MONITORING OF TREES DETERIORATION FACTORS IN THE URBAN CENOSES OF ZHYTOMYR CITY

Andreieva Olena
Doctor of Agricultural Sciences, Associate Professor, Polissia National University, Ukraine
ORCID ID: 0000-0003-0851-800X

Shvets Maryna
Ph.D. in Biological Sciences, Associate Professor, Polissia National University, Ukraine
ORCID ID: 0000-0002-1116-3986

Martynchuk Ivan
Ph.D. in Economics, Associate Professor, Polissia National University, Ukraine
ORCID ID: 0000-0002-1370-677X

Marchuk Danylo
Post-Graduate Student, Polissia National University, Ukraine
ORCID ID: 0009-0000-8503-6835

Introduction.

Urban green spaces perform important ecological functions, but at the same time, they are more vulnerable than forests to any adverse factors, in particular to insect damage [11, 15]. Their condition has recently deteriorated, primarily due to climate change and anthropogenic load [5, 8, 9, 23]. Since the air temperature in the city is higher than in the forest, insects have the opportunity to develop faster, produce more generations, and cause more damage to trees [16]. In Zhytomyr, green spaces grow in parks, on the territories of enterprises, and on the streets [24, 26]. In many regions, alien or adventitious species of phytophagous insects have penetrated green spaces, which have found better conditions for development and wintering in the city than in the forest [40–42]. The most resistant to man-made pollution and common in urban green spaces are insects that develop inside leaves, in particular, the so-called leaf miners. Prevention of the harmful effects of leaf miners should be based on the study of the features of their distribution and biology. Insects that develop inside leaves, in particular, the so-called miner insects [43–46], are the most resistant to man-made pollution and are widespread in green areas of cities. Prevention of the harmful effects of mining insects should be based on the study of the peculiarities of their distribution and biology.

1.1. General characteristics of the research region and research methodology

The city of Zhytomyr was founded 1130 years ago. It is located at an altitude of 220–240 m above sea level with a surface slope in the northeast direction. The city is surrounded by forests, the Teteriv River flows through it. The relief is a slightly undulating plain, among which there are large, rounded moraine hills with long, gentle slopes. The soil cover is mainly represented by sod-podzolic soils of varying degrees of podzolization and granulometric composition. The most common are sandy and clay-sandy, sod-weakly podzolic soils.

The city is located in a zone of humid continental climate with warm and humid summers and mild winters. The average annual air temperature is +7.2°C; the average temperature in January is -4.4°C, and in July, it is +17.8°C. The last spring frosts are recorded in the third decade of May, the latest in the first half of June, and the first autumn in the second decade of September. The duration of the frost-free period is 150–170 days. The snow cover is uniform (10–20 cm) and lasts for 95–110 days but is unstable due to frequent thaws. The average height of the snow cover in December is 2.3 cm, in January – 6.4 cm, in February – 8.4 cm, and in March – 4.3 cm. The average date of formation of a stable snow cover is December 15, and its destruction is March 9.

During the year, 530–600 mm of precipitation falls, of which 40–45% falls in the summer months. The amount of precipitation in individual years has significant deviations: in some rainy years, it can fall up to 1000 mm, and in dry years, only 300 mm. The maximum amount of precipitation falls in June (61–106 mm) and July (76–106 mm). The region is dominated by northwesterly winds. In general, the climatic conditions of the city are favorable for the growth and development of plants. A comparison of data on air temperature and precipitation for 2020 and multi-year data for 1990–2019 shows that in 2020, the amount of precipitation was inferior to the multi-year data in most months and slightly exceeded them only in May and June. We calculated that the air temperature, on the contrary, exceeded the multi-year data in most months and was slightly lower than them only in April and May. The average air temperature for the growing season of 2020 was 16.7°C, which exceeded the multi-year data (15.8°C) by 0.9°C (Table 1).

The sum of temperatures during the growing season in 2020 exceeded this indicator for 1990–2023 by 158.8°C, and the amount of precipitation in 2020 was 107.4 mm lower than long-term data (Fig. 2.1). As a result of such changes, the hydrothermal coefficient according to G.T. Selyaninov (HTC) decreased from 1.28 according to long-term data to 0.86 in 2020, i.e. by 0.4. These changes are not beneficial for vegetation.

Table 1. Weather conditions in 2020 and their deviations from multi-year data for 1990–2019 (Zhytomyr weather station)

	Precipitation, mm		**T °C**		**Sum for IV–IX, T °C**		**Deviation**	
Months	**2020 year**	**1990–2019**	**2020 year**	**1990–2019**	**2020 year**	**1990–2019**	**precipitation, mm**	**T °C**
I	18	31,6	1,0	-3,9	–	–	-13,6	4,9
II	48	29,7	3,0	-2,6	–	–	18,3	5,6
III	18	33,8	6,0	2,1	–	–	-15,8	3,9
IV	23	38,6	9,0	9,3	270	279	-15,6	-0,3
V	59	58,5	12,0	14,4	372	446,4	0,5	-2,4
VI	77	74,6	20,0	18,3	600	549	2,4	1,7
VII	42	80,6	20,0	19,4	620	601,4	-38,6	0,6
VIII	24	59,2	21,0	19,4	651	601,4	-35,2	1,6
IX	39	59,9	18,0	13,9	540	417	-20,9	4,1
X	70	40,5	13,0	8,1	–	–	29,5	4,9
IV–IX	264	371,4	16,7	15,8	3053	2894,2	–	–

Many species of trees and shrubs grow in parks and street plantings in Zhytomyr. Since the city is surrounded by forests, some old trees have been growing in the city since ancient times. Planned landscaping is carried out in parks and new districts. Since industrial enterprises operate in Zhytomyr and highways and railways pass through the city, connecting Kyiv with many western regions, the city has a high anthropogenic load. Atmospheric air and soils contain heavy metals, salts, and residues from the activities of enterprises and vehicles, which negatively affect woody plants.

The research was conducted in Shoduarivskyi Park, and 30-richchia Peremohy, on the streets of the center – Peremohy St., Kyivska, and Velyka Berdychivska St., as well as on the streets of the industrial zone – Koroliova and Paradzhanova.

Starting from the 1st decade of May, 100 leaves were picked every decade, randomly selected from trees of each species and placed in separate bags with labels. During the office processing of the research material, the number of mines, pupae, larvae, and exuviae of miners on each leaf was determined [23, 27]. The density of mines of each insect species was calculated per leaf. The population of each species was determined as the average proportion of leaves with the presence of mines.

Statistical analysis of data was carried out using the MS Excel software package.

1.2. Anthropogenic factors in urban ecosystems

Under the influence of man, the Earth's natural ecosystems are transformed into agrobiocenoses, urban ecosystems, and technocenoses [15]. Agrobiocenoses, or agrocenoses (from the Greek agros - field), are created and maintained by man for the production of agricultural products. These are fields, vegetable gardens, orchards, vineyards, meadows, etc. Technocenoses are ecosystems under the influence of industrial facilities. Urban ecosystems (from the Latin urban - urban) are ecosystems under urban conditions. Urban ecosystems include architectural and construction facilities (industrial and residential buildings, communications, etc.), artificial landscapes, and disturbed natural ecosystems (parks, gardens, etc.). Unlike natural ecosystems, urban ecosystems are incapable of self-regulation. The natural heterogeneity of the environment, which was originally of natural origin, changes to zonal heterogeneity of anthropogenic origin, which often has a concentric type (from the periphery to the center) [15].

Green spaces in cities are designed to create optimal conditions for work and recreation for the population, as they can purify the air from dust and emissions from industrial enterprises and vehicles, reduce noise levels, improve the microclimate (reduce temperature through transpiration, enrich the atmosphere with oxygen, protect from wind), emit phytoncides, and also have a positive effect on the human nervous system [16]. At the same time, such spaces are weakened by the aforementioned emissions, dust, etc., and become vulnerable to pests and pathogens, in particular to alien species [20]. Trees are also weakened due to insufficient area for root development and their destruction during the construction and repair of roads and communications.

Dust and moisture form fog, which prevents the respiration and photosynthesis of leaves. The air temperature in the center of cities is several degrees higher than in the forest, which affects the rate of development of insects and the attractiveness of the leaves for their nutrition [21].

Urban plantings feature tree species that grow in forests and gardens of the region but also use introduced species due to their decorativeness or resistance in urban environments [15]. Trees in urban plantings, like in the forest, produce oxygen and emit phytoncides, and also capture dust and toxic substances from the air, soften the microclimate, and improve people's moods [16].

At the same time, trees grow in the city in conditions of increased temperature since brick, concrete, and asphalt heat up during the summer and cool down slowly. In winter, the central heating system of houses operates, which also contributes to an increase in temperature compared to its values outside the city. Temperature changes affect the timing and rate of development of buds, shoots, and leaves in spring, flowering, and fruiting, as well as the success of preparing trees for winter [21]. Increased temperature also affects the phytophagous insects and pathogens of tree species. These organisms accelerate development in conditions of increased temperature, which can affect their harmfulness. At the same time, both trees and their pests and pathogens suffer from air pollution, and the consequences of their interaction are not always predictable [22].

The main sources of air pollution in cities are industry and vehicles, and the role of the latter has recently increased. Typically, individual districts and streets of cities differ in the intensity of traffic, which is determined by the average number of cars and trucks per day. Transport emissions negatively affect the condition of trees in green spaces of cities, and the most sensitive tree species can serve as indicators of air pollution [2–4].

In urban conditions, trees quite often receive mechanical injuries during construction and repair work, as well as due to vandalism by residents. Through the places of such injuries, as well as in frost cracks and occasionally - in places where lightning strikes, wood-destroying fungi - pathogens of rot, gradually destroy individual parts of the trunks [13]. If such fungi destroy the core of a tree, it can remain viable for many years and have a healthy-looking crown. At the same time, trees that have been affected by wood-destroying fungi for a long time can be very dangerous for people and vehicles in the event of strong winds, which lead to the breaking off of individual branches or even the tops or part of the trunk [12].

In the conditions of settlements with strong human intervention in the composition of the soil and water regime, factors of negative action increase their impact [25, 26]. The composition of the soil in cities differs from that of forests, it contains many fragments of building materials covered with asphalt. The place for root growth is limited [15].

The city is characterized by specific microclimate, light and wind regimes, gas composition of the air, etc. [21]. In the city, there is less penetration of ultraviolet radiation, lower relative humidity, and more frequent fogs. Due to lower atmospheric pressure and wind speed, air pollution increases [20].

Building surfaces and road surfaces heat up more intensively during the day and give off heat more slowly at night than soil or topsoil in rural areas. The increase in air temperature is contributed by the activities of industrial enterprises, vehicles, and the heating of buildings [15].

The air temperature is several degrees higher in the city center than on the periphery and beyond [15]. This affects the timing of the beginning and end of vegetation, in particular, leaf development. With increasing temperature and dryness of the air, burns form on the leaves of trees, which reduces the surface area capable of photosynthesis.

Trees in the city receive mechanical damage during construction and repair work, as well as as a result of injury by vehicles and the population. Pathogens penetrate places of mechanical damage. Injury to the roots and trunk creates conditions for the settlement of trees by harmful insects [24, 28].

One of the important factors of negative anthropogenic impact on the environment in general and on green spaces in particular is the exhaust gases of motor vehicles. At the same time, the highest concentrations of harmful substances are observed near large settlements. It has been proven that the concentrations of pollutants decrease at a distance of 12–20 m from the road, and in densely built-up areas, the concentration of pollutants is much higher than in open areas [26].

The number of motor vehicles is steadily increasing, despite the increase in fuel prices. Motor vehicles pollute the atmospheric air of cities and negatively affect human health and the condition of green spaces, which are unable to compensate for these negative effects. It is estimated that the volume of emissions of harmful substances from motor vehicles is almost three times higher than the volume of emissions from stationary sources of pollution [25].

1.3. Biotic factors influencing the condition of stands in urban ecosystems

Biotic factors influencing trees are associated with plants that compete for moisture and soil nutrients, with vertebrate and invertebrate phytophagous animals and phytopathogenic organisms, in particular bacteria, viruses, and fungi [27]. In general, trees in the city can be damaged by mammals, birds, ticks, and insects and be affected by viral, fungal, and bacterial diseases [1, 5–7]. At the same time, the distribution of various types of damage in urban green spaces and the harmfulness of these species differs from forest ecosystems.

The entomofauna of urban plantings was initially formed mainly due to the penetration of species from neighboring forests and gardens [10–11]. Recently, its composition has been changing due to an increase in the proportion of representatives of ecological groups of insects that are resistant to technogenic pollution, dust, and temperature fluctuations [41], in particular, miners [44]. The species composition of the entomofauna of urban plantations is also replenished due to the penetration of adventitious species with plant material and packaging, which find attractive food species and favorable conditions for survival in the winter [39, 43].

1.3.1. Phytophagous insects. Insects that damage leaves are called phyllophage

These insects can have an open, semi-hidden, or hidden lifestyle [14, 18, 19]. An open lifestyle is characterized by species with both gnawing and sucking mouthparts. Lepidoptera and hymenoptera larvae, adults and larvae of coleopterans have gnawing mouthparts, with which they eat and skeletonize leaves. Larvae and adults of representatives with a piercing-sucking mouthpart (bugs, aphids) suck plant juices. The latter species are less directly affected by pollutants. A hidden lifestyle is characterized by miners (which have gnawing mouthparts) and gall-formers (which may have gnawing or sucking mouthparts). As a result of the miners' feeding, a cavity is formed in the leaf tissues, and as a result of the gall-forming insects' feeding, the plant tissues grow, and galls are formed. Insects that develop inside rolled, glued, or woven leaves have a semi-hidden lifestyle.

Leaf-eating insects, while on or in leaves, cause various types of damage, by which they can be recognized even after the insects have left their feeding sites [38, 42]. Damage caused by leaf miners and gall-forming insects is particularly characteristic, but the feeding traces of species with an open lifestyle also allow us to estimate their prevalence in different parts of the stand. Thus, leaves may be partially eaten away, skeletonized, holes or cuts of almost regular shape may be gnawed in the middle or from the edges, small holes, and leaf tissues may be scraped off [44]. Therefore, the proportion of the removed leaf area indirectly reflects the number of leaf-eating insects with a certain type of feeding [40].

Mass reproduction of leaf-eating insects in cities occurs relatively rarely, but individual trees may be noticeably damaged by leaf miners, leaf eaters or leaf gnawers [32, 37]. According to their ability to form outbreaks of mass reproduction, phytophagous insects are divided into indifferent, prodromal, and eruptive species [23]. Thus, the number of indifferent species in long-term dynamics varies slightly relative to the background level. Prodromal and eruptive species are capable of repeatedly increasing their number, which fluctuates in prodromal species near the lower stationary level, and in eruptive species it can remain at the level of the upper stationary level of the phase portrait for several generations without losing the ability to regulate the population size [8, 9].

It is believed that leaf damage by insects negatively affects the growth and fruiting of stands [34]. At the same time, unlike forests, in urban plantations, the main criterion for assessing the harmfulness of phyllophages should be the impact not on tree growth but on the loss of the trees' ability to purify the air and decorate. If the plantation has lost these characteristics, then its durability and fruiting intensity are of less importance [15].

It is believed that deciduous trees can withstand the loss of up to 30% of their leaves without losing their viability and growth intensity [47]. Thus, losses are determined only during outbreaks of mass reproduction of individual insect species, which occur once every 10–12 years. In general, to determine the number of phyllophage insects of a certain species or group, their limiting number is calculated by dividing the mass of leaves on a tree of a certain species and age by the larval food norm. At the same time, a tree weakened by adverse factors contains fewer leaves, and its severe damage can be caused by fewer insects [40]. The harmfulness of any insect species depends on its ability to damage the plant during feeding, negatively affect the environment, and form outbreaks of mass reproduction (such as population dynamics) [38].

In parks and forest parks created based on former forest areas, the phytophagous complex is the most diverse and includes phyllophages, miners, sucking insects, gall-forming insects, and xylophagous insects [29, 30]. In street stands, the insect complex is the poorest. The above-ground part of trees growing near roads is openwork, blown and exposed to atmospheric pollutants and powerful wind currents from traffic. Under such conditions, a complex of insects adapted to the action of adverse factors is formed. These are species that are mechanically protected by waxy covers - coccidia, leaf epidermis - miners, as well as species that compensate for increased mortality with high fecundity and a large number of generations per year – aphids, spider mites, etc. [27].

Insects adapt to climate change faster than trees since they have shorter life cycles. If the leaves are not sufficiently moistened, leaf eaters will destroy a larger mass of them [40].

An additional threat to urban plantings in new ecological conditions may be alien (adventitious) species that penetrate urban stands with packaging, planting material, seeds, soil, and on vehicles [36].

Changes in urban ecosystems can be detected by monitoring and bioindication – recording the reaction of living organisms to different levels of anthropogenic load. In this case, species and complexes of species that are widespread and easily detected are used, in particular, turunas, gall-forming insects, and miners [31, 35].

The species composition of insects and mites – phytophagous insects of urban stands is generally similar to that of the surrounding forests. These species feed on various organs of trees – leaves, buds, generative organs, damage, and colonize roots and trunks [33].

At the same time, some species cannot withstand the effects of elevated temperatures or harmful impurities in the air [47]. In urban stands, leaves are removed for the winter, which makes it impossible for some phytophagous and entomophagous insects to overwinter. Some species are unable to feed on dust-covered leaves, or it has a toxic effect on them. In urban conditions, the proportion of small-sized species with sucking mouthparts and a secretive lifestyle – miners and gall-forming insects – increases [38].

In cities, spring begins earlier than in the forest or field, autumn comes later, and the air temperature is higher [15]. Therefore, polyvoltine insects in urban conditions have a larger number of generations and are able to further increase their numbers. At the same time, insects also do not always withstand the effects of polluted air, and in urban conditions, outbreaks of mass reproduction develop very rarely [27].

Pollution of plants by industrial and transport emissions affects the chemical composition of leaves, the overall resistance of plants, and their resistance to insect damage [15]. In cities, the soil is compacted, and therefore, insects that do not depend on it for development have an advantage [28]. In urban stands, phytophagous, leading a secretive lifestyle, and insects with a prickly-sucking mouthparts [11] predominate. In particular, miners and gall-forming insects have a secretive lifestyle, and representatives of various ecological groups of insects have a semi-secretive lifestyle. Miners are known among lepidopterans, beetles, hemi-beetles, and dipterans. Galls on various plant organs can be formed by mites and insects, in particular, dipterans, aphids, and even beetles. Bedbugs and aphids have prickly-sucking mouthparts [10].

Species with a semi-hidden lifestyle include leafhoppers, whose caterpillars roll up leaves and feed inside. Tubeworms roll up a leaf and lay an egg inside to provide the larvae with food - a dried leaf [27]. Insects that feed inside plant tissues are provided with a relatively constant humidity regime, protected from extremely high temperatures, and due to the high thermal conductivity of leaf tissues, from low temperatures. Such insects are less sensitive to abiotic factors in air pollutants [1].

The species composition of the phytophagous in the city is quite rich, but their number rarely reaches the level of that in the forest [23]. Dozens of species of insects and mites feed on various organs of trees, but not all of them are pests. Harmful species are those whose damage leads to a decrease in the viability or death of trees. Typically, a tree can withstand damage of up to 30% of the leaf mass and compensate for it during further development [40].

The appearance of the damage often identifies the order, family, and sometimes the species of the pest. For example, leafhoppers weave silk threads that they produce and form a shelter. Some larvae or adults skeletonize the leaves. The larvae of butterflies, sawflies, and occasionally beetles bore holes in the leaves. Sucking insects - aphids, scale insects, and leafhoppers feed on the sap of poplars [27].

Gall-forming organisms live inside the tissues of poplars and form galls on branches, shoots, petioles, and leaves. Younger insects live in the galls, which provide food and protection from natural enemies. Galls are formed by some mites (Acari), butterflies (Lepidoptera), sawflies (Hymenoptera), aphids, bedbugs (Hemiptera), and flies (Diptera). Galls can be simple or complex, and it is often possible to recognize the insect by their appearance [27].

Buds and young shoots damage the leaves. Some beetles eat the entire buds, and other species lay eggs in them. The larvae feed inside, and then the bud falls off. Glassworms and some barbels gnaw through the passages in the shoots of poplars [7]. As a result, young plants develop several tops. The decorative value of the trees and the commercial value of the wood decrease. Rot pathogens penetrate the trunk. The roots of trees are damaged by beetle larvae, as well as some trunk pests - glassworms and woodworms [30].

As trees grow, a complex of stem pests is formed, which are confined to certain areas of the bark or parts of the tree [44]. These species, like most stem insects, can actively or passively transmit spores of pathogenic, wood-staining, and wood-destroying fungi, in particular blue mold.

Close attention to the study of insect communities in green spaces began to be paid in the middle of the last century in connection with the emergence of large industrial zones [18, 19]. Such studies were aimed at determining the minimum size of a green area at different levels of pollution and the minimum size of individual plantings that would positively affect the environment and maintain the resistance of this environment to negative influences.

Insect miners feed inside plant tissues that are the most humid, rich in nutrients, and poor in protective substances [47]. This lifestyle protects these insects from moisture deficiency and natural enemies and allows them to overcome plant defenses. Insect miners are highly specific to specific plant organs and tissues [1]. Miners spread to new regions along with planting material and packaging [47]. They are more easily established in urban areas than in forest stands since cities have a greater selection of attractive forage species, and elevated air temperatures facilitate insect survival in winter [15].

Typically, most phyllophage insects do not cause significant damage to urban stands, but the negative impact of individual insect species on the condition of trees weakened in urban conditions may increase in years of mass reproduction outbreaks [47]. Since both the anthropogenic load and the species composition of phyllophage insects differ in urban stands of different types [10], it is advisable to compare the species composition and distribution of these species in street stands, parks, and the Forest Park.

1.3.2. Urban green spaces as a medium for the spread of harmful insects

Urban green spaces are a collection of woody, shrubby, and herbaceous plants that form arrays, alleys, lawns, and flower beds in parks, squares, on the sides of sidewalks, in the courtyards of the private sector, enterprises, educational and medical institutions, etc. [2].

Urban green spaces are created not only to perform a recreational function. These stands absorb air pollutants (dust, gases, etc.), cool the urban environment, stabilize the wind regime, increase the relative humidity of the air and mitigate its daily and seasonal fluctuations, enrich the atmosphere with oxygen, increase the concentration of negatively charged ions in the atmosphere, secrete biologically active substances that suppress pathogenic microflora in the atmosphere, reduce the noise level by absorbing mechanical vibrations, retain part of the precipitation and reduce surface runoff, improve soil structure, retain snow cover and melt water, consolidate loose soils and reduce the level of erosion, and improve the appearance of urban landscapes [17].

Therefore, when selecting plants for parks, it is necessary to take into account their ability to withstand cultivation in a wide range of soil mechanical composition and richness, their tolerance to moisture conditions, resistance to industrial gas and aerosol pollution, absorption of pollutants from the atmosphere or soil, the presence of a branched crown with dense foliage for effective noise absorption, aesthetic properties, etc. [30, 36]. At the same time, urban green spaces are weakened by pollutants and are more susceptible to damage by insects [27]. There is almost no vegetation in the city on which entomophagous insects can provide additional nutrition.

The presence of houses, fences, utility rooms, and other structures provides conditions for the successful wintering of harmful insects, which contributes to the growth of their numbers in cities [18]. Trees in cities have sparser crowns and smaller leaves compared to forest trees. Leaves covered with dust reduce the intensity of photosynthesis. Under such conditions, damage to leaves by insects in cities can have more significant consequences for the viability of trees [22]. In cities, leaf-mining insects are more common than in forests, which are characterized by a secretive lifestyle and are therefore more resistant to adverse weather factors and air pollutants than leaf-borers [14].

In the context of climate change, urban stands may suffer primarily because non-native species are often used in landscaping, as well as with faster climate changes in cities, where stone, concrete and brick buildings and road surfaces are heated more strongly by sunlight and give off heat more slowly than soil or topsoil in rural areas. Temperatures also rise as a result of industrial activities, vehicle engines, and the heating of buildings [17].

Weakened trees become susceptible to insect infestation or disease. Increased air temperature accelerates the development of trees and pests, and insects adapt more quickly to new conditions since they have one or more generations per year. New climatic conditions may unexpectedly become favorable for previously inactive pests [14].

The entomofauna of urban stands is very similar to the entomofauna of neighboring forests [17], but has differences related to the characteristics of the urban climate, soil cover, and gas composition in the air. Since it is warmer in cities, insects that can develop in several generations additionally increase their numbers. Under the influence of technogenic emissions, the chemical composition of leaves, plant resistance, and their resistance to insect damage change. Since the soil in cities is compacted, insects that do not depend on it for development have advantages [36]. In urban stands, phytophagous insects that lead a secretive lifestyle and insects with a prickly-sucking mouthparts predominate [10].

Alien species of phytophagous insects have advantages over local ones due to the lack of specialized entomophagous insects. Introduced species can affect community structure, biodiversity, food chains, and overall ecosystem productivity [14, 22].

1.3.3. Insect miners of deciduous trees in green stands

Insect miners develop inside plant organs or parts and gnaw holes, or “mines” in them [1]. Miners are known among representatives of the orders Lepidoptera, Hymenoptera, Diptera, and Coleoptera. The population density of many miners varies little over the years, and they do not cause harm to forage plants [39]. Some species are capable of mass reproduction, in particular, the chestnut miner (Cameraria ohridella Deschka & Dimic, 1986) [43] and the poplar lower leaf moth (Phyllonorycter populifoliella (Treitschke, 1833)) [19]. Other species, even at low population densities, can significantly reduce the decorativeness and resistance of individual trees and stands [1].

Larvae of obligate miners carry out the entire larval development cycle inside the mine, while facultative ones do so only for several instars. In all cases, the first larval instars pass inside the plant tissues [8]. Most often, miners damage species of the same or similar genera of woody plants, which have the corresponding names - “poplar”, “maple”, “willow” [11]. One larva develops in each mine, and in the case of merging mines, the youngest larvae die. At the same time, the larvae of some species can develop several individuals in one mine [23].

Miners most often pupate outside the mine, although some species can pupate in the first generation outside the mine, and in the second – in mines, and others – pupate both inside the mine and outside it [43].

Miners mainly overwinter as pupae, but some overwinter as larvae on the soil surface, in leaf sheaths on branches, in mines in fallen leaves, or as adults in bark cracks on tree trunks. In the pupal stage, miners can overwinter in the soil, in mines in fallen leaves, or bark cracks on tree trunks [39].

The number of generations of mining insects depends mainly on the ambient temperature [43].

Some species of leaf miners feed only in spring or early summer, others only in summer (birch leaf miners, linden leaf miners, and elm leaf miners). At the same time, some species have two or more generations (linden leaf miners and chestnut leaf miners) or an extended development period and feed throughout the season [23].

Leaf miners can be transported by air currents, and therefore, the centers of their mass reproduction are often located along transport routes [26].

Female leaf miners lay mainly one egg per leaf, which eliminates competition between larvae of one species for food [39].

Among the factors of leaf miner population dynamics, competition between individuals of the same population and with other species of phytophagous insects, as well as food quality, the effect of pathogens, predators, and parasitoids [14] are important.

Abiotic factors are mainly manifested in the form of destruction of mines under the influence of wind and precipitation and the effect of frost on the viability of miners at different stages of development. In the case of a decrease in temperature, the synchrony of the development of miner larvae and the availability of suitable food may be disrupted. In the case of rapid coarsening of leaf tissues, younger larvae are unable to consume them [39]. Most often, abiotic conditions create the prerequisites for the emergence of miner foci due to the positive effect on the viability of these insects. If the growing season is prolonged, the last generation of miners has time to complete its development [23]. Since the food base of miners on a tree depends on the available mass of leaves, an increase in the density of settlements causes competition, an increase in larval waste, and a decrease in the mass of pupae, size, and fecundity of adults [1]. If the mass of the leaf is not enough to complete the feeding of the larva, it dies. The larva will also die if the leaves fall prematurely [39]. Among the miners, mono- and oligophagous ones prevail – species that feed on one or several plant species [23].

According to the nature of damage to the leaf tissues, mines are divided into 4 types. In the first mines, the leaf parenchyma is completely eaten away, but the upper and lower epidermis are not damaged. If the palisade parenchyma is damaged, the mines are classified as upper-lateral, and if the spongy parenchyma is damaged, as lower-lateral. In the latter case, only the epidermis of the leaf is damaged - then the mine belongs to the epidermal type. The depth and shape of the mines depend on the insect species [1].

Insect miners develop much faster than insects with a free lifestyle. This is due to the fact that miners use leaf tissues that are easily digested and leave the epidermis, cuticle, and vascular bundle tissues. Caterpillars are able to develop only in tissues with a low content of protective substances [39]. Only some miners feed at the imago stage. Females select egg-laying sites based on chemical cues released by the plant, choosing leaves of a specific age and leaf blade size [23].

Adventitious species of mole miners can be dangerous because they have no natural enemies in a new place. The most well-known representatives of adventitious species of mole-miners are the *Phyllonorycter issikii* Kumata, *Cameraria ohridella* Desc, *Parectopa robiniella* Clemens, *Macrosaccus robiniella* Clemens, and *Phyllonorycter platani* Staud. [14, 23].

The chestnut miner damages the common chestnut (*Aesculus hippocastanum* L.), which is common in natural forests in the Balkans and is used for landscaping settlements throughout Europe. In western Ukraine, the chestnut miner appeared in 1996–1997, in 2003 in Kyiv, and in 2006 in Kharkiv [23].

The chestnut miner overwinters as a pupa in mines inside fallen leaves. The moths emerge in late April - early May and lay eggs on bitter chestnut leaves. The larva develops for 25–36 days, pupating inside the mine. In different regions, there are 2–4 generations per year [27].

Two species of miners develop on the *Robinia pseudoacacia* L. – the *Parectopa robiniella* and the *Macrosaccus robiniella*. Both species have several generations per year, which overlap. They overwinter in the pupal stage. They fly out in the third decade of May, during the development of the leaves [46]. The linden miner spread in the 80s of the last century in the European part of the former USSR and the 90s in European countries. The linden miner overwinters in the adult stage in cracks in the bark of linden trees. Females lay eggs one by one on the lower surface of linden leaves, which by that time have fully bloomed. After 10–14 days (in early June), the mines appear. After the development is complete, the caterpillars pupate in mines, usually in late June. After 7–9 days (in early July), the new generation of butterflies emerges, mates, and lays eggs on leaves. The second generation caterpillars develop in August, pupate in late August, and in September, the pupae emerge as adults that overwinter [12–13].

In the first generation, chestnut, lime, and acacia miners do not cause much damage to trees. According to data from many regions, the chestnut miner damages 1% of the leaf surface in June and over

60% in September [14]. As leaf mines develop, the surface area involved in photosynthesis decreases. Trees reduce productivity, and leaves lose the ability to fully perform ecological functions in green areas of cities - to retain dust and atmospheric emissions [17]. In the presence of a large number of mines, the decorativeness of trees decreases, their susceptibility to the penetration of pathogens increases, and leaves often fall prematurely [8]. So important pathogens of common bitter chestnut are the fungi *Guignardia aesculi* and *Erysiphe flexuosa,* which originate from North America. These fungi cause leaf necrosis, which in appearance resembles damage caused by miners. At the same time, chestnut leaf miner-butterflies lay fewer eggs on leaves affected by these fungi [44].

At high densities of insect miners, infested leaves reduce photosynthetic activity. At the same time, photosynthesis continues in the uninhabited parts of the leaves, and the anatomy of the veins is preserved even with the presence of more than 90% of the mines [11]. Trees damaged by insect miners often re-bloom in late summer or autumn. This weakens the trees, they do not have the opportunity to prepare for the winter cold and often freeze out. In the spring, individual branches of such trees dry out, they are affected by diseases. At the same time, in the southern regions, damage to chestnut trees by the chestnut miner for several years did not cause mass tree loss and did not hurt annual wood growth [8]. This reaction of the common bitter chestnut tree to damage by the chestnut miner is explained by the ability of this species to form additional layers of wood with large openings in the conductive tissue during the year. Trees severely damaged by the chestnut miner begin growing later in the following spring, which may to some extent protect them from attacks by harmful insects [10].

The effect of miners on the generative organs of damaged bitter chestnut trees was also studied. It was found that in trees with severely damaged leaves, the size and weight of the fruits decrease, but the number of inflorescences on the tree, flowers in the inflorescence, and seeds in the fruit does not change. In urban stands, such a phenomenon is not significant, but in natural forests, it will negatively affect the restoration of bitter chestnut and will also not allow obtaining planting material for landscaping of high quality and in sufficient quantity [8].

The effect of the linden miner on the productive and generative organs of the small-leaved linden in the Forest-Steppe was quantitatively assessed [4]. It was found that the linden miner causes the greatest damage in June, during the growth period of the host tree. With a high density of the miner settlement, the number of flowers and inflorescences decreases, which causes damage to beekeeping in the region. It has been proven that the density of lime tree leaf miners increases in shaded areas. The undergrowth, lower crown tiers, and parts of branches at the base are most populated [13]. Since light leaves play a greater role in photosynthesis than shade leaves, damage to trees by lime tree leaf miners may not have noticeable consequences for productivity. At the same time, at high mine densities, a decrease in shoot length, the number of formed buds, and the growth of early wood were noted [12]. Thus, in urban green spaces, leaf miners are spreading, which worsens the sanitary condition of the plantings and their decorativeness. To prevent the damage that these insects cause, it is necessary to clarify the features of the development and distribution of the most dangerous species.

1.3.4. Pathogens of tree diseases

Foliar diseases usually do not cause deterioration of the condition of trees, in particular spotting [33]. Branches are affected by necrotic-cancer diseases. As the age of trees increases, the prevalence of stem rots increases, which are caused by fungi, in particular, *Polyporus squamosus* (Huds.) Fr., *Stereum rugosum* Pers., *Lenzites betulina* (L.) Fr., *Fomitiporia punctata* (P. Karst.), *Laetiporus sulphureus* (Bull.) Murrill. Brown central destructive rot is caused by the woolly scale fungus (*Pholiota squarrosa* (Oeder) Kumm: Stophariaceae) and the fatty scale fungus (*Pholiota adiposa* Fr.), white peripheral rot by the woolly stereum (*Stereum hirsutrum* (Willd.) Pers.: Stereaceae), white mixed corrosive rot by the common tinder fungus (*Fomes fomentarius* (L.) Gill.: Polyporaceae), and white corrosive central rot by the scaly tinder fungus (*Polyporus squamosus* (Hudz.: Fr.)) and the false tinder fungus (*Phellinus igniarius* (L.) Quel: Hymenochaetaceae) [44].

Recently, a disease called chalaro necrosis, caused by the fungus *Hymenoscyphus fraxineus* [36], has spread throughout the entire range of common ash. Signs of the disease have been registered in Ukraine since 2010. Symptoms of the disease include gradual dieback of crowns, necrotic spots on the bark of shoots, discoloration of wood and leaves, leaf necrosis, premature leaf fall, trunk necrosis, etc. Other important diseases of ash trees are bacterial blight (causative agent: *Erwinia amylovora* (Buril) Winslow et al.), bacterial wetwood (causative agent: phytopathogenic bacterium *Leliottia (Erwinia) nimipressuralis* Carter, 1945) and tuberculosis (causative agent: phytopathogenic bacterium *Pseudomonas syringae* pv.savastanoi (Smith 1908) Young et. Al. 1978)) [5, 6].

Decaying trees are colonized by tinder fungus, whose spores penetrate through wounds on the trunks. One of the most harmful diseases of birch is wetwwod, which is caused by the bacterium *Leliottia nimipressuralis* [24]. Usually, the earliest signs of the development of bacteriosis are thinning of the crowns, the appearance of dry tops, and premature yellowing and falling of leaves. If such signs are detected, attention should be paid to the presence of brown streaks of exudate on the branches and trunks. Trees weakened by bacterial wetwood are actively colonized by trunk pests [24].

1.4. Stability of plantations in urban ecosystems

In addition to abiotic and biotic factors common in natural ecosystems, the growth and development of plants in the city are influenced by specific physical and chemical factors [2, 3, 12, 21]. Physical factors of influence are manifested in soil and climatic conditions, the content of basic nutrients, soil density, acidity of the water regime, etc. Chemical factors are associated with smoke, gas, and dust, changes in lighting and temperature regimes, and anthropogenic factors are associated with violations of agricultural techniques for planting and caring for stands, mechanical damage, and recreational pressure. Plants weakened by these factors become susceptible to damage by phytophagous insects and pathogens [16].

The growth rate and health of trees depend on both hereditary traits (genotype) and environmental conditions that determine the phenotype. Identifying trees that are characterized by the fastest growth or the greatest resistance to adverse effects of certain environmental factors, with subsequent reproduction, is one of the tasks of selection [44].

The resistance of trees to insect damage or disease is related to two mechanisms. One of them (resistance) allows a tree to avoid damage or damage due to morphological features (has thorns, waxy coating), physiological features (repels with an unpleasant odor, fills with resin), or a certain shift in the life cycle. For example, the leaves of a late-forming oak tree bloom later than the caterpillars of the green oak leaf beetle hatch from their eggs, and these insects do not damage such trees. The second mechanism (tolerance) reflects the ability of a tree to restore its growth or reproduction rate after damage. These mechanisms are genetically inherited, so the selection of resistant families or clones is one way to reduce losses from the action of harmful organisms [35, 37].

Studies in many regions show that mixed-species, mixed-age, and multi-tiered stands are more resistant to the adverse effects of insects, mammals, pathogens, wind, or fire damage compared to pure, same-aged, and single-tiered stands. Such stands also recover more quickly after damage or injury [17].

Signs that are a manifestation of resistance are sufficient growth intensity, crown density, and leaf or needle color. Indirect evidence of resistance is the proportion of damaged, populated, and withered trees, the degree of disturbance of the structure and density of the soil, and the development of undergrowth and grass cover. Resistance refers to the resistance of organisms to the action of other organisms, substances, or other factors. Thus, plants can be resistant to drought, frost, damage by certain pathogens, damage by insects or mites, and treatment with herbicides, and insects, in turn, to damage by entomopathogenic microorganisms and treatment with insecticides, phytopathogenic fungi to the action of competitive organisms and treatment with fungicides [44].

Any city has recreational areas, which include city and suburban parks, forest parks, meadow parks, hydroparks, landscape and architectural museums, and suburban forests of the city's green zone. In each type of plantation, the composition of trees and shrubs should be selected taking into account the mechanical and chemical composition of the soil, the range of tolerance to the level of moisture, resistance to industrial and domestic pollution, the ability to absorb pollutants from the atmosphere or soil, the ability to ionize atmospheric air. The presence of branched crowns with dense foliage or dense needles to absorb noise, as well as the decorativeness of crowns, flowers, and fruits, is also important [47].

The resistance of trees to insect damage or disease is associated with two mechanisms. Thanks to resistance, a tree avoids damage due to its morphology, physiology, or phenology. Thanks to tolerance, a tree restores its condition, growth rate, or reproduction intensity after damage. The growth intensity and condition of trees depend on hereditary traits and environmental conditions. One of the tasks is to identify tree species and varieties that are characterized by the fastest growth or the greatest resistance in urban communities to the most harmful environmental factors. Mixed species, mixed-age, and multi-tiered stands are most resistant to the adverse effects of many abiotic, biotic, and anthropogenic factors compared to pure, same-age, and single-tiered stands. In forest parks, parks, and street stands, the composition of trees and shrubs should be selected taking into account the mechanical and chemical composition of the soil, the range of tolerance to moisture levels, resistance to industrial and domestic pollution, the ability to absorb pollutants from the atmosphere or soil, etc.

1.5. Tree species of green stands in Zhytomyr and insect miners on them

We examined the stands in the Shoduarivskyi Park, and the 30-richchia Peremohy, the streets of the Center – Peremohy St., Kyivska and Velika Berdychivska St., as well as the streets of the industrial zone – Koroliova and Paradzhanova, where the stands grow near roads with intensive traffic and railway tracks. In the surveyed stands, the most common tree species are common oak (*Quercus robur* L.), linden (*Tilia cordata* Mill.), maple (*Acer platanoides* L.), white poplar (*Populus alba* L.), common chestnut (*Aesculus hippocastanum* L.), black poplar (*Populus nigra* L.), elms (*Ulmus laevis* Pall., Ulmus *glabra* Huds.), robinia (*Robinia pseudoacacia* L.). During the survey of the stands, we found insect miners from the order of Lepidoptera of the Gracillariidae family: – on common oak – *Acrocercops brongniardella* (Fabricius, 1798) (Fig. 1); – on common chestnut – *Cameraria ohridella Deschka* & Dimic, 1986 (Fig. 1); – on robinia – *Parectopa robiniella* (Clemens, 1863) and *Macrosaccus robiniella* (Clemens, 1859) (Fig. 2); – on linden – *Phyllonorycter issikii* (Kumata, 1963) (Fig. 3);– on black poplar – *Phyllonorycter populifoliella* (Treitschke, 1833) (Fig. 3).

We paid attention to studying the distribution features of these species. In the 2020 growing season, the chestnut miner was the most common, while the linden miner and white acacia miner were found to a much lesser extent.

Fig. 1. *Mine of the Acrocercops brongniardella on an oak leaf (left) and mines of the Cameraria ohridella on a chestnut leaf (right)*

Fig. 2. *Mines of the Parectopa robiniella (left) and mines of the Macrosaccus robiniella (right)*

Fig. 3. *Mines of the Phyllonorycter issikii (left) and mines of the Phyllonorycter populifoliella (right)*

1.6. Seasonal dynamics of the distribution of the chestnut miner

The chestnut miner was first discovered in 1984 in Macedonia near Lake Ohrid [44]. Soon it quickly spread to almost all countries of Western, Central and Eastern Europe. It is a narrow oligophagous, as it can inhabit various species of the genus Aesculus [41].

Butterflies overwinter in leaf litter. Therefore, one of the means of preventing the spread of the chestnut miner in the city is to clean up and compost fallen leaves. Butterflies fly out of their wintering grounds in late April-early May, initially they are on the bark of trunks, and after sufficient development of the leaves, they begin to lay eggs in them. This phenomenon coincides with the mass flowering of bitter chestnut. During the summer, leaf damage increases, and in August the leaves of some trees are completely covered with mines and fall prematurely. Young trees planted in the spring were not colonized by the first generation of the pest, but in August, chestnut borer mines were found on the leaves of these trees. The caterpillars went through six stages of development, and the mines of caterpillars of different ages differed in shape and size (Fig. 4).

Fig. 4. *Chestnut leaf miner caterpillar of the 4th age*

The first pupae of the chestnut miner were found in mid-June, the first exuviae in the third decade of June. By this time, the leaves were populated by the miner at the entire height of the crowns, the leaves began to turn yellow and curl, and butterflies of a new generation appeared on the trunks. Later, it was possible to simultaneously detect individuals of different stages and generations. In the seasonal dynamics of the density of chestnut miner mines, three waves were recorded with maxima in the second decade of June (12.8 mines/leaf), the second decade of July (56.4 mines/leaf) and the third decade of August (28.6 mines/leaf) (Fig. 5).

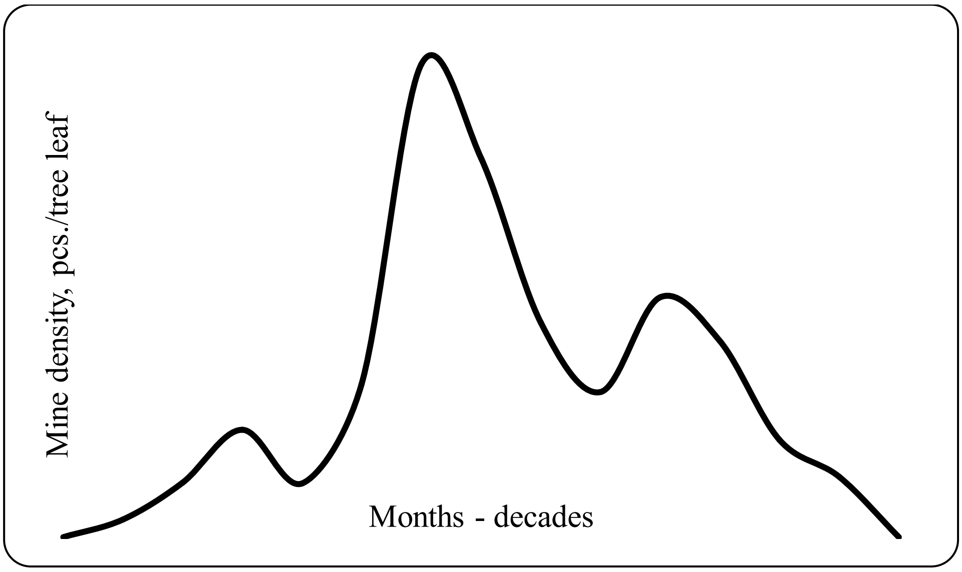

Fig. 5. *Seasonal dynamics of the average density of chestnut miner mines (pcs/leaf; averaged over all recording areas)*

The population of chestnut by the chestnut miner increased slowly at first, sharply in July, and slowly again at the end of August (Fig. 6).

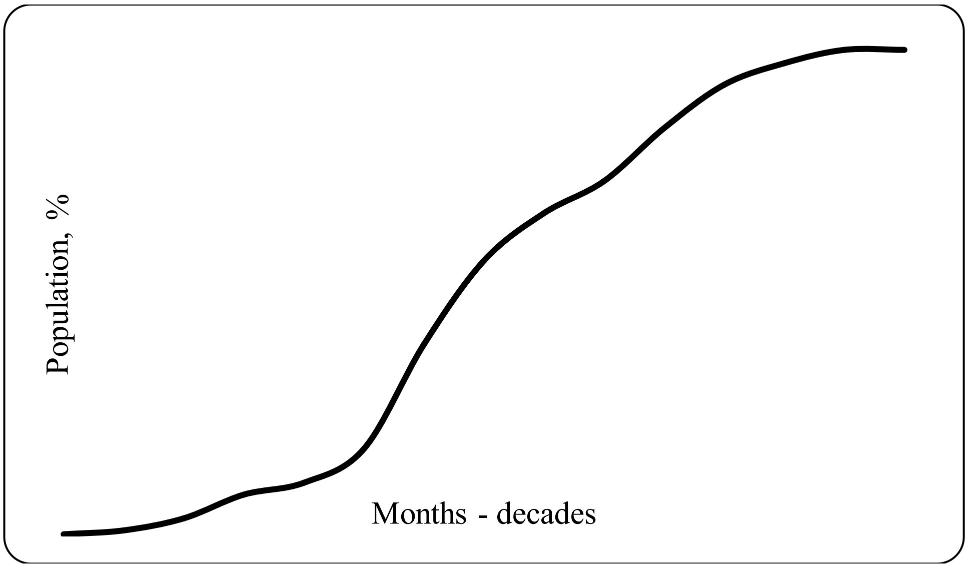

Fig. 6. *Seasonal dynamics of the population of common chestnut by the chestnut mine*

A slow increase in population occurred during the development of the 1st generation, a rapid one during the development of the 2nd generation. From the 3rd decade of May to the end of the flight of the 3rd generation (2nd – 3rd decade of August) with separate periods of a sharp increase in the indicator, which correspond to the flight dates of butterflies of the corresponding generations (Fig. 5).

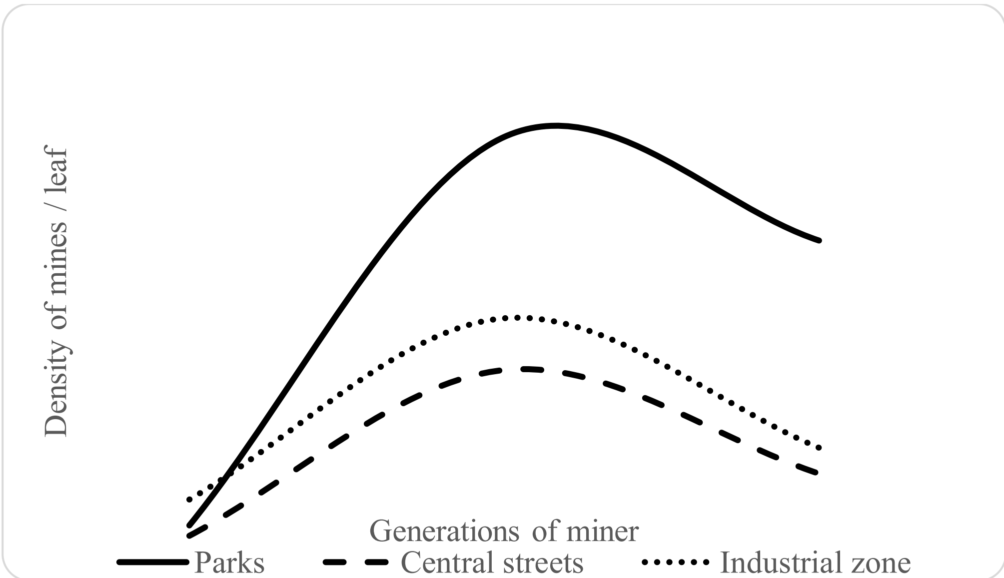

Fig. 7. *Dynamics of the average density of chestnut miner mines at different recording points (pcs./leaf)*

At the same time, if there was a place on the leaf, the butterflies laid eggs on the leaves where the mines of the previous generation were already located, and the overall population changed slightly.

The average density of mines per leaf was calculated for each of the three generations of the chestnut leaf miner for three groups of recording points: parks, central streets, and streets of the industrial zone (Fig. 7, Table 2).

Table 2. *Dynamics of the density of chestnut miner mines in different groups of stands*

Months, decade	**Mine density, pcs./tree leaf**			
	Parks	**Downtown streets**	**Streets of the industrial zone**	**Average**
V-2	0	0	0	0
V-3	0,5	2,1	3,6	2,1
VI-1	1,8	8,2	9,4	6,5
VI-2	8,8	11,9	17,8	**12,8**
VI-3	3,2	6,2	9,8	6,4
VII-1	26,2	15,8	12,8	18,3
VII-2	78,2	42,8	48,2	**56,4**
VII-3	58,2	33,8	43,5	45,2
VIII-1	38,2	16,4	22,1	25,6
VIII-2	22,1	12,3	17,4	17,3
VIII-3	52,4	15,7	17,8	**28,6**
IX-1	42,3	13,8	14,2	23,4
IX-2	18,1	8,3	8,5	11,6
IX-3	12,1	5,1	4,5	7,2
X-1	0	0	0	0

Analysis of the data obtained shows that at the beginning of the season, the density of chestnut miner settlements differed little at different recording points, although in the parks and streets of the center, where fallen leaves were removed in the fall, this indicator was slightly lower than on the streets of the industrial zone.

In subsequent generations, the density of chestnut miner settlements increased most intensively in parks and reached a maximum of 78.2 mines/leaf. On the streets of the city center, the maximum density of chestnut miner settlements was 42.8 mines/leaf, and in the industrial zone – 48.2 mines/leaf. The lower density of mines in street plantings may be due to the fact that the leaves of the common bitter chestnut were also affected by burns due to the effects of industrial and motor vehicle emissions. At the end of summer, a significant part of the leaves fell off, and the rest were not suitable for settlement by the chestnut miner, since they already contained many mines of this pest from previous generations, as well as traces of burns and fungal damage. Therefore, in all areas, the density of mines at the end of the development of the third generation is lower than that of the second generation.

During the survey of street and park plantings, a dependence of the damaged area of leaves of common chestnut on the density of mines was established (Fig. 8). At the same time, at high population density, such a relationship was absent due to competition between pest individuals.

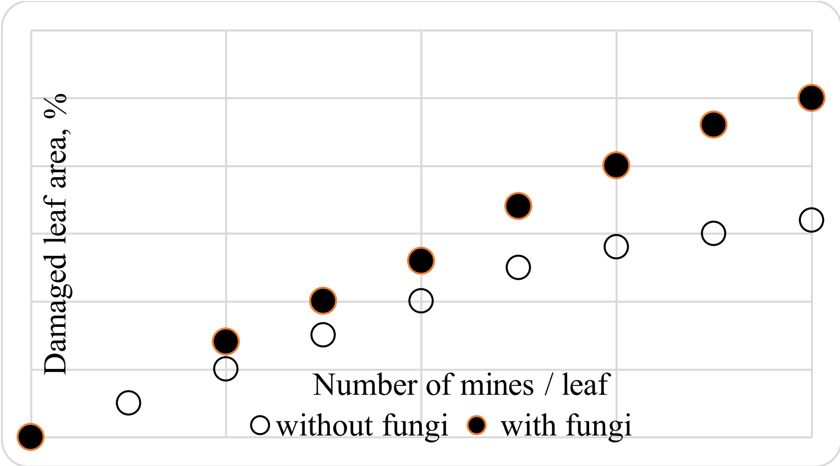

Fig. 8. *Dependence of the damaged area of a leaf of common chestnut on the density of chestnut miner mines in the absence and presence of additional fungal damage*

The use of the revealed dependence for predicting the level of leaf damage is not promising, since chestnut leaves are also damaged by vehicle emissions and affected by pathogens. These factors together lead to a decrease in the assimilation surface and a general weakening of trees. Thus, with 30 mines on a leaf, the damaged area was 15.2 and 20.1% in the presence and absence of fungal damage, respectively (Fig. 3.8).

1.7. Seasonal dynamics of the distribution of the *Phyllonorycter issikii*

Ph. issikii is widespread in Japan [45]. The caterpillars form folded mines on the underside of linden leaves. It entered in Kyiv in 1987, and now it is widespread in Ukraine. It is a narrow oligophagous, as it can inhabit various species of the genus *Tilia* Mill. The number of *Ph. issikii* in the city is not high compared to the forest [29].

We found the *Ph. issikii* only in park plantings. Butterflies flew out of wintering grounds in early May, and mines could be seen in late May, when the linden leaves reached full size. Single mines appeared in the first decade of June. Mines are located mainly on the underside of the leaf, often between the central and other large vessels (Fig. 9).

The caterpillar of the *Ph. issikii* passed through 4 instars (Fig. 10) and pupated in the mine, usually at the end of June. After 7–9 days, the pupa broke through the mine and emerged for most of its length.

Fig. 9. *Miner on the underside of a linden leaf*

Fig. 10. *Ph. issikii caterpillar in a mine*

The first butterflies of the new generation flew out in early July. They mated and laid eggs on the leaves. Caterpillars of the second generation developed in August. Pupae were found in late August, and adults in September. Butterflies overwintered in deep cracks in the bark, cracks in fences and buildings.

In 2020, the linden miner had a low population density - the maximum value of the indicator was noted in the second decade of August and was 0.4 mines/leaf (Fig. 11).

In the seasonal dynamics of the mine density, two maxima can be clearly distinguished, which correspond to the periods of the end of hatching of larvae of the I and II generations. The first maximum (0.1 mines/leaf) was noted in the second decade of June, and the second (0.4 mines/leaf) - in the second decade of August.

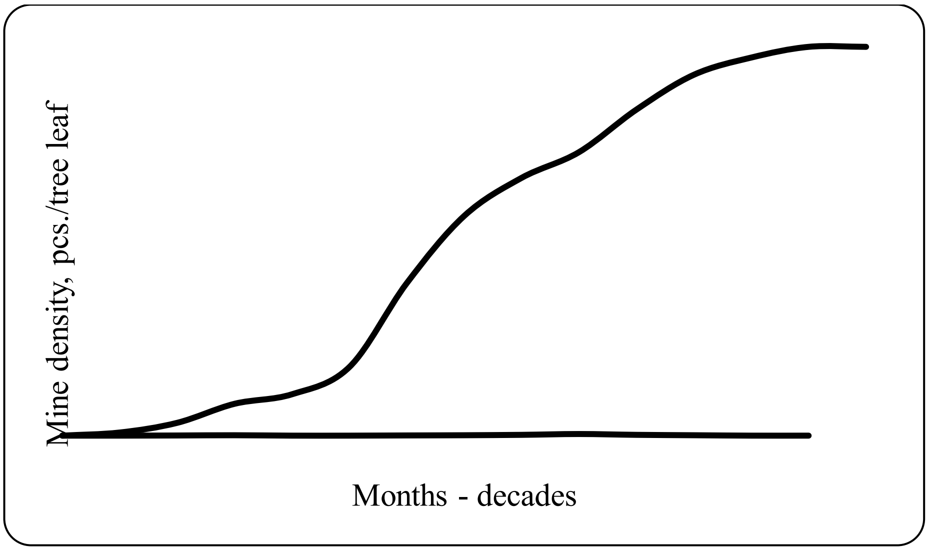

Fig. 11. *Seasonal dynamics of the average density of Ph. issikii mines (pcs/leaf; averaged over all recording areas)*

The population of linden leaves by the *Ph. issikii* at the beginning of June was 1.1% (Fig. 12).

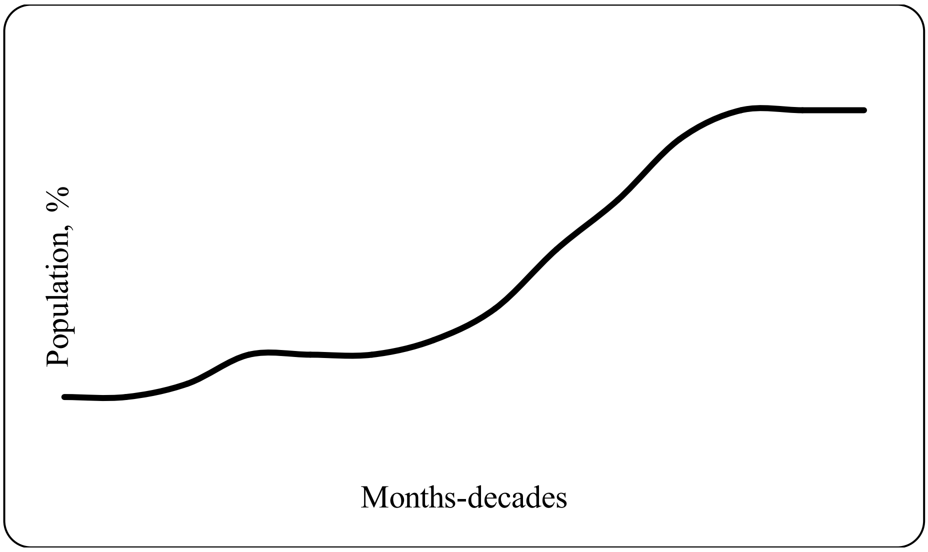

Fig. 12. *Seasonal dynamics of the population of linden Ph. issikii*

As the summer generation of butterflies fledged, leaf occupancy increased from 4.7% in the second decade of July to 23.7% in early September.

1.8. Seasonal dynamics of the distribution of *M. Robiniella*

M. robiniella was introduced to Switzerland from North America in 1983 [46]. By 2000, the species had spread across Europe. The white acacia motley moth entered Italy from North America in 1970 and is now widespread in many European countries, including Ukraine [1].

In 2020, we found *M. robiniella* only in parks. The density of mines was low, but three maxima can be distinguished in its dynamics (Fig. 13).

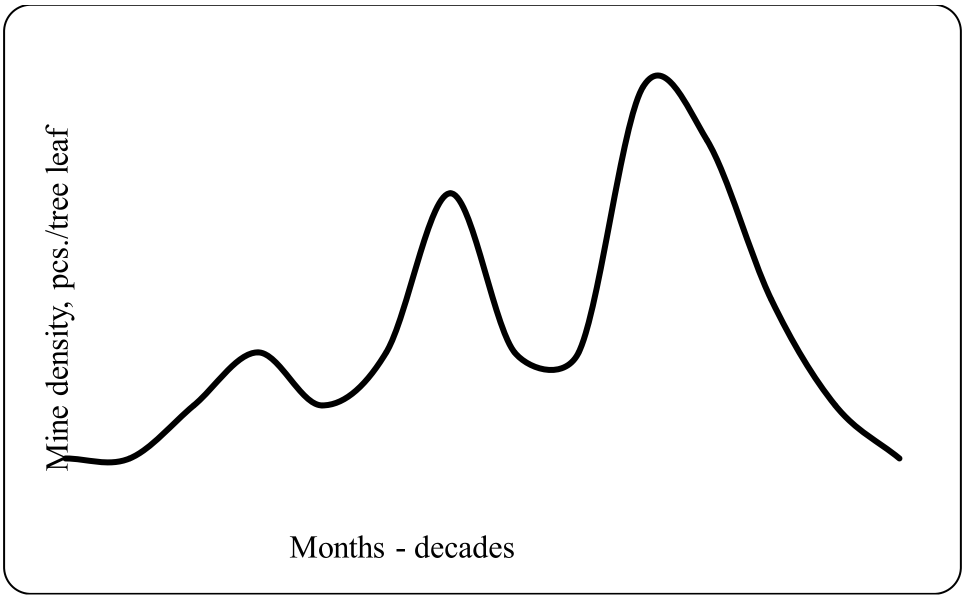

Fig. 13. *Seasonal dynamics of the average density of M. robiniella mines (items/leaf; averaged over all research areas)*

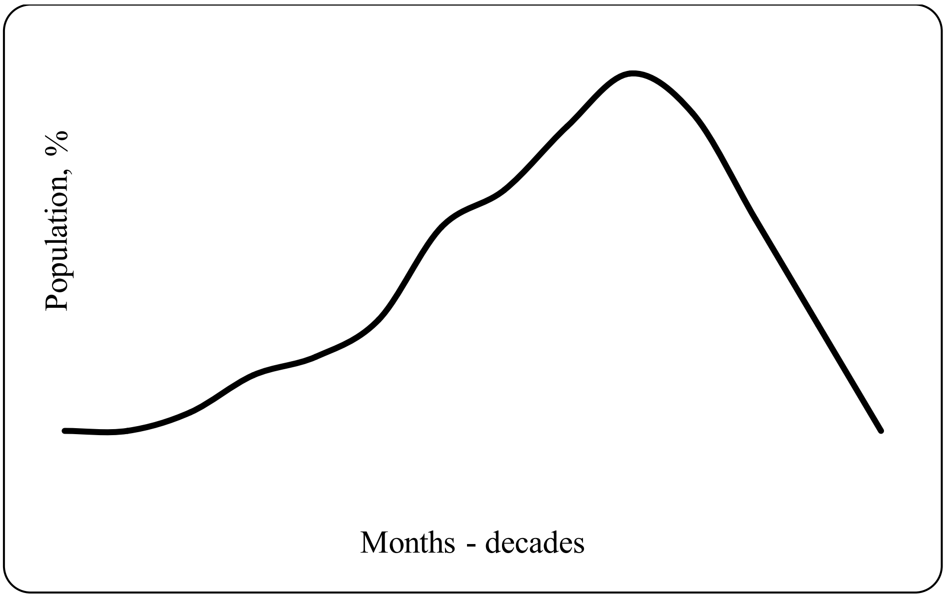

Fig. 14. Seasonal dynamics of the population M. robiniella

The first maximum of the mine density was 0.02 pcs./leaf (second decade of June), the second – 0.05 pcs./leaf (second decade of July) and the third – 0.07 pcs./leaf (second decade of August).

The population of Robinia by the miner during the first wave (second decade of June) was 0.4%, during the second wave (second decade of July) – 1.5%, respectively, and during the last wave (second decade of August) – 2.7%, respectively (Fig. 14).

P. robiniella was found singly. *M. robiniella* and *P. robiniella* feed only on plants of the genus Robinia. The last-instar caterpillars pupate in mines in white oval cocoons. Both species develop in 2–3 generations per year, which usually overlap.

Thus, in 2020, among the six species of insect miners identified, only the chestnut miner became widespread. The remaining species had low numbers and did not cause noticeable damage to trees. We suggest monitoring the distribution and development of the identified insect miners. Removing fallen leaves in autumn allows you to reduce the number of the chestnut miner of the spring generation and does not affect the further growth of its number. Therefore, it is necessary to provide for a gradual replacement of the common bitter chestnut with other species.

Conclusions and Production Recommendations

1. Urban stands play a significant role in creating a favorable environment for people, mitigating the climate, absorbing dust and emissions, but they themselves are weakened by anthropogenic factors and vulnerable to pests and pathogens, in particular to alien species.

2. In urban conditions, the spread of insects with a smaller size, secretive lifestyle and with a sucking mouthpart increases, the participation of eruptive species decreases, and alien species are added.

3. Among the diseases, trunk rots are the most dangerous. The crowns of affected trees often have a good crown appearance, but during strong winds, branches or tops can injure people or damage vehicles.

4. The resistance of trees to damage by insects or pathogens is associated with two mechanisms. Thanks to resistance, a tree avoids damage or damage due to its morphology, physiology or phenology. Thanks to tolerance, a tree restores its condition, growth rate, or reproductive intensity after damage has been caused.

5. The growth intensity and condition of trees depend on hereditary traits and environmental conditions. One of the tasks is to identify the species and varieties of trees that are characterized by the fastest growth or the greatest resistance in urban ecosystems to the most harmful environmental factors.

6. In the surveyed stands, the most common tree species are common oak (*Quercus robur* L.), linden (*Tilia cordata* Mill.), maple (*Acer platanoides* L.), white poplar (*Populus alba* L.), common chestnut (*Aesculus hippocastanum* L.), black poplar (*Populus nigra* L.), elms (*Ulmus laevis* Pall., *Ulmus glabra* Huds.), robinia *(Robinia pseudoacacia* L.). During the survey of the stands, we found insect miners from the order of Lepidoptera of the Gracillariidae family: on common oak – *Acrocercops brongniardella* (Fabricius, 1798); on common chestnut – *Cameraria ohridella* Deschka & Dimic, 1986; on robinia – *Parectopa robiniella* (Clemens, 1863) and *Macrosaccus robiniella* (Clemens, 1859); on linden – *Phyllonorycter issikii* (Kumata, 1963); on black poplar – *Phyllonorycter populifoliella* (Treitschke, 1833).

7. In the dynamics of the density of chestnut leaf miner mines, three maxima were recorded: in the second decade of June (12.8 mines/leaf), the second decade of July (56.4 mines/leaf) and the third decade of August (28.6 mines/leaf). The population increased slowly during the development of the first generation, quickly during the development of the second generation and slowly during the development of the third generation. The latter is associated with the lack of space on the leaves for settlement.

8. In spring, the density of chestnut leaf miners was the lowest in parks and streets of the center, where fallen leaves were removed. At the same time, in subsequent generations, the maximum value of the indicator was 78.2; 42.8 and 48.2 mines / leaf in parks, streets of the center and industrial zone.

9. The damaged area of bitter chestnut leaves depends on the density of chestnut leaf miners, damage by fungi and technogenic factors.

10. In the seasonal dynamics of the density of lime leaf miners, two maxima coincide with the periods of the end of the appearance of larvae of the 1st and 2nd generations. The first maximum (0.1 mines / leaf) was noted in the 2nd decade of June, and the second (0.4 mines / leaf) - in the 2nd decade of August. The population of lime leaves by lime leaf miners in early June was 1.1%, in early September - 23.7%.

11. In the dynamics of the density of white acacia miner mines, the first maximum was 0.02 pcs./leaf (second decade of June), the second – 0.05 pcs./leaf (second decade of July) and the third – 0.07 pcs./leaf (second decade of August). The population of leaves during this time increased from 0.4 to 2.7%

12. In forest parks, parks and street plantings, the composition of trees and shrubs should be selected taking into account the composition of the soil, tolerance to the level of moisture, resistance to industrial and domestic pollution, the ability to absorb pollutants from the atmosphere or soil, etc.

13. It is necessary to monitor the condition of trees in urban stands, assess the impact of factors of various nature and clarify the conditions that can be influenced by economic activities in the urban environment. This will allow to increase the ecological role of plantings in the urban environment.

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