BIOLOGICAL CHARACTERISTICS AND DISTRIBUTION OF *VISCUM ALBUM* L. IN UKRAINE

Melnyk Tetiana
PhD of Biological Sciences, Department of Horticulture and Forestry,Professor, Sumy National Agrarian University, Ukraine
ORCID ID: 0000-0002-3839-6018

Melnyk Andrii
Doctor of Agricultural Sciences, Professor, Sumy National Agrarian University, Ukraine
ORCID ID: 0000-0001-7318-6262

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

Viscum album L. belongs to the Santalaceae family and represents a perennial evergreen hemiparasitic plant that colonizes a wide range of woody species, using them as a source of water and mineral nutrients. Despite possessing its own photosynthetic apparatus, which enables partial autotrophic nutrition, the plant remains physiologically dependent on its host. This dual nutritional strategy ensures high ecological plasticity and allows mistletoe to successfully persist both in natural forest ecosystems and in anthropogenically transformed environments, including urban and protective plantations [1, 9].

The life cycle of *Viscum album* typically spans 4 to 6 years and includes several distinct developmental stages: seed germination, haustorium formation, vegetative growth, flowering, and fruiting. The plant retains green leaves capable of photosynthesis throughout the year, including during winter dormancy of the host tree. This physiological feature provides a competitive advantage, as mistletoe remains metabolically active when host trees significantly reduce their physiological activity.

Morphologically, *Viscum album* forms a characteristic spherical crown with a diameter ranging from 20 to 100 cm, composed of repeatedly dichotomously branched shoots. Leaves are opposite, leathery, elliptical to lanceolate, 2–8 cm long, and light green in color. The flowers are small, yellowish-green, unisexual, and are pollinated both by wind and insects. The fruit is a globose pseudoberry, 7–10 mm in diameter, containing viscin – a sticky mucilaginous substance commonly referred to as “bird glue” [5, 12, 20].

Seed dispersal mechanisms differ among subspecies. Unlike *Viscum album* subsp. *album*, whose seeds are dispersed by numerous bird species, the dispersal of *Viscum album* subsp. *austriacum* is primarily associated with two bird species, notably the mistle thrush and the waxwing. These birds consume the fleshy viscin layer, while the sticky seeds adhere to their beaks. Subsequently, birds remove the seeds by wiping their beaks against branches, facilitating seed attachment to suitable host surfaces.

Following germination, a specialized organ – the haustorium – is formed. It penetrates the bark and cambial layers of the host tree and establishes a physiological connection with the xylem tissues. The initial developmental phase is relatively slow: during the first year, only the internal haustorial system develops, while the emergence of aerial shoots occurs 1–2 years after infection (Fig. 1). Flowering typically begins at the age of 4–5 years, and fruiting continues throughout the lifespan of the plant, which may reach 25–30 years [31].

Figure 1. Development of Viscum album individuals on the host plant [23].

The primary physiological mechanism of parasitism is based on the formation of an extensive haustorial system that extracts water and dissolved mineral nutrients directly from the host's xylem. Since mistletoe lacks a root system in the soil, it is entirely dependent on the host for water supply. Notably, the transpiration rate of mistletoe exceeds that of host tree leaves by 2–3 times, resulting in significant water stress within host tissues [16, 40, 41].

Numerous studies conducted in Central Europe have demonstrated that trees infected with mistletoe, particularly pines and poplars, may lose up to 40% of their annual increment. Infected trees exhibit reduced chlorophyll content, decreased photosynthetic activity, and premature dieback of shoots. Under drought conditions, mistletoe maintains high transpiration rates, while host trees reduce water loss, leading to xylem tension imbalance and physiological weakening of the host [22, 24, 26].

Despite its parasitic nature, *Viscum album* also plays a notable ecological role. Its fruits serve as an important food resource for birds during winter, while its dense crowns provide microhabitats for insects and avifauna. Consequently, some researchers consider mistletoe an indicator of ecosystem transformation and declining stability of forest stands.

However, excessive spread of mistletoe in natural forests and protective plantations disrupts biocenotic equilibrium. Infection levels exceeding 30 % of trees within a stand indicate degradation processes, loss of ecological functionality, and the necessity for implementing sanitary and silvicultural measures [12, 18].

In Ukraine, *Viscum album* is a widespread component of both forest and urban ecosystems (Fig. 2). The main distribution zones are concentrated within the Forest-Steppe and Polissya regions. Significant infection foci have been recorded in forest stands of Kyiv, Cherkasy, Poltava, Sumy, Zhytomyr and Volyn regions, where mistletoe commonly affects species such as *Populus alba*, *Salix alba*, *Acer platanoides*, *Tilia cordata*, *Fraxinus excelsior*, as well as certain coniferous species [4, 7, 13].

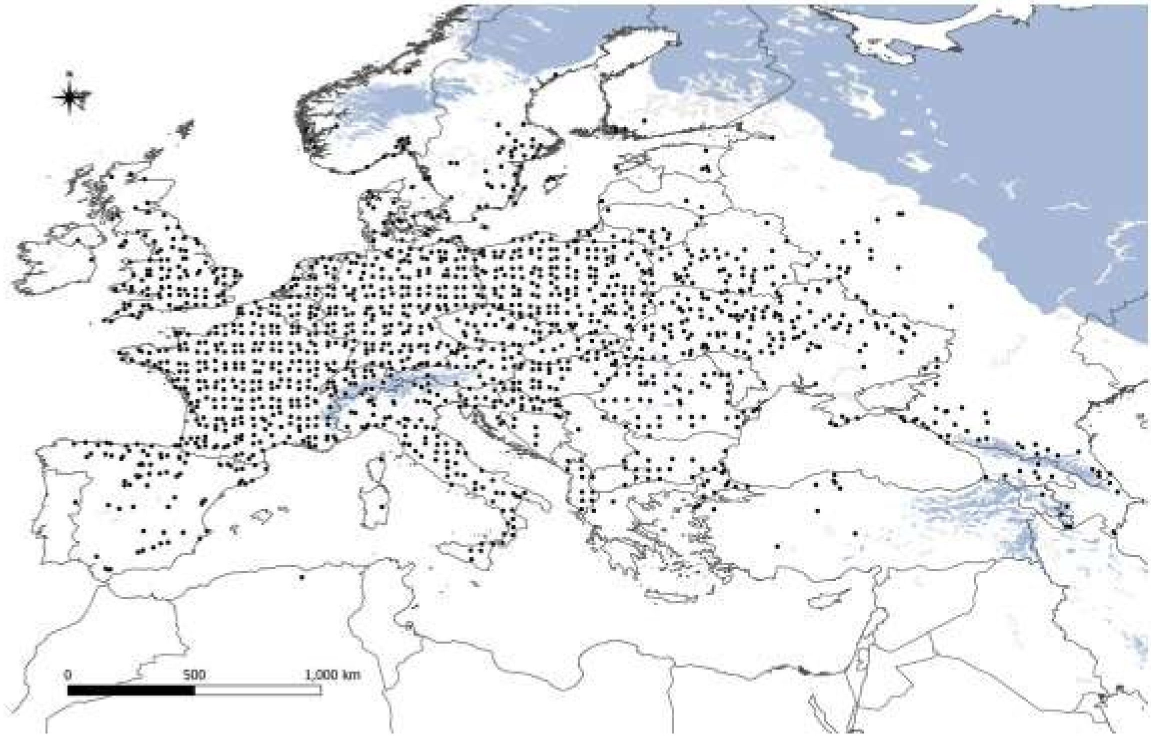

Figure 2. Occurrence of Viscum album in Europe [18].

Three subspecies are registered in Ukraine: *Viscum album* subsp. *album*, subsp. *austriacum*, and subsp. *abietis*. The first predominantly occurs in deciduous forests, the second in pine forests, while the third is mainly confined to the Carpathian region.

According to data reported in the Ukrainian Botanical Journal, the proportion of infected trees in floodplain forests of the Sumy region reaches 40–60% among stands older than 50 years. In recent years, an expansion of mistletoe distribution has been observed across Ukraine, largely attributed to climate warming, increased frequency of droughts, and the aging of forest stands.

The spread of mistletoe is particularly pronounced in degraded and thinned forests, where increased light availability and accessibility of branches for bird dispersers create favorable conditions for colonization. In the Forest-Steppe zone, especially within Sumy region, mistletoe is most frequently found on *Populus alba*, *Salix alba*, *Tilia cordata*, and *Acer platanoides*.

Within the forestry practices of the Romny agroforestry enterprise, infection hotspots are primarily associated with older age classes (50–70 years), particularly in shelterbelts and protective plantations. Most infected trees are located in open areas such as roadsides, agricultural fields, and river floodplains, where both insolation levels and bird activity are high [8, 13, 40].

Conversely, mistletoe is rarely found in dense young stands with closed canopies, which confirms its dependence on sufficient light availability for maintaining photosynthetic activity. Field observations indicate that approximately 35% of trees exhibit weak infection, 40% moderate infection, and 25% severe infection. The upper parts of the crown are most commonly affected, particularly branches aged 2–5 years, while skeletal branches are less frequently infected.

Viscum album is a significant factor contributing to the degradation of forest stands, especially in overmature plantations. The parasite intensifies water stress, reduces growth rates, and accelerates physiological aging processes in host trees. The loss of foliage above infection sites disrupts the balance of photosynthesis and negatively affects wood increment.

Studies conducted in Poland have shown that infected pine stands experience a reduction in annual growth by 41–64%, while needle density in the upper crown decreases by 30–50 %. Similar trends have been observed in pine forests of Zhytomyr and Volyn regions in Ukraine [19, 22, 41].

The decline in tree vitality increases susceptibility to secondary pests, including bark beetles and saprotrophic fungi, which further accelerate stand degradation. In deciduous forests, the consequences include reduced ornamental value, increased brittleness of branches, and heightened risk of tree failure, particularly in urban and recreational areas [9].

In summary, *Viscum album* is a typical hemiparasitic species that actively spreads in forest ecosystems of Europe and Ukraine, including the Sumy region. Its biological characteristics – such as year-round photosynthetic activity and high transpiration rates – contribute to its ecological success and persistence. Under conditions of climate change and forest aging, the intensity of infestation continues to increase, necessitating systematic monitoring and the implementation of appropriate forest management and sanitary measures.

The study of mistletoe distribution and impact is therefore of considerable importance for ensuring sustainable forest management, maintaining ecological balance, and enhancing the resilience of forest ecosystems in the Forest-Steppe zone of Ukraine.

Research Methodology. The research methodology was designed to ensure a comprehensive and integrated assessment of the distribution patterns of *Viscum album* L. within urban and peri-urban plantations, as well as to evaluate the infection load affecting trees of different species and age groups. The study combined classical forestry approaches with modern analytical techniques, including visual taxation methods, geobotanical surveys, biometric measurements, remote sensing techniques, and elements of geoinformation analysis. Such a multidisciplinary approach enabled both detailed field-level observations and large-scale spatial generalizations.

At the initial stage of the research, route-based field surveys were conducted across selected plantations. During these surveys, particular attention was paid to determining the species composition of stands, the general condition and vitality of trees, as well as the presence, density, and spatial configuration of mistletoe infection foci. Each tree within the surveyed plots was individually assessed.

A visual evaluation of the degree of infestation was carried out using a standardized five-grade scale commonly applied in forestry and phytopathological studies. This scale allows differentiation between weak, moderate, strong, and very strong levels of infestation, based on the number of mistletoe bushes and the proportion of the crown occupied by the parasite. The use of this widely accepted classification system ensured comparability and consistency of the obtained results with existing scientific data.

For *Populus alba* L., which proved to be one of the most susceptible host species, an additional quantitative assessment method was applied. This method involved the precise counting of mistletoe bushes on individual trees, followed by their classification according to size (diameter) and developmental stage (age). Such a detailed approach made it possible to evaluate the internal structure of the infection load and to identify patterns in the development and expansion of the haustorial system within the host tissues.

In parallel, morphological characteristics of mistletoe individuals were recorded. These included measurements of bush size, internode length of shoots, leaf coloration, and leaf morphometry. The analysis of these parameters provided additional insights into the physiological condition of the parasite and its degree of adaptation to specific host species. Variability in morphological traits was also considered as an indirect indicator of environmental conditions and host–parasite interactions.

To ensure precise spatial referencing of infected trees, GPS devices were used to record their geographic coordinates. The collected geospatial data were subsequently integrated into digital maps using geographic information systems (GIS). This enabled the identification of spatial distribution patterns of mistletoe, the delineation of high-density infection zones, and the analysis of relationships between infestation intensity and environmental factors.

For validation and visualization purposes, selected sites were subjected to detailed photographic documentation, including crown structure analysis and the assessment of structural damage caused by infestation. Additionally, remote sensing methods were applied, including photogrammetric surveys using unmanned aerial vehicles (UAVs) and the analysis of satellite imagery. These techniques allowed for the acquisition of generalized data on infestation patterns over large areas and significantly enhanced the reliability and representativeness of the results.

Special attention was given to identifying and evaluating environmental and biological factors influencing the intensity of mistletoe infestation. These factors included tree age, soil conditions, stand density, crown illumination, the presence of mechanical damage to trunks and branches, and the activity and abundance of bird dispersers. The integration of these variables allowed for a more comprehensive understanding of the ecological drivers of mistletoe spread.

Based on the collected empirical data, statistical analyses were performed to determine average infestation levels across different tree species and age groups. In addition, graphical models and diagrams were developed to visualize the distribution patterns of mistletoe within plantations. These analytical tools facilitated the identification of key trends, correlations, and spatial regularities, forming the basis for further interpretation and practical recommendations.

Bioecological features of the distribution of *Viscum album* and analysis of tree species resistance to infestation in the Sumy region. The distribution of *Viscum album* L. in the Sumy region represents a characteristic example of dynamic processes occurring within phytocoenoses under the combined influence of climatic and anthropogenic factors. Over recent decades, this species has demonstrated a pronounced tendency toward active range expansion, which can be attributed both to ongoing climate warming and to the progressive aging of tree stands. Under these conditions, mistletoe has emerged as one of the key biotic stress factors affecting the condition of deciduous, and to a lesser extent coniferous, tree species in the region. Its impact is particularly evident in shelterbelts, floodplain forests, and recreational plantations.

In the Sumy region, mistletoe predominantly occurs on deciduous tree species. The highest frequency of infestation is recorded on *Populus alba* L., *Salix alba* L., *Tilia cordata* Mill., *Betula pendula* Roth, *Acer platanoides* L., *Quercus robur* L. and *Ulmus laevis* Pall. In addition, mistletoe is occasionally found on fruit tree species such as *Malus domestica* Borkh., *Pyrus communis* L. and *Crataegus monogyna* Jacq. In contrast, infestation of coniferous species – such as *Pinus sylvestris* L. and *Abies alba* Mill. – is significantly less common and typically occurs in weakened stands or on isolated trees growing in open environments [14].

The increased susceptibility of trees in the region can be explained by the combined action of several factors, including stand aging, elevated air dryness, frequent summer droughts, and increased solar radiation. Mistletoe spreads particularly intensively in shelterbelt plantations, where the openness of tree crowns and high light availability create optimal conditions for seed germination and the establishment of young parasitic shoots. The highest proportion of infected trees is observed in age classes ranging from 40 to 70 years, corresponding to mature and overmature stands that gradually lose their natural resistance to external stressors.

The spatial distribution of mistletoe within the region is distinctly mosaic. Infection foci are most commonly formed in low-lying relief areas, near water bodies, in old parks, along forest edges, and in roadside plantations. In contrast, mistletoe is rarely found in dense forest stands with closed canopies, which clearly indicates its dependence on sufficient light conditions for successful establishment and development.

Seed dispersal is primarily mediated by birds, including thrushes, waxwings, and magpies, which feed on mistletoe berries during the winter period. These birds play a crucial role as dispersal agents, transporting seeds over considerable distances and thus ensuring the persistence and expansion of mistletoe populations within the region. This biological mechanism contributes to the formation of stable and self-sustaining populations across diverse habitats.

The impact of *Viscum album* on woody vegetation is complex and multifaceted, manifesting in physiological exhaustion, reduced growth rates, and decreased resistance of host trees. Infestation affecting more than 30% of the crown is considered critical, as it leads to disruption of the water balance, suppression of photosynthetic processes, and a decline in overall stand productivity. When infestation exceeds 60% of the crown area, trees typically lose their regenerative capacity and must be removed as part of sanitary measures.

In addition, infected trees become centers for secondary infestation by fungal pathogens and insect pests, which further accelerates their decline and increases the risk of stand destabilization. This is particularly important in protective and recreational plantations, where the loss of tree stability may pose ecological and safety risks.

The conditions in the Sumy region are characterized by a combination of natural and anthropogenic factors that facilitate the active spread of mistletoe. Climate change trends, including increasing average annual temperatures and decreasing precipitation, lead to frequent drought events and water deficits, particularly during the summer period. Under such conditions, physiologically weakened trees become more vulnerable to parasitic infestation.

In stands affected by windthrow or mechanical damage, mistletoe most frequently establishes on exposed branches in the upper crown layer, where light conditions are most favorable. This pattern further confirms the importance of insolation as a limiting factor for mistletoe development.

Control of *Viscum album* within the region is currently based primarily on mechanical methods. The most effective approach involves pruning infected branches along with a portion of healthy wood, typically at a distance of 15–20 cm below the point of parasite attachment. In cases of severe infestation, especially in shelterbelt plantations, selective or complete removal of heavily infected trees is recommended, followed by the establishment of young stands.

Removed branches and mistletoe bushes must be transported outside the plantation area and destroyed to prevent further seed dispersal. At present, no effective chemical control agents against mistletoe have been developed or approved in Ukraine. Therefore, management strategies are focused on preventive measures and systematic monitoring of plantation conditions.

For forestry enterprises in the region, including the Romny agroforestry branch, the control of mistletoe represents an ongoing task within the framework of sanitary and silvicultural measures. These activities are closely linked with the formation of younger and more resilient stands, where preference is given to tree species demonstrating higher tolerance to parasitic infestation.

Equally important are timely thinning operations, maintenance of optimal stand density, and preservation of biological diversity, all of which contribute to enhancing the overall resilience of forest ecosystems. Integrated forest management approaches are therefore essential for mitigating the negative impact of mistletoe.

In summary, *Viscum album* in the Sumy region represents a natural but currently overactive component of forest ecosystems. Its distribution is driven by a complex interaction of ecological, climatic, and anthropogenic factors, while the level of damage is directly dependent on the age structure and sanitary condition of tree stands. Improving the effectiveness of control measures requires a combination of continuous monitoring, preventive management, and the establishment of new plantations with a rational selection of resistant species. Such an approach will contribute to a gradual reduction in infestation levels and stabilization of forest ecosystem conditions in the region.

Classification of tree species according to resistance to *Viscum album* infestation. The classification of tree species according to their resistance to infestation by *Viscum album* L. is inherently conditional and is primarily based on long-term observational studies conducted by researchers between 2007 and 2024 across several regions of Ukraine, including Kyiv, Chernihiv, Zhytomyr, and Sumy oblasts. In addition to field observations, a substantial body of scientific literature authored by both Ukrainian and international researchers was analyzed, focusing on the distribution of mistletoe in Ukraine and across Europe. These sources provided valuable insights into the susceptibility and resistance of various woody species to infestation by this hemiparasitic plant.

The proposed classification should be considered indicative rather than absolute and may be refined through further long-term monitoring and experimental investigations. It reflects current trends in the changing resistance of tree species in urban and semi-natural environments, driven by climatic shifts, the physiological condition of stands, and the proximity of potential host plants that facilitate the spread of mistletoe [6, 9, 14].

Group I. Tree Species Resistant to *Viscum album*

This group includes species in which *Viscum album* has not been detected in tree crowns throughout the entire observation period, even when these trees were located in close proximity to heavily infested individuals of other species. Such resistance may be attributed to anatomical, physiological, or biochemical traits that inhibit haustorial penetration or reduce the suitability of host tissues for parasite development.

The following species belong to this group: *Ailanthus altissima* (Mill.) Swingle, *Carya illinoinensis* (Wangenh.) K. Koch, *Catalpa* spp. (all species and hybrids), *Celtis occidentalis* L., *Cornus mas* L., *Corylus colurna* L., *Fagus sylvatica* L., *Ginkgo biloba* L., *Gymnocladus dioicus* (L.) K. Koch, *Morus* spp. (all species), *Ostrya carpinifolia* Scop., *Platanus* spp. (all species), *Prunus avium* L. (including most ornamental cherry cultivars), *Quercus imbricaria* Michx., *Quercus palustris* Münchh., *Quercus robur* L., *Rhus typhina* L.

In addition, nearly all coniferous species belong to this group, including representatives of the genera *Picea*, *Thuja*, *Juniperus*, *Pseudotsuga*, *Chamaecyparis*, and *Taxus*. Exceptions include species of the genera *Pinus*, *Abies*, and *Larix*, which may be affected by other subspecies of mistletoe, such as *Viscum album* subsp. *austriacum* and *Viscum album* subsp. *Abietis* [14, 16, 19].

Group II. Relatively Resistant Tree Species

This group comprises species on which mistletoe infestation has been observed only sporadically, either on isolated individuals or mentioned in individual scientific reports. These species demonstrate a certain degree of tolerance, although under favorable environmental conditions or increased infection pressure, they may become susceptible.

The group includes: *Acer negundo* L., *Aesculus hippocastanum* L., *Alnus glutinosa* (L.) Gaertn., *Carpinus betulus* L., *Cercis canadensis* L., *Gleditsia triacanthos* L., *Liquidambar styraciflua* L., *Liriodendron tulipifera* L., *Magnolia* spp. (all species), *Prunus serotina* Ehrh., *Pyrus communis* L., *Quercus rubra* L., *Styphnolobium japonicum* (L.) Schott, *Ulmus* spp. (all species).

Group III. Highly Susceptible Tree Species

This group includes species in which mass infestation by *Viscum album* has been consistently recorded, often resulting in significant ecological and physiological impacts on host trees. These species typically possess structural or physiological characteristics that facilitate mistletoe establishment and proliferation.

The most susceptible species include: *Acer platanoides* L., *Acer pseudoplatanus* L., *Acer saccharinum* L., *Betula pendula* Roth, *Crataegus monogyna* Jacq., *Juglans nigra* L., *Malus* spp. (almost all species), *Populus* spp. (almost all species; less susceptible is *Populus nigra* var. *pyramidalis*), *Robinia pseudoacacia* L., *Salix* spp. (almost all species), *Sorbus aucuparia* L., *Tilia cordata* Mill.

The results of long-term observations clearly demonstrate that *Viscum album* possesses a broad spectrum of potential host species, predominantly among deciduous trees. The highest infestation intensity is observed in stands dominated by representatives of the families Salicaceae, Rosaceae, and Aceraceae, particularly *Tilia*, *Populus*, *Acer*, *Betula*, and *Robinia* species.

In contrast, coniferous species and certain introduced or exotic taxa exhibit either high tolerance or complete resistance to mistletoe infestation. These differences are likely related to variations in wood anatomy, chemical composition of tissues, bark structure, and physiological responses to stress.

The obtained results have significant practical importance for forestry and urban landscape management. In particular, they can be used to:

- optimize the selection of tree species for urban greening projects;
- design more ecologically stable and resilient green infrastructure;
- develop preventive strategies aimed at limiting the spread of *Viscum album*;
- support the implementation of targeted sanitary and silvicultural measures in affected areas.

Thus, the classification of tree species according to their resistance to mistletoe infestation serves as an important tool for improving the sustainability of urban and forest ecosystems, especially under current conditions of climate change and increasing anthropogenic pressure.

Analysis of the species composition of trees infected by *Viscum album* within the operational area of the Romny district

The results of field surveys indicate that the majority of trees affected by *Viscum album* L. within the study area belong to *Populus alba* L., which accounts for approximately 58 % of the total number of examined specimens. This clearly demonstrates the high susceptibility of this species and confirms its role as one of the primary host species facilitating the spread of mistletoe in protective and urbanized plantations.

Significantly lower infestation levels were recorded for other tree species. In particular, *Tilia cordata* Mill. accounts for about 10 % of the surveyed trees, while *Acer platanoides* L. and *Salix alba* L. each represent approximately 7–8 %. *Acer campestre* L. and other species collectively constitute around 5 % of the total (Fig. 3). This distribution reflects both species-specific susceptibility and the structural characteristics of the plantations under study.

The assessment of infestation levels was carried out using a standardized five-grade scale, which allows for a differentiated evaluation of parasite load on individual trees: 5 points – no signs of infestation; 4 points – weak infestation (up to 5 mistletoe bushes per tree); 3 points – moderate infestation (6–15 bushes); 2 points – strong infestation (16–24 bushes); 1 point – very strong infestation (25 or more bushes per tree).

This classification system ensures consistency in evaluating the severity of infestation and enables comparative analysis across species and sites.

For a more detailed analysis of infestation patterns, a representative sample of 30 individuals per species was selected, including *Fraxinus excelsior* L., *Robinia pseudoacacia* L., *Salix alba* L., *Tilia cordata* Mill., *Acer platanoides* L., *Aesculus hippocastanum* L., *Populus alba* L., *Acer campestre* L., and *Picea abies* (L.) H. Karst. The results of these observations are presented in Table 1.

The analysis of the obtained data indicates that the majority of examined trees exhibit either moderate or weak levels of crown infestation by mistletoe. However, a certain proportion of individuals with pronounced and locally high levels of damage was also recorded. On average, the infestation intensity for most studied species ranges between 3 and 4 points, corresponding to a moderate level of colonization. This suggests that mistletoe is stably present within the plantations, although its spread remains, to some extent, within a controllable range.

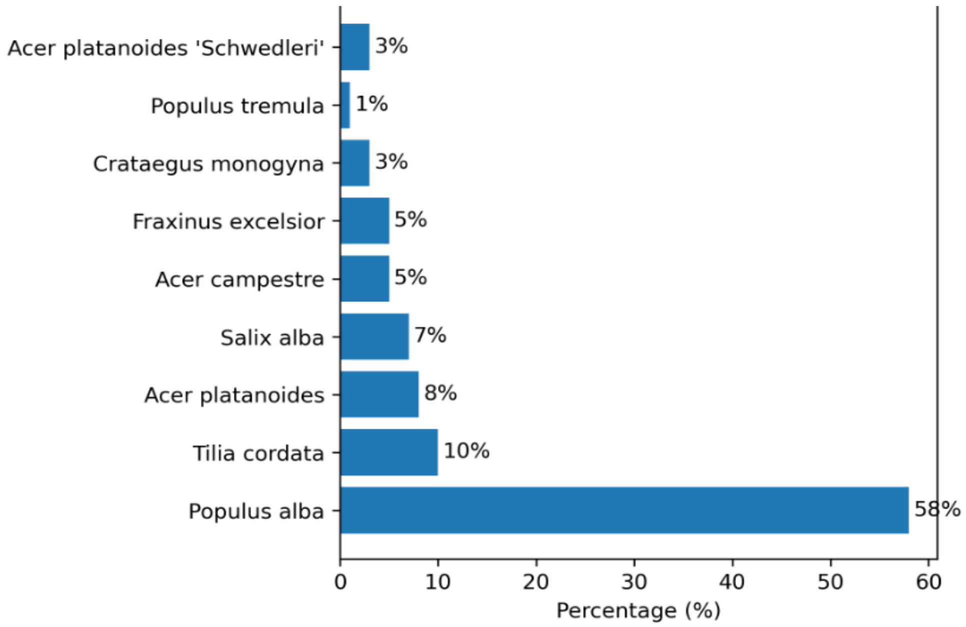

Figure 3. Species composition of woody plants infected by Viscum album in protective plantations of the Romny district

Such a distribution of infestation levels reflects not only species-specific characteristics but also the influence of tree age, crown architecture, and the degree of anthropogenic pressure in urban and peri-urban environments. The interaction of these factors determines both the vulnerability of host trees and the success of parasite establishment.

Table 1. Degree of infection of woody species by European mistletoe

Plant name	Degree of damage, score
Picea abies	1
Acer campestre	4
Acer platanoides	4
Aesculus hippocastanum	1
Fraxinus excelsior	2
Robinia pseudoacacia	3
Populus canadensis	4
Populus alba	5
Salix alba	1
Tilia cordata	2

According to the generalized assessment of settlements within the protective plantations of the Romny district, the most heavily infested species include *Populus nigra* L., *Fraxinus excelsior* L., *Acer platanoides* L., *Acer campestre* L., *Robinia pseudoacacia* L. and *Salix alba* L. These species typically exhibit a moderate to high degree of infestation (3–5 points), characterized by the formation of numerous mistletoe bushes in the upper crown layers (Fig. 4).

Figure 4. Visual examples of different degrees of tree infestation by Viscum album in the study region.

This pattern is primarily explained by the ecological preferences of mistletoe, which favors well-illuminated parts of the crown. Branches aged 2–5 years provide optimal conditions for seed germination and haustorium development. In contrast, infestation of skeletal branches and the central stem occurs less frequently, highlighting the light-dependent nature of parasite development and its adaptation to actively growing peripheral shoots.

To identify age-related patterns in mistletoe distribution, the examined trees were grouped into age categories. This approach allowed for the analysis of ontogenetic dynamics of infestation and the evaluation of changes in tree resistance throughout their lifespan.

The results demonstrate that the highest levels of infestation are observed in trees aged 50–60 years and older. In these age groups, infestation intensity increases significantly: the number of mistletoe bushes per tree often exceeds 20–25 individuals, and infection foci may cover a substantial portion of the crown.

In contrast, trees belonging to younger age groups (up to 30 years) exhibit either sporadic infestation or no signs of infection at all. This can be explained by several factors, including the morphological characteristics of young trees-such as dense crown structure, high growth rates, and active shoot regeneration – as well as their generally higher physiological resistance, which limits the successful establishment of mistletoe.

The proportion of infected trees in the 60–80-year age group averages 25–29 %, indicating a gradual decline in natural resistance and an increased vulnerability to biotic stressors with age (Fig. 5).

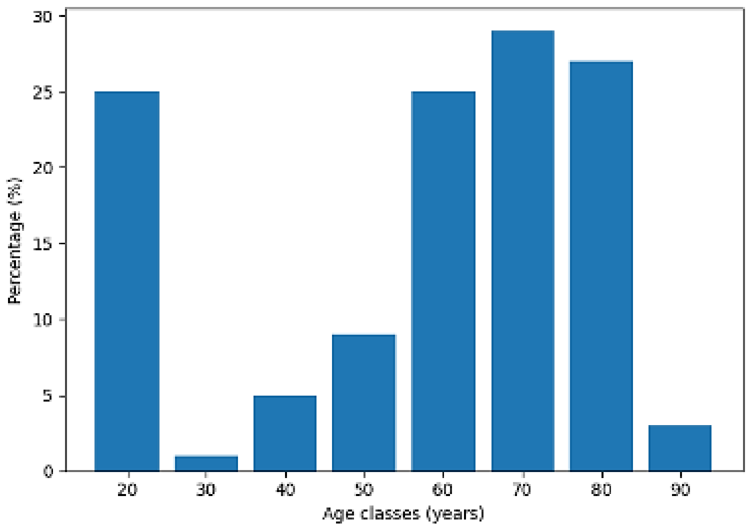

Figure 5. Age structure of plantations affected by Viscum album in protective plantations of the Romny district.

Thus, the relationship between tree age and mistletoe infestation intensity is clearly expressed and predictable. As trees approach maturity and overmaturity, infestation levels increase not only due to physiological weakening but also as a result of changes in crown architecture. Older trees tend to have more open and fragmented crowns, which are more accessible to bird dispersers.

Furthermore, mature trees provide a larger surface area of branches suitable for colonization, while localized reductions in bark thickness facilitate haustorium penetration. These factors collectively contribute to the selective colonization of older trees by mistletoe.

In summary, *Viscum album* exhibits pronounced ecological and ontogenetic selectivity, preferentially colonizing trees of middle and older age classes. This finding has important implications for the planning and implementation of measures aimed at improving the sanitary condition of urban and protective plantations. Incorporating age structure and species composition into management strategies will significantly enhance the effectiveness of efforts to control mistletoe spread and maintain the stability of forest ecosystems.

Discussion and Prospects for Further Research. The obtained results confirm that *Viscum album* is a highly adaptive hemiparasitic species with a broad ecological amplitude and a pronounced ability to colonize a wide range of deciduous host plants. The observed distribution patterns within protective plantations of the Romny district are generally consistent with previously reported data for Eastern Europe, indicating that species of the genera *Populus, Acer, Tilia*, and *Salix* represent the most vulnerable hosts under current environmental conditions.

The predominance of *Populus alba* among infected trees (up to 58%) highlights its key role in maintaining and spreading mistletoe populations in anthropogenically transformed landscapes. This finding is particularly important for the design of urban and protective plantations, where the use of highly susceptible species may significantly accelerate the formation of infection foci.

The classification of tree species according to their resistance to mistletoe infestation should be considered dynamic and context-dependent, as it reflects not only inherent biological traits but also the influence of external factors such as climate change, air pollution, and stand condition. The increasing frequency of drought stress and temperature fluctuations may weaken host resistance and create more favorable conditions for mistletoe establishment, especially in urban and peri-urban environments.

A clear relationship between tree age and infestation intensity was identified. Older trees (50–80 years) were significantly more affected, which can be explained by a combination of physiological weakening, structural changes in crown architecture, and increased attractiveness for bird-mediated seed dispersal. In contrast, younger trees demonstrated higher resistance, likely due to active growth processes and denser crown structures.

The results also emphasize the importance of light availability for mistletoe development. The concentration of mistletoe bushes in the upper and well-illuminated parts of the crown confirms the light-demanding nature of this species and its ecological strategy focused on peripheral shoot colonization.

From a practical perspective, the findings provide a scientific basis for improving the management of protective and urban plantations. In particular, they support the need to:

– limit the use of highly susceptible species in new plantings;
– prioritize resistant or relatively resistant taxa in landscape design;
– implement regular sanitary measures (selective pruning, removal of heavily infested trees);
– consider stand age structure when planning plantation reconstruction.

Prospects for Further Research. Further research on Viscum album should be oriented toward a comprehensive and integrative understanding of its ecology, host interactions, and management. In particular, sustained long-term monitoring is essential to identify temporal trends in host susceptibility and to evaluate the dynamics of mistletoe spread under ongoing climatic changes. At the same time, in-depth studies of physiological and biochemical resistance mechanisms at anatomical and molecular levels would provide valuable insights into the factors determining host tolerance or vulnerability.

An important research priority is the assessment of abiotic stress factors, including drought, temperature extremes, and soil conditions, which may significantly influence the establishment and development of mistletoe. In parallel, the development of predictive models that incorporate species composition, stand age structure, and landscape connectivity is necessary to improve forecasting accuracy and support decision-making in forest and urban ecosystem management.

Moreover, further investigations should address ecosystem-level effects, particularly the impact of mistletoe on productivity, biodiversity, and overall ecosystem stability. Finally, the development of integrated management approaches – combining silvicultural, ecological, and biotechnical methods, such as the regulation of bird-mediated seed dispersal and targeted pruning – represents a promising direction for enhancing the effectiveness of control strategies.

In general, the study of mistletoe infestation remains a highly relevant research area, particularly in the context of climate change and increasing anthropogenic pressure on forest and urban ecosystems. Expanding the scientific understanding of this host–parasite system will contribute to the development of sustainable strategies for maintaining the health and resilience of green infrastructure.

Conclusions. The conducted study demonstrates that Viscum album is widely distributed within protective plantations of the Romny district and exhibits pronounced host selectivity. The highest susceptibility was observed in representatives of the genera Populus, Fraxinus, Acer, and Salix, which play a key role in maintaining and spreading mistletoe populations. In contrast, certain species and forms, including Robinia pseudoacacia, Tilia cordata, and columnar poplar cultivars, showed relatively higher resistance, indicating their potential suitability for use in sustainable planting design.

The intensity of mistletoe infestation is strongly influenced by the age structure and morphological characteristics of host trees. The highest levels of infection were recorded in middle-aged and older stands (50–80 years), whereas younger trees (up to 30 years) exhibited only sporadic or no infestation. This pattern reflects age-related changes in physiological resistance, as well as structural transformations of the crown.

Crown architecture and anatomical features of host plants significantly determine the success of mistletoe establishment. Open, well-illuminated, and structurally heterogeneous crowns create favorable conditions for seed germination and haustorium development, particularly on peripheral shoots aged 2–5 years. In contrast, dense crowns and active growth processes in younger trees limit parasite establishment.

The distribution of mistletoe within tree crowns is non-uniform and primarily concentrated in the upper, well-lit parts, confirming its ecological dependence on light availability. This feature reflects the adaptive strategy of the species and should be taken into account when planning control measures.

The obtained results highlight the importance of species selection and stand management in reducing the spread of mistletoe. Incorporating resistant or relatively resistant species, considering stand age structure, and implementing timely sanitary measures are essential components of effective management strategies aimed at maintaining the ecological stability of protective and urban plantations.

REFERENCES

1. Ahmed Z. and Dutt H.C. Restriction of Viscum album to few phorophytes in a habitat with diverse type of tree species, Austin. J. Plant. Biol., 2015, 1, 2, 101–105.
2. Barbu C.O. Impact of white mistletoe (Viscum album ssp. abietis) infection on needles and crown morphology of silver fir (Abies alba Mill.), Not. Bot. Hort. Agrobot., 2012, 40, 2, 152–158. https://doi.org/10.15835/nbha4027 906
3. Bardini M., Lee D., Donini P. Tubulin-based polymorphism (TBP): a new tool, based on functionally relevant sequences, to assess genetic diversity in plant species, Genome, 2004, 47, 281–291. https://doi.org/10.1139/g03-132
4. Barney C.W., Hawksworth F.G., Geils B.W. Host of Viscum album, Eur. J. Forest. Pathol., 1998, 28, 187–208. https://doi.org/10.1111/j.1439-0329.1998.tb01249.x
5. Bilan M.V., Henyk A.O. (2019) Distribution of Viscum album in woody plantations of cities in Central Ukraine. Visnyk of Dnipropetrovsk University. Biology Series, 27(2), 54–63. https://doi.org/10.15421/021907
6. .Bondar O.S., Doroshenko S.A. (2021) Features of infestation of woody plantations by Viscum album in green zones of cities in Sumy region. Scientific Bulletin of Sumy National Agrarian University. Agronomy and Biology Series, 42, 88–94.
7. Bilgili E., Kadir Coskuner A., and Baysal I., The distribution of pine mistletoe (Viscum album ssp. austriacum) in Scots pine (Pinus sylvestris) forests: from stand to tree level, Scand. J. Forest Res., 2020, 35, 1–2, 20–28. https://doi.org/10.1080/02827581.2020.1729402
8. Bilonozhko O. M., Holubets M. A., & Zub L. M. Genetic polymorphism and host specificity of Viscum album L. in Eastern Europe. Ukrainian Botanical Journal, 2021, 78(3), 45–57. https://doi.org/10.15407/ukrbotj78.03.045.
9. Bilonozhko Y. O., Rabokon A. M., Postovoitova A. S., Kalafat L. O., Privalikhin S. M., Demkovych A. Ye., Pirko Ya. V. Some characteristics of woody plants inhabited by Viscum album (Santalaceae) in the city of Kyiv. Ukrainian Botanical Journal, 2020, 79(6), 388–396.
10. Bilonozhko Y., Ponomarenko L.O., Rabokon A.M. Distribution of mistletoe (Viscum album L.), which parasitizes different woody plants species, in Kyiv and its genetic characteristics, Factors Experim. Evol. Organisms, 2019, 25, 106–110. https://doi.org/10.7124/FEEO.v25.1148

11. Bohling N., Greuter W., Raus T. Notes on the Cretan mistletoe, Viscum album subsp. creticum subsp. nova (Loranthaceae/Viscaceae), Israel. J. Plant Sci., 2002, 50, 77–84. https://doi.org/10.1560/RRJ4-HU15-8BFM-WAUK
12. Braglia L., Gavazzi F., Giovannini A. TBP-assisted species and hybrid identification in the genus Passiflora, Mol. Breed., 2014, 33, 1, 209–219. https://doi.org/10.1007/s11032-013-9945-6
13. Breviario D., Baird W.V., Sangoi S. High polymorphism and resolution in targeted fingerprinting with combined β-tubulin introns, Mol. Breed., 2007, 20, 3, 249–59. https://doi.org/10.1007/s11032-007-9087-9
14. Chakraborty D., Móricz N., Rasztovits E., Dobor L. Schueler S. Provisioning forest and conservation science with European tree species distribution models under climate change (Version v1). Zenodo https://doi.org/10.5281/zenodo.3686918 (2020).
15. Galasso I., Manca A., Braglia L. h-TBP: an approach based on intron-length polymorphism for the rapid isolation and characterization of the multiple members of the β-tubulin gene family in Camelina sativa (L.) Crantz., Mol. Breed., 28, 635–645. https://doi.org/10.1007/s11032-010-9515-0
16. Galkin S.I., Dragan N.V., Doyko N.M. Mistletoe in the relations system of "host–parasite," Plant Introd., 2017, 3, 71–78. doi 10.5281/zenodo.2325002
17. Holubets M.A., Bilonozhko O.M. (2020) Anatomical structure of the haustorium of Viscum album on different deciduous tree species in Ukraine. Ukrainian Botanical Journal, 77(4), 33–42. https://doi.org/10.15407/ukrbotj77.04.033
18. .Kornus L.A., Pashkevych N.O. (2018) Assessment of resistance of woody plantations to Viscum album in urban ecosystems of Right-Bank Ukraine. Agroecological Journal, 2, 115–121.
19. Kartoolinejad D., Hosseini S.M., Mirnia S.K. The relationship among infection intensity of Viscum album with some ecological parameters of host trees, Int. J. Environ. Res., 2007, 1, 2, 143–149.
20. Kim B.Y., Park H.S., Kim S. Development of microsatellite markers for Viscum coloratum (Santalaceae) and their application to wild populations, Appl. Plant Sci., 2017, 5, 1. https://doi.org/10.3732/apps.1600102
21. Kim Ch.S., Kim S.Y., Sun B.Y. A review of the taxonomic and ecological characteristics of Korean mistletoe types (Viscum, Korthalsella, Loranthus and Taxillus), Korean J. Pl. Taxon, 2013, 43, 2, 81–89. https://doi.org/10.11110/kjpt.2013.43.2.81
22. Kolodziejek J., Patykowski J., Kolodziejek R., Distribution, frequency and host patterns of European mistletoe (Viscum album subsp. album) in the major city of Lodz, Biologia, 2013, 68, 1, 55–64. https://doi.org/10.2478/s11756-012-0128-4
23. Krasylenko Y., Klymenko S., & Martynenko I. Patterns of distribution and host selectivity of Viscum album in urban woody plants of Northern Ukraine. Urban Forestry & Urban Greening, 2023, 88, 128034. https://doi.org/10.1016/j.ufug.2023.128034.
24. Krasylenko Y., Sosnovsky Y., Atamas N. The European mistletoe (Viscum album L.): distribution, host range, biotic interactions, and management worldwide with special emphasis on Ukraine, Botany, 2020, 98, 9. https://doi.org/10.1139/cjb-2020-0037
25. Krasylenko Y., Sosnovsky Y., Atamas N., Popov G., Leonenko V., Janošíková K., Sytschak N., & Sytnyk D. (2020). The European mistletoe (Viscum album L.): distribution, host range, biotic interactions, and management worldwide with special emphasis on Ukraine. Botany, 98(9).
26. Lech P., & Żółciak A. Occurrence of European Mistletoe (Viscum album L.) on forest trees in Poland and its dynamics of spread in the period 2008-2018. Forests, 11(83).
27. López de Buen L., Ornelas J. F. Host compatibility of mistletoes: Physiological drivers and ecological consequences. Ecology Letters, 2011, 14(2), 127–134.
28. Lyubov O. Some characteristics of woody plants that are colonised by Viscum album (Santalaceae) in the city of Kyiv. Ukrainian Botanical Journal, 2022, 79(6), 388–396.
29. Malova T. I., Mashtaler O. V. Morphobiological characteristics of development of Viscum album in the conditions of urbanised environment of Vinnytsia, Ukraine. Chornomorski Botanical Journal, 2024, 20(4), 471–481.
30. Mejnartowicz L. Relationship and genetic diversity of mistletoe (Viscum album L.) subspecies, Acta Soc. Bot. Polon., 2006, 75, 1, 39–49. https://doi.org/10.5586/asbp.2006.007
31. Milewicz M., Sawicki J. Sex-linked markers in dioecious plants, Plant Omics, 2013, 6, 2, 144–149.
32. Nei M., Li W.H. Mathematical model for studying genetic variation in terms of restriction endonucleases, Proc. Natl. Acad. Sci. U. S. A., 1979, 76, 5269–5273.
33. Pannell J.R. Plant sex determination, Curr. Biol., 2017, 27, 5, 191–197. https://doi.org/10.1016/j.cub.2017.01.052
34. Pavlicek A., Hrda S., Flegr, J. FreeTree—freeware program for construction of phylogenetic trees on the basis of distance data and bootstrap/jackknife analysis of the tree robustness. Application in the RAPD analysis of the genus Frenkelia, Folia Biol., 1999, 45, 97–99.
35. Rademacher P., Weih M. Growth responses of Viscum album to different host species and environmental conditions. Plant Ecology, 2017, 218, 1091–1103.
36. Raftoyannis, Y., Radoglou, K., and Bredemeier, M., Effects of mistletoe infestation on the decline and mortality of Abies cephalonica in Greece, Ann. For. Res., 2015, 58, 1, 55–65. https://doi.org/10.15287/afr.2015.347

37. Sallé A., Brignolas F. Water relations and xylem anatomy of mistletoe–host associations. Tree Physiology, 2020, 40(6), 771–784.
38. Schaller G., Urech K., Grazi G. Viscotoxin composition of the three European subspecies of Viscum album, Planta Med., 1998, 64, 677–678.
39. Schiebel V., Müller J., Bässler C. Host tree traits shape the growth performance of European mistletoe (Viscum album). Trees, 2019, 33(4), 1127–1138. https://doi.org/10.1007/s00468-019-01845-7.
40. Skrypnik L., Maslov D., Kulbachko Y. Remote sensing-based assessment of mistletoe infestation intensity in Salicaceae stands of Eastern Europe. Environmental Monitoring and Assessment, 2020, 192(10), 643. https://doi.org/10.1007/s10661-020-8559-4.
41. Zuber D.Biology and ecology of European mistletoe (Viscum album L.). Botanical Review, 2024, 70(1), 111–157.
42. Zuber, D. and Widmer, A., Genetic evidence for host specificity in the hemi-parasitic Viscum album L. (Viscaceae), Mol. Ecol., 2000, 9, 1069–1073.
43. Zuber, D. and Widmer, A., Phylogeography and host race differentiation in the European mistletoe (Viscum album L.), Mol. Ecol., 2009, 18, 1946–1962. https://doi.org/10.1111/j.1365-294X.2009.04168.x
44. Zuber, D., Biological flora of Central Europe: Viscum album L., Flora, 2004, vol. 199, pp. 181–203.