their ecological functions and benefit city residents.

Several scientific works are devoted to the study of modern phytosanitary problems caused by biological agents that weaken and damage urban plantings around the world, resulting in the disruption of the various services they usually provide. The study by F. Bălăcenoiu *et al.* (2020) involved a comprehensive study of the role and place of invasive species of pathogens and pests in urban plantings in Europe (in particular, the city of Bucharest, Romania). M. Lisovyy *et al.* (2023) conducted monitoring studies of invasive species of bed bugs in green areas of Kyiv (Ukraine). The studies of T.O. Boyko (2020) concern the factors of deterioration of phytosanitary conditions of green areas of Kherson (Ukraine). M.V. Matusiak (2020) assessed the current state of development of diseases and pests in green areas of Vinnytsia and their impact on the viability of woody plants. present in the region or may spread their, to reveal their distribution, and ecological significance and predict the consequences of impact on the overall biodiversity of urban phytocenoses. At the same time, there is very little information about the spread and impact of phytopathogenic bacteria on woody plants growing within urban stands. Bacteriosis can lead to a significant deterioration in the condition of trees, their dieback, which negatively affects the ecological situation in the city, the aesthetic appearance and the quality of life of residents. The study aimed to comprehensively study the bacteriosis of woody plants in local urban phytocenoses of Kyiv. This included analysing the characteristics of symptoms, identifying pathogens, and understanding the patterns of disease spread. Therefore, research into the features of the symptoms, etiology and spread of phytopathogenic bacteria in urban phytocenoses is an important step for developing effective strategies for protecting green spaces and preserving urban biodiversity.

Materials and Methods

The study of the symptoms, etiology and spread of bacteriosis of woody plants was conducted in the urban phytocenoses of Kyiv using the example of green spaces in the territory of the “Respublika Park” and “Retroville” shopping and entertainment complexes. In the surveyed territories, plantings of woody plants were mainly presented in a linear form along streets, boulevards or along the perimeter of areas bounded by fences. As part of the study, a total of 375 woody plants from two species were examined in the territories of shopping and entertainment centres in Kyiv. These included 200 *A. saccharinum* and 50 *U. laevis* specimens at "Respublika Park" shopping center, and 100 *A. saccharinum* and 25 *U. laevis* specimens at "Retroville shopping centre. The sampling was carried out using a complete enumeration method, covering all available and representative individuals of the respective species at each location. As such, the variability in the number of trees across diameter classes reflects the actual structure of the plantings rather than a result of selective sampling. Despite the relatively narrow interval between diameter classes (2 cm), the chosen grouping allowed for the identification of potential trends in the spread of the bacterial pathogen, even with minor differences in morphometric parameters. The diameter at breast height (DBH) of each tree was measured at 1.3 metres using a measuring tape, and trees were grouped into diameter classes with a 2 cm interval (16, 18, 20 cm).

The general assessment of the sanitary condition of the plantations was carried out by the method of phytosanitary inspection during the growing season of 2024 with a division into sanitary condition categories (I-VI) (Resolution of the Cabinet of Ministers of Ukraine No. 756, 2016). During the monitoring, stands were inspected by route and list methods in order to identify typical signs of infection by the bacteriosis pathogen, as well as identify foci of infection. The development of bacteriosis was evaluated using a four-stage scale developed by the authors: 0 – absence of visible symptoms; 1 – initial manifestation of infection; 2 – active pathological development; 3 – reduction of pathological activity. Identification of pathogens of bacterial diseases of woody plants was carried out by the polymerase chain reaction method based on the private laboratory and production complex Farmer.ua. The object of the study was the plant material of *A. saccharinum* and *U. laevis*.

The procedure for identifying bacterial pathogens consisted of the following stages: sampling, DNA isolation (which included both plant and bacterial DNA), and PCR analysis. Sampling was carried out on trees that were potentially affected or exhibited visible signs of bacteriosis infection. A total of 24 plant material samples were analysed, comprising 12 samples of *A. saccharinum* vegetative organs (shoots (3), leaves (3), bark (3), and wood (3)) and 12 similar samples from *U. laevis* trees. The samples were taken under sterile conditions and stored refrigerated until further analysis. For DNA extraction, a modified method based on the J.J. Doyle & J.L. Doyle (1987) protocol for plant material was used. A feature of this method is the use of cetyltrimethylammonium bromide (cetavlon, CTAB) as a detergent for DNA extraction and subsequent precipitation with alcohol. PCR (polymerase chain reaction) analysis was performed using specific primers complementary to unique DNA regions of potentially pathogenic bacteria. Primers targeting the following bacterial species were used: *Xylella fastidiosa* (Wells *et al.*)*, Pseudomonas syringae* (Van Hall)*, Erwinia amylovora* (Burrill) Winslow *et al*., and *L. nimipressurallis*. PCR products were analysed by electrophoresis in a 1.5-2% agarose gel for 5 hours in 1 × SB buffer (5 mM Na2B4O7, pH 8.5). The presence of a specific DNA fragment, visualised by staining with ethidium bromide and photographed under UV light, indicated the presence of a disease-causing bacterium in the sample. Additionally, two controls were used for each pathogen in PCR: a positive control (containing the pathogen's genetic sequences) and a negative control (lacking biomaterial to check for contamination or nonspecific reactions).

Each sample also contained an internal control, an amplification of the plant genomic sequence, to verify successful nucleic acid isolation. DNA Marker 100 bp (100 bp + 1.5 Kbp; SibEnzyme) was used as a standard for determining the size of DNA fragments.

Latin names of higher plant species were given by: World Flora Online (n.d.), fungi by: Index Fungorum (n.d.), bacteria by: International Committee on Systematics of Prokaryotes (n.d.). Certain conclusions were obtained based on data that were established during the processing of herbarium specimens, as well as during the analysis of special literature. The study was conducted in accordance with the ethical standards specified in the Convention on Biological Diversity (1992).

Results and Discussion

Symptoms. The general sanitary condition of woody plants is an important indicator of the "health" of the urban environment and its ability to fulfill its functional purpose fully. After all, cities' trees create aesthetic appeal provide shade, and play a key role in regulating the microclimate, purifying the air from pollution, reducing noise levels, and creating favorable conditions for people's lives. The results of phytosanitary monitoring of woody plants of urban phytocenoses in Kyiv showed signs of a violation of the normal physiological state of trees, which is visually manifested in the form of growth retardation, a decrease in the size of the leaf, openwork crown, ulcers on woody organs, and dieback (Fig. 1).

a *b* *c*

Figure 1. General phytosanitary condition of the surveyed stands of the urban phytocenoses of Kyiv

Note: a – trees without visible signs of damage; b – ulcer on the trunk of *Acer saccharinum*; c – a tree that dieback

Source: compiled by the authors

Signs of weakening have been recorded on *Acer saccharinum, Acer platanoides, Ulmus laevis* and *Tilia cordata*. However, the particularly dangerous symptoms characteristic of the known bacteriosis have only been detected on *Acer saccharinum* and *Ulmus laevis*, so further research is focused on these tree species. The spread of bacteriosis symptoms occurs from the bottom up, i.e., from the root system to the crown of the tree. The first signs of infection are swelling of the bark and the formation of longitudinal peeling cracks (Fig. 1a), the bark on which changes color to dark (black). Over time, the swellings begin to actively crack (peel), fall off in large pieces, exposing the cambium. A characteristic sign of infection is the formation of longitudinal necrotic lesions of the phloem in the basal zone of the trunk. Also, over time, relatively short (from 0.5 to 10 cm) transverse cracks form, which ring the affected organ – the trunk or branch, partly resembling transverse oak cancer or stepped cancer in the early stages of pathogenesis. Also, a typical sign is the leakage of exudate. Usually, it is a viscous liquid of dark color with an unpleasant odor, which is localised within the ulcer (Fig. 2b). The intensity of the leakage of exudate depends significantly on weather conditions and the condition of the affected tree. At the end of the growing season, the leakage process stops, but on the trunks for a long time you can notice weeping wounds or dirty streams.

a *b* *c*

Figure 2. Typical symptoms of bacteriosis development on maple trunks
Note: a – peeling cracks; b – open longitudinal wound with exudate leakage; c – development of wood-destroying fungi on the surface of the ulcer
Source: compiled by the authors

The pathogen actively multiplies in the tissues of the tree, affecting the bark, phloem and cambium. In one growing season, it is able to form significant lesions in terms of area, which leads to serious consequences for the tree. Tangential spread of necrotic lesions of the phloem with longitudinal connection into continuous strips of ulcers covering the phloem and cambium was detected during a detailed examination of the trees. The lesion covered a significant part of the tree, starting from young branches in the upper part of the crown and reaching the base of the trunk. Tangential spread of necrotic lesions of the phloem on the tree trunk was often localised in the areas of branch attachment, where increased ribbing of the bark was observed. Local necrosis of the cambium was observed in the affected area. This is indicated by the radial growth of the xylem beyond the necrotic lesions, where the cambium retained its functional activity, and the formation of a "traumatic ring" in the xylem of the branches, which are morphological signs of local death of the cambium within the pathological changes. Despite the lesions, the parenchyma cells under the wood remained alive, their death was not detected. Problems with wood growth were observed only where the cambium was already dieback.

The final stage of the development of bacteriosis is the coloni sation of the affected wood tissues by wood-destroying and wood-staining fungi (Fig. 2c). This process can last for years, gradually destroying the structure of the wood and weakening its mechanical strength. Wood-destroying fungi feed on cellulose and lignin, which form the basis of wood. They secrete enzymes that break down these substances, converting them into nutrients available to them. This process is accompanied by the decomposition of wood, its softening and loss of strength. Wood-staining fungi, in turn, do not destroy the structure of the wood, but can change its color, causing the appearance of spots, stripes or other visual defects. This occurs due to the fact that the fungi penetrate the cells of the wood and secrete pigments that color it in different colors. The combination of bacterial damage with fungal coloni sation significantly accelerates the process of wood destruction and leads to its rapid decay. This is especially dangerous for trees growing in urban environments, where they are already under significant stress from air pollution, lack of moisture, and other negative factors.

Etiology. Analysis of symptoms of pathologies registered during phytosanitary monitoring of woody plants of urban phytocenoses of Kyiv allowed us to state that the detected diseases have an infectious origin (Table 1).

Table 1. Results of PCR analysis of plant material of trees of urban phytocenoses in Kyiv

Type of bacteria	Plant material for research	
	Acer saccharinum	*Ulmus laevis*
Xylella fastidiosa	–	–
Pseudomonas syringae	–	–
Erwinia amylovora	–	–
Lelliottia nimipressurallis	+	+

Note: + detected, – not detected
Source: compiled by the authors

PCR analysis revealed the presence of the bacterium *Lelliottia nimipressurallis* in plant material of both *Acer saccharinum* and *Ulmus laevis*. As is known, this bacterium is a dangerous phytopathogen that causes the disease bacterial wetwood. This disease is currently registered in Ukraine, both on deciduous (*Betula pendula* Roth., *Quercus robur* L.) and coniferous (*Abies alba* Mill.) species of woody plants, which was experimentally confirmed by research. The bacteria *Xylella fastidiosa, Pseudomonas syringae*, and *Erwinia amylovora* were not detected in the tested samples, indicating their absence or presence in quantities below the sensitivity limit of the PCR method. Thus, the etiology of the disease of *Acer saccharinum* and *Ulmus laevis* trees was associated with the dangerous phytopathogenic bacterium *Lelliottia nimipressurallis*, which is dynamically spreading in Ukraine, characterised by the rapid development of pathogenesis, the final stage of which is the dieback of affected trees. Therefore, in the absence of early diagnosis and accurate identification of the pathogen, it is practically impossible to choose an effective plant protection scheme.

Distribution. Woody plants have an important role in creating a comfortable microclimate, purifying the air and aesthetic design of urban space. Maintaining the health, and therefore the possibility of normal functioning, of green spaces is important for ensuring ecological stability and quality of life in cities. Currently, *Acer saccharinum* and *Ulmus laevis*, due to their unpretentiousness to growing conditions and decorativeness, are often used in urban landscaping. Both types of trees can be planted to create shady alleys, which is important in hot climates.

At the same time, a large number of these trees in a limited area in specific conditions of urban phytocoenoses creates favorable conditions for the rapid spread of dangerous types of phytopathogens, including pathogens of bacteriosis. A detailed analysis of the phytosanitary inspection of woody plants on the territory of the "Respublika Park" and "Retroville" shopping malls allowed us to obtain an objective picture of the spread of bacteriosis (Tabl. 2).

Table 2. Results of phytosanitary inspection of woody plants with signs of bacteriosis, which is part of the urban phytocenoses of Kyiv

Species name	Number of surveyed trees, pcs.	Sanitary condition category											
		I		II		III		IV		V		VI	
		pcs.	%	pcs.	%	pcs.	%	pcs.	%	pcs.	%	pcs.	%
Territory of the "Respublika Park" shopping mall													
A. saccharinum	200	89	44.5	6	3.0	51	25.5	44	22.0	10	5.0	0	0.0
U. laevis	50	19	38.0	7	14.0	18	36.0	6	12.0	0	0.0	0	0.0
Territory of the "Retroville" shopping mall													
A. saccharinum	100	50	50.0	25	25.0	14	14.0	9	9.0	2	2.0	0	0.0
U. laevis	25	16	64.0	5	20.0	2	8.0	2	8.0	0	0.0	0	0.0

Source: compiled by the authors

On the territory of the "Respublika Park" shopping mall, a significant part of *Acer saccharinum* trees (47.5%) has visible signs of weakening (trees are classified as III–V sanitary condition), which indicates the need to implement sanitary measures, including treatment or removal of individual specimens. At the same time, the majority (over 50.0%) of the surveyed *Ulmus laevis* trees are in satisfactory condition, but are characterised by a medium or high level of infection by infectious agents (including the causative agent of bacteriosis), which requires monitoring and measures for their recovery.

A somewhat better, but also alarming, phytosanitary situation is observed with the trees of the urban phytocenoses of the "Retroville" shopping center: a quarter of *Acer saccharinum* trees have minor signs of weakening, and 3/4 of the trees can be considered viable. However, 14.0% of the trees have an average level of weakening, 9.0% – severe weakening, and 2.0% of the trees are currently in a critical condition, which requires their urgent removal. The general condition of elms is better than that of maples: 64.0% of the trees are healthy, 20.0% have minor signs of weakening, 16.0% are classified as III–IV categories of sanitary condition, which indicates the need for care and regular monitoring.

Analysis of the spread of bacteriosis on *Acer saccharinum* shows that the largest proportion (55.0%) of affected specimens is observed among trees with a thickness of 16 cm (Table 3, Fig. 3). The largest number of lesions (259 pieces) was recorded on trees with a trunk diameter of 18 cm, and the bacterium spread to practically every second tree (the proportion of affected trees is 49.0%). In trees with a diameter of 20 cm, the proportion of infected specimens is slightly lower (42.6%), while type II lesions prevail (76.9%), which indicates a progressive stage of the disease. In all groups of examined trees, type II lesions prevail over type I, which means an aggressive disease development.

Table 3. Distribution and types of symptomatic signs of bacteriosis on Acer saccharinum and Ulmus laevis trees

Thickness level, cm	Total number of trees counted, pcs.	Including infected trees, pcs.	Number of visible lesions by type				Total lesions, pcs.	Disease prevalence, %
			Type I		Type II			
			pcs.	%	pcs.	%		
Acer saccharinum								
16	20	11	10	23.8	32	76.2	42	55.0
18	151	74	107	41.3	152	58.7	259	49.0
20	129	55	45	23.1	150	76.9	195	42.6
Total	300	140	162	-	334	-	496	-
Ulmus laevis								
16	15	7	9	69.2	4	30.8	13	46.6
18	35	16	19	67.9	9	32.1	28	45.7
20	25	8	6	54.5	5	45.5	11	32.0
Total	75	31	34	-	18	-	52	-

Note: *affected – all plants that had visible symptoms of infection with the bacteriosis pathogen were considered affected; **type I (primary symptoms – swelling of the bark, peeling cracks, exudate secretion), type II (secondary symptoms – deep longitudinal ulcers, necroti sation of the wound surface, settlement of xylotrophic fungi)

Source: compiled by the authors

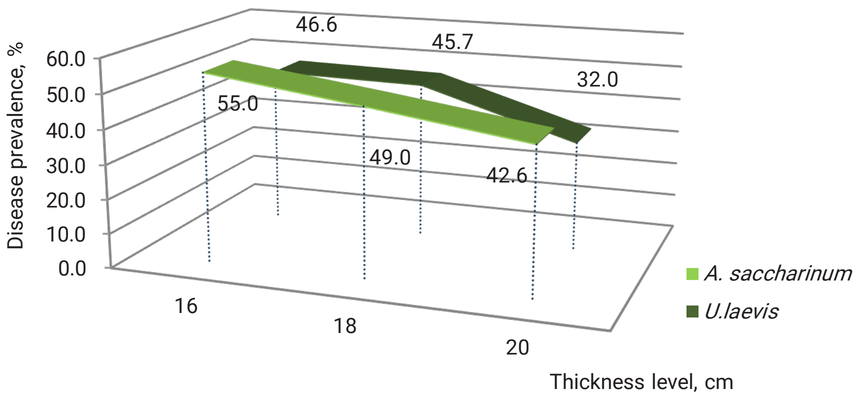

Figure 3. The dependence of the spread of *L. nimipressuralis* on *A. saccharinum* and *U. laevis* of different degrees of thickness

Source: compiled by the authors

The total proportion of infected *Ulmus laevis* trees is 41.3%, which is slightly lower than that of *Acer saccharinum*. Within the surveyed trees, a certain trend is observed: with increasing trunk diameter, the proportion of infected specimens decreases (for trees with a diameter of 16 cm, the infection rate was 46.6%, and for trees with a diameter of 20 cm – 32.0%), which may indicate an increased vulnerability of trees with a smaller diameter to damage by phytopathogens, although this trend requires additional verification taking into account age indicators. The type of lesions dominates in all examined plants, which indicates a less aggressive development of the disease compared to *Acer saccharinum*. The largest total number of lesions (28 pieces) was recorded on trees with a diameter of 18 cm, which may indicate a high vulnerability of trees that are in the phase of active growth, which weakens protective plant barriers.

The key characteristics of bacteriosis development and spread by location are summarised in Table 4.

Table 4. The main characteristics of the development and spread of bacteriosis

Location of experimental plots	Average number of ulcers, pcs.		Degree of bacteriosis development, score		The nature of the spread of bacteriosis (according to the authors' method)	
	A. saccharinum	*U. laevis*	*A. saccharinum*	*U. laevis*	*A. saccharinum*	*U. laevis*
Territory of the "Respublika Park" shopping mall	4	1	2	1	Rapid	Gradual
Territory of the "Retroville" shopping mall	3	1	2	1	Rapid	Gradual

Note: the analysis presented in this table is based on data collected from all 375 surveyed trees
Source: researched by the authors

It has been established that the visible signs of infection of *A. saccharinum* and *U. laevis* trees are the formation of longitudinal necrotic ulcers on the woody parts of the plant (branches and trunk). The length of the ulcers varies from 1.0 cm to 150 cm. Their number is also variable – from 1 to 10 pcs./m^2 and occupies from 5.0 to 100% of the branch circumference. When assessing the degree of bacteriosis development, the following criteria were taken into account: the area of tissue damage, the depth of pathogen penetration, the presence of secondary infections, and the general condition of the tree. The highest score for bacteriosis development was assigned to *A. saccharinum* trees since the pathogenesis of the disease is characterised by very active visual manifestations of the disease, and as a result, an already noticeable impact on the physiological state of the trees. *U. laevis* trees were assigned a score of 1 for bacteriosis development (according to the authors' method), i.e. initial signs of infection are recorded, macro signs of the lesion are barely noticeable, and the intensity of development is weak.

Two types of bacteriosis spread were identified during the analysis: rapid and gradual. The rapid nature of bacteriosis spread was found to be characteristic of *A. saccharinum* trees growing in the surveyed areas. This means that there is a high probability that in a short time, a significant number of trees growing next to the infected ones may be affected, which will lead to significant losses of green spaces. The development of the rapid nature of the spread of the disease may be due to or enhanced by various environmental factors, such as favorable weather conditions for the development of the pathogen; the presence of susceptible tree species; the presence and activity of pathogen vectors; insufficient plant care, etc. The gradual nature of the development of bacteriosis is inherent in the surveyed *U. laevis* trees. This means that the disease can develop imperceptibly for a long time, and only later manifest itself in the form of visible symptoms. That is why it is important to remember that the health of urban plantings is the key to the environmental safety and comfort of city residents.

According to data from C. Copeland *et al.* (2023), *Ulmus* spp. (elms) in urban environments are currently threatened by complex biotic pressures. Specifically, the phytopathogenic fungi *Ophiostoma ulmi* (Buism.) Nannf. and *O. novo-ulmi* Brasier cause Dutch Elm Disease (DED), which is one of the most dangerous elm diseases in the Northern Hemisphere. Simultaneously, these trees are significantly damaged by the leaf-eating pest *Aproceros leucopoda* (Takeuchi, 1939), whose larvae cause extensive leaf gnawing, premature leaf fall, and reduced photosynthesis. The simultaneous action of these factors, in combination with the bacterial pathogen *Lelliottia nimipressuralis* identified in the present study, may result in a cumulative weakening of *Ulmus* spp. in urban conditions. Even when bacterial symptoms begin as superficial lesions (Type I), their interaction with fungal infections and insect damage may amplify the overall decline of trees. This observation highlights the importance of a holistic view of tree health that integrates multiple stressors rather than treating them in isolation.

A. Scattolini Rimada *et al.* (2023) emphasise that trees of the genus *Platanus* spp., especially in Europe and North America, are significantly negatively affected by phytopathogenic microorganisms, in particular, the fungus *Ceratocystis platani* (J.M. Walter) Engelbr. & T.C. Harr., which causes sycamore canker (canker stain disease). Studies by M. Lisovyy *et al.* (2023) confirmed the spread of the invasive species of the bug *Corythucha ciliata* (Say, 1832) in Europe (including Ukraine), where it actively infects *Platanus* spp., sucking sap from the leaves, which leads to a weakening of photosynthetic activity, premature yellowing, and leaf fall, as well as general inhibition of tree growth. The current study contributes to this broader context by documenting the presence of *L. nimipressuralis* in *Acer saccharinum* and *Ulmus laevis* in Kyiv's urban phytocenoses. The observed symptoms – ranging from bark cracking and exudate production to secondary fungal colonisation – are consistent with chronic, system-wide physiological stress. Taken together, these findings illustrate how urban tree populations are exposed to an escalating array of biotic stressors, which, under the compounded pressure of climate change, pollution, and anthropogenic disturbance, may act synergistically to compromise tree vitality. The diversity of pathogenic organisms (bacteria, fungi, and insects) in these ecosystems points to the need for integrated plant health monitoring systems in urban forestry.

Quercus spp. trees, as noted by researchers J. Meunier *et al.* (2019), and C. Pintos *et al.* (2023), are significantly weakened by the fungi *Biscogniauxia mediterranea* (De Not.) Kuntze, *Phytophthora ramorum* Werres, De Cock & Man, *Cronartium quercuum* (Berkeley), *Ceratocystis fagacearum* (Bretz) Hunt. A particularly dangerous disease for oak is bacterial wetwood (the causative agent is the bacterium *Lelliottia nimipressuralis* (Carter 1945), also identified in study on *Acer saccharinum* and *Ulmus laevis*). As demonstrated in I.M. Kulbanska *et al.* (2021), this bacterium is capable of causing not only chronic weakening but also rapid death of oaks, including trees of older age groups, which emphasises its high pathogenic potential. This makes *L. nimipressuralis* a universal and particularly dangerous phytopathogen for a wide range of deciduous trees in cities. Thorough studies of the species composition of phytopathogens of *Acer* spp. trees belong to T. Jung *et al.* (2018), which concern the history, dynamics of distribution, features of symptoms, and etiology of cancer diseases caused by representatives of the genus of oomycetes Phytophthora in forests and natural ecosystems of Europe, Australia, and America. The impact of the fungus *Phytophthora acerina* on maples is described in particular detail by T. Jung *et al.* (2018). Symptoms of the lesion include necrotic lesions of the bark and cambium, which often lead to the formation of deep cracks and ulcers; the appearance of wet, dark spots on the bark; wilting of leaves and partial drying of the crown; rotting of the tree's root system. These symptoms share many similarities with the clinical picture of bacterial infection described for Acer saccharinum, highlighting the difficulty of differential diagnosis in urban environments where multiple pathogens, both bacterial and fungal, may be present. Known phytopathogens of trees of the genus *Fraxinus* spp. are the fungus *Hymenoscyphus fraxineus* (T. Kowalski) Baral *et al.* (2014) (Volke *et al.*, 2019), the bacterium *Pseudomonas syringae* pv. *savastanoi* (Smith, 1908) Young *et al.* 1978 (Goychuk *et al.*, 2020; 2022) and the pest *Agrilus planipennis* Fairmaire (Subburayalu & Sydnor, 2018). Each of these pathogens has specific mechanisms of damage and leads to significant losses among ash populations, particularly in urbanised areas.

Such findings reflect the general tendency of increasing vulnerability of urban tree species due to multifactorial stress, including climate change, pollution, and anthropogenic disturbances, which may facilitate the establishment and spread of invasive or opportunistic pathogens. In this regard, the bacterial species described in the current study should be viewed not only as isolated agents of infection but as part of a complex phytopathogenic consortium that influences tree health and survival. The fact that many of these microorganisms have been identified in both local and international studies points to their high ecological plasticity and adaptability to a wide range of hosts. This underscores the importance of applying integrative phytopathological monitoring approaches that combine molecular diagnostics, symptom analysis, and spatial mapping of infection foci in urban green infrastructure. Consequently, the findings of the current research contribute to the broader understanding of urban tree health and demonstrate the practical value of targeted diagnostics in forming evidence-based strategies for maintaining biodiversity and ecosystem services in cities.

The study by P. Romon-Ochoa *et al.* (2024) on the susceptibility of trees of the genus *Castanea* spp. to the fungus *Cryphonectria parasitica* (Murrill) Barr is an important contribution to the study of early symptoms of damage, monitoring, and development of measures to protect trees from mycoses. The authors paid special attention to the identification of early symptoms of the lesion, such as local ulcers, changes in bark color, the formation of necrotic areas, and impaired sap flow. Comparing these results, it should be noted that the presence of common pathogenetic features with the bacterial wetwood detected on *Acer saccharinum* and *Ulmus laevis* is observed. In particular, both types of lesions are accompanied by the formation of ulcers, cambium necrosis and impaired sap flow, which ultimately leads to the weakening and degradation of trees. As in the case of chestnut cancer, bacterial lesions in urbanised plantations remain latent in the early stages, which complicates their timely detection without the use of molecular genetic diagnostic methods. This observation aligns with the challenges P. Romon-Ochoa *et al.* (2024) faced in identifying early symptoms of *Cryphonectria parasitica* infection. Findings in current research also show parallels with research on *Pinus* spp., where trees are significantly weakened by various threats.

For instance, *Pinus* spp. are weakened by the fungi *Heterobasidion irregulare* Garbel. & Otrosina (Gonthier, & Garbelotto, 2023), the nematode *Bursaphelenchus xylophilus*, Nickle, 1970 (Faria *et al.*, 2021), the pests *Leptoglossus occidentalis* Heidemann, 1910 (Muntean & Grozea, 2021) and *Matsucoccus feytaudi* Ducasse, 1941 (Panzavolta *et al.*, 2021). These phytopathogens affect the condition of pine both individually and in combination, reinforcing the negative impact of each other, therefore the complex combination of these threats can have a cumulative effect. The results also indicate a significant weakening of tree stands in urban phytocenoses, in particular due to the spread of bacteriosis, which confirms the tendency towards multifactorial damage to trees in urban ecosystems. As in the case of *Pinus* spp., where pathogens act in a complex manner, bacterial wetwood caused by *Lelliottia nimipressuralis* is accompanied by a combination of primary and secondary symptoms, which complicates early detection and control. This shared characteristic of complex and often synergistic pathogen interactions highlights a broader ecological principle of vulnerability in urban tree populations, irrespective of the specific pathogen or tree species.

While P. Romon-Ochoa *et al.* (2024) primarily focused on fungal pathogenesis in *Castanea* spp. and its early detection, our study, by demonstrating commonalities in symptomology and the challenges of early detection across different tree species and pathogen types (fungal, bacterial, and invertebrate), contributes to a more comprehensive understanding of tree health in urban environments. The work of T. Panzavolta *et al.* (2021) on alien invasive pathogens and pests also echoes the multifactorial threats observed in our study, emphasising pathways, global consequences, and management strategies.

Thus, phytopathogens that weaken trees in urban stands pose a serious threat to the health of green spaces. They destroy tree tissues, disrupt water and nutrient metabolism, reduce stress resistance, and increase vulnerability to other negative environmental factors. The combination of the effects of various pathogens and pests has a cumulative effect, enhancing the overall negative impact on trees. This leads to significant environmental and economic losses, so it is important to carry out phytosanitary monitoring and timely implement control measures to preserve the health of trees in urban phytocenoses.

Conclusions

Dangerous symptoms of bacteriosis were found on *Acer saccharinum* and *Ulmus laevis* trees that are part of the urban phytocenoses of Kyiv and grow on the territory of the “Respublika Park” and “Retroville” shopping and entertainment complexes. The primary signs of damage (type I) include the following symptoms: swelling of the bark surface, superficial peeling cracks, and the release of bacterial exudate during the growing season. Secondary signs (type II), which indicate the aggressive and rapid nature of the development of bacteriosis, are deep longitudinal ulcers (length from 1.0 cm to 150 cm), necroti sation of the wound surface, and the settlement of wood-destroying and wood-staining fungi on the affected surface. Analysis of the sanitary condition of green stands on the territory of the “Respublika Park” shopping mall showed a high degree of weakening of *A. saccharinum* and *U. laevis* trees. Half of the surveyed trees are classified as III–V categories of sanitary condition, which indicates the need to implement sanitary measures, including treatment or removal of individual specimens. The phytosanitary situation of the urbophytocenoses of the “Retroville” shopping mall is better: 25.0% of *A. saccharinum* trees have minor signs of weakening, and 75.0% of the trees can be considered viable. Minor signs of weakening are also noted on *U. laevis* trees, which indicates the need for care and regular monitoring.

A tendency to decrease the proportion of *Acer saccharinum* trees affected by L. nimipressuralis with increasing trunk diameter was found (at a diameter of 16 cm, 55.0%, at 18 cm, 49.0%, at 20 cm, 42.6%). However, due to the absence of a statistically significant difference between the indicators, and also taking into account that the diameter is not a direct indicator of the age of the trees, such a dependence should be considered as a preliminary observation that requires further confirmation. In all examined tree thickness levels, type II lesions predominate, which may indicate the aggressive nature of the development of the infectious process. Similar dynamics are observed among *Ulmus laevis* trees: the spread of bacteriosis decreases from 46.6% (at a diameter of 16 cm) to 32.0% (at 20 cm). In trees of this species, type I of the lesion dominates, which probably indicates a less aggressive course of the disease compared to *Acer saccharinum*.

When assessing the degree of development of bacteriosis, the average number of ulcers per tree and the prevailing type of lesion were taken into account. That is why it is important not only to monitor the condition of urban plantings but also to carry out preventive measures because their health directly affects the ecological balance, air quality, and comfort of city residents. Further research should focus on identifying the specific conditions that trigger the aggressive "Type II" symptoms observed in *Acer saccharinum* and investigating the long-term ecological impact of *Lelliottia nimipressuralis* on the overall health and resilience of urban tree populations in Kyiv.

Acknowledgements

None.

Funding

None.

Conflict of Interest

None.

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Бактеріози деревних рослин у локальних урбофітоценозах Києва: симптоми, етіологія та поширення

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Анотація. Урбоекосистеми сучасних міст характеризуються високим рівнем антропогенного навантаження, що негативно впливає на стан зелених насаджень. Особливо вразливими до негативного впливу є деревні рослини, які відіграють ключову роль у забезпеченні екологічної стабільності міського середовища. Фітосанітарний стан дерев є важливим індикатором здоров'я екосистеми міста, тому його моніторинг та аналіз є актуальним завданням сучасної екології. Метою дослідження було комплексне вивчення бактеріозів деревних рослин в локальних урбофітоценозах м. Києва, включаючи аналіз особливостей симптомів, ідентифікацію збудників та закономірностей поширення захворювання. Дослідження проводили впродовж вегетаційного періоду 2024 року у межах зелених насаджень на територіях торгово-розважальних комплексів "Respublika Park" та "Retroville". У роботі використано сучасні мікробіологічні методи ідентифікації збудників бактеріозів, а також класичні прийоми фітосанітарного обстеження. Для уточнення сучасного систематичного положення та актуальної назви таксонів використано інформацію із інтерактивних баз даних "Index Fungorum" та "International Committee on Systematics of Prokaryotes". Досліджено, що санітарний стан урбофітоценозів торгово-розважальних комплексів "Respublika Park" і "Retroville" характеризується високим ступенем ослаблення дерев *Acer saccharinum* L. та середнім ступенем для *Ulmus laevis* Pall. Встановлено, що головною причиною ослаблення дерев є бактеріоз, збудником якого є бактерія *Lelliottia nimipressurallis* (Carter 1945) Brady *et al*. 2013, що підтверджено методом полімеразної ланцюгової реакції. Зазначено, що первинними ознаками ураження бактеріозу дерев *Acer saccharinum* та *Ulmus laevis* урбофітоценозів є поверхневі відлупні тріщини, вздуття кори та виділення ексудату. Вторинними ознаками ураження є глибокі виразки, некротизація ран та оселення грибів-дестукторів. Показано, що ступінь розвитку бактеріозу на деревах Acer saccharinum складає 2 бали і характеризується як стрімкий, а для дерев *Ulmus laevis* – 1 бал і характеризується як поступовий. Таким чином, дане дослідження дозволило отримати комплексну картину поширення та впливу бактеріозів на деревні рослини урбофітоценозів м. Київ, а також, базуючись на описаних особливостях симптоматики, ключових діагностичних елементах – розробити заходи для своєчасного фітосанітарного управління станом зелених насаджень міст для покращення екологічного стану та підвищення якості життя мешканців

Ключові слова: *Acer saccharinum*; *Ulmus laevis*; мікробоценоз; фітопатогени; бактерія; міські насадження