5TH INTERNATIONAL FOREST ENTOMOLOGY AND PATHOLOGY SYMPOSIUM (IFEPS 2026)

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Keynote Speech

On behalf of the Organizing Committee, it is my distinct honour and privilege to welcome you to the *5th International Symposium on Forest Entomology and Pathology*, held in Kastamonu—the very heart of Turkish forestry. This gathering represents not only a continuation of a valued scientific tradition but also a reaffirmation of our collective commitment to the health and sustainability of forest ecosystems.

Kastamonu occupies a singular place in our country's forestry heritage. Within its borders lie two of Türkiye's most significant protected areas: Ilgaz Mountain National Park and Küre Mountains National Park—the latter being Türkiye's first Pan Parks-certified area and the 13th in Europe. These landscapes are not merely repositories of exceptional biodiversity; they are living laboratories where the fragility of forest ecosystems is most vividly observed. They remind us that forest health is not an abstract ideal but a measurable, manageable, and urgently defendable reality.

A healthy forest, as we define it, possesses the innate capacity for self-renewal and resilience. Even when subjected to destructive forces, it can recover and continue to deliver vital ecosystem services. Yet we must confront an uncomfortable truth: this resilience is perpetually threatened by invisible adversaries. Unlike wildfires, which announce themselves with flame and smoke, insect infestations and fungal pathogens advance silently, often unnoticed until their damage reaches epidemic proportions. By then, intervention is frequently too late.

The international scientific community has long recognised this challenge. The International Cooperative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests), established under the UNECE in 1985 and now involving 42 countries, stands as a testament to what can be achieved through systematic, long-term collaboration. With its dual-level monitoring approach—Level I encompassing some 6,000 observation points and Level II comprising around 600 intensive sites—ICP Forests has generated harmonised datasets that allow us to distinguish the effects of air pollution from those of climate change and biodiversity loss. More importantly, it has enabled the development of early warning systems and science-based policy responses.

In the United States, the annual forest area affected by pests is approximately 45 times greater than that affected by fire, and the economic damage caused by insects is estimated to be six times higher. For Türkiye, bark beetle outbreaks alone result in annual timber losses of 1.5–2 million cubic metres, corresponding to direct economic losses of 300–400 million TL, while fungal diseases render 0.2% of our forest land unusable each year, adding a further 250–300 million TL in losses. These figures, however, only capture the visible tip of the iceberg; they do not account for the irreversible degradation of carbon sequestration, water regulation, biodiversity, and recreational values—ecosystem services that defy simple market valuation.

It is with this understanding that I wish to propose a pragmatic roadmap, informed by the vision of ICP Forests and tailored to our national context:

First, we must establish an integrated, nationally and internationally aligned forest health monitoring network. This system should combine remote sensing capabilities with ground-truth data, enabling early detection at the larval or initial disease stage, rather than after visible damage has occurred.

Second, we need to operationalise the concept of economic damage thresholds. Scientific criteria must guide decisions on when pest populations warrant intervention and when they can be

tolerated. I acknowledge that this remains a knowledge gap among both academic entomologists and pathology specialists and practitioners within the General Directorate of Forestry.

Third, we must prioritise preventive silvicultural approaches that foster stands resilient to pests and diseases. The experience of ICP Forests has demonstrated that proactive measures, grounded in continuous monitoring, can avert the direst predictions—such as the collapse of European forests once feared in the 1980s.

Fourth, our assessment frameworks must extend beyond timber production to include non-market ecosystem services. To date, only two of eight recognised economic impact assessment approaches have been applied in Türkiye. We must broaden our perspective to evaluate how pest and pathogen outbreaks affect carbon storage, hydrological regimes, biodiversity, and recreational potential.

I am reminded here of the proverb attributed to Genghis Khan: *"Never underestimate a nail. A nail saves a horseshoe, a horseshoe saves a horse, a horse saves a commander, a commander saves an army, and an army saves an entire country."* In our context, a larva noticed in time may save a tree; that tree may save a stand; that stand may save a forest; and that forest may ultimately safeguard our water, our climate, and our very existence. The 40-year success of ICP Forests bears witness to the power of small, timely interventions in averting large-scale catastrophes. This, in essence, is the profound significance of forest entomology and pathology.

Let us never forget that forestry is not merely a profession—it is a vocation that demands respect, sincerity, and compassion, extended not only toward our own species but toward all living beings and the ecosystems they comprise. Forestry is a responsibility we bear toward trees, insects, fungi, soil, and water. The papers to be presented over the next three days, the discussions we will engage in, and the questions we will pose to one another are nothing less than the scientific manifestation of that commitment.

I am deeply grateful to each participant for joining us and thereby demonstrating this shared dedication. I also extend my sincere thanks to all sponsors and supporting institutions. It is my earnest hope that this symposium will generate fruitful debate, illuminate new pathways for forest health research, and contribute meaningfully to the sustainable management of our forests.

May this symposium be auspicious and productive, and may it mark yet another enduring link in the chain of our scientific endeavours. I wish you all a stimulating and rewarding meeting.

With warm regards and respect.

Prof. Dr. Sabri ÜNAL

On behalf of the 5th International Symposium on Forest Entomology and Pathology Organizing Committee, Kastamonu, 2026

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Keynote Speakers

Benefits and Risks of Predatory Insects in the Biological Control of Forest Pests: Examples of *Calosoma sycophanta* and *Rhizophagus grandis* within the Context of the Role of Entomopathogens

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Abstract

One of the main causes of forest loss is pest insects. The fact that forests provide ideal habitats for many other species limits chemical control of forest pests. The use of predatory insects as an alternative to chemical insecticides in controlling forest pests is gaining increasing interest. In this context, Türkiye sets an example in Europe with the rearing of the predatory insects, *Calosoma sycophanta* against the pine processionary moth and *Rhizophagus grandis* against the spruce bettle, *Dendroctonus micans*. *C. sycophanta* not only acts as a predator but also increases the effectiveness of entomopathogens by spreading these microorganisms, specific to this pest in pine processionary moth populations. Both predatory insects require significant financial and labor costs. However, a considerable portion of the predators released into the field after production are ineffective. Another issue is the high mortality rates observed in rearing laboratories. The main reason of both problems is that pathogens such as fungi, protists, bacteria and algae, which cause undesirable infections in these two beneficial insects, leading to diseases in the laboratory or in the field. These pathogens can be transmitted from harmful insect larvae used as prey or from rearing conditions, or they can be transmitted to the new generation through the eggs of female individuals carrying the pathogen, leading to continuous disease, reduced yield, and significant economic and labor losses. Preventing undesirable infections in predator insects primarily involves maintaining maximum hygiene conditions in rearing laboratories, selecting parent insects that do not carry any pathogens, and screening the new generations for pathogens before releasing them into the field. These measures require significant expert support. This presentation provides more detail information about undesirable infections, diseases and their prevention in predatory insects and their rearing laboratories.

Key words: Predatory insects, Undesirable infections, Diseases, Entomopathogens, Türkiye

Alien Invasive Forest Pathogens as a Growing Threat to Türkiye's Forest and Urban Trees

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Abstract

Alien invasive pathogens represent one of the most serious and rapidly escalating threats to forest and urban tree populations worldwide. Increased trade through accelerated globalization also accelerated the movement of pathogens beyond their native ranges, exposing naïve host populations with no prior evolutionary experience of these organisms, sometimes with catastrophic consequences.

Several alien invasive pathogens are already established in Türkiye, causing serious damage to forest and urban trees. These include *Cryphonectria parasitica* (sweet chestnut canker), *Ophiostoma novo-ulmi* (Dutch elm disease), *Seiridium cardinale* (Cupressus canker), *Calonectria pseudonaviculata* (boxwood blight), and *Lecanosticta acicola* (Brown spot needle blight of pines). Among these, canker stain of Plane, caused by *Ceratocystis platani*, is of particular concern. A pathogen of North American origin, *C. platani* was introduced into Europe most probably on military equipment during World War II and has since caused severe mortality in both planted and natural stands of *Platanus orientalis* and *P. × hispanica* across the Mediterranean region. In Türkiye, the pathogen has been confirmed killing Plane trees in Istanbul. Platanus orientalis, native to Türkiye and a keystone species of riparian ecosystems in the eastern Mediterranean Region, is highly susceptible and dies rapidly following infection. Gaining entry through pruning wounds, *C. platani* disrupts host water balance, causing wilting, dieback and death. Routine urban tree management thus becomes a significant driver of spread, and further expansion into both urban and natural stands across Türkiye is considered highly likely.
Strengthened biosecurity protocols, coordinated surveillance networks, and broader stakeholder awareness are urgently needed to limit further spread and protect Türkiye's forests and urban tree heritage from ongoing and future invasions.

Keywords: Alien invasive pathogens, Ceratocystis platani, Canker stain, *Platanus orientalis*, Biosecurity

5TH INTERNATIONAL FOREST ENTOMOLOGY AND PATHOLOGY SYMPOSIUM
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Abstracts

Multidimensional Effects of Forest Fires on Bark Beetles

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Abstract

Forest fires exert extensive impacts on ecosystems, ranging from vegetation and soil properties to wildlife and microclimatic conditions. Trees that are damaged and weakened following fire events provide suitable breeding and dispersal habitats for bark beetles in particular. In this process, weakening of tree defense mechanisms, reduced resin production, and tissue damage can trigger mass outbreaks of bark beetles.

Bark beetles are affected by forest fires both directly and indirectly. Direct effects include mortality caused by high temperatures, whereas indirect effects are associated with post-fire habitat alterations. Especially in the first years following fire, the increased availability of dead and weakened trees creates ideal conditions for bark beetles, potentially leading to population outbreaks.

This review aims to evaluate and elucidate the effects of forest fires on the population dynamics of bark beetles and their consequences for ecosystem health. Additionally, it seeks to provide a scientific framework for the development of post-fire bark beetle management and monitoring strategies. Furthermore, the study aims to improve early warning systems for forestry practices, prevent biotic damage, and develop sustainable forest management strategies.

Keywords: Forest fires; Forest ecosystems; Bark beetles

Impact of *Leptoglossus occidentalis* on Conifer Seed Production: A Systematic Review with Global and Türkiye Perspectives

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Abstract

Leptoglossus occidentalis is a widely distributed conifer pest known to affect seed production in several economically important tree species. This systematic review aimed to synthesize available evidence on seed loss caused by *L. occidentalis* in conifer species globally, with particular emphasis on Türkiye. We collected literature from Web of Science, Scopus, and Google Scholar using defined search queries. A total of 489 records were identified, and after removing 127 duplicates and screening titles and abstracts, 37 studies were included for full-text analysis and data extraction. The results indicate that *L. occidentalis* causes significant seed loss through conelet abortion, kernel damage, and reduction in seed viability. Most of the studies relied on visual assessment methods, although techniques such as X-ray analysis and bioassays were also used. Quantitative impacts varied across host species and environmental conditions. Experimental studies reported seed production reductions of up to 75%, while field studies showed wide variability depending on location and infestation levels. In some regions, particularly in the Mediterranean basin and Türkiye, seed yield losses ranged from 14% to 98%, with extreme cases reaching up to 95%. Feeding behavior influenced damage patterns, with *L. occidentalis* showing preference for certain conifer species such as *Pinus pinea* and for healthy, developing seeds, resulting in substantial kernel damage and reduced yield per cone. Overall, our review findings confirm that *L. occidentalis* is a major biotic factor affecting conifer seed production. Implementation of integrated management strategies, including biological control and targeted chemical control, is recommended a further investigation to mitigate its impact.

Keywords: *Leptoglossus occidentalis*; Seed damage; Seed loss; Production; *Pinus*

Evaluation of the Impact of *Ips typographus* in Spruce Forests Using Deep Learning Approaches

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Abstract

Ips typographus is one of the main biotic stress factors that cause significant economic and ecological losses in spruce forests and threaten forest health. Infestations caused by this pest disrupt the physiological processes of trees, leading to extensive forest losses and directly affecting the sustainability of forest ecosystems. Understanding the pest's spread dynamics and developing early warning systems is crucial, especially in Artvin and surrounding regions, which are critically important for Türkiye's spruce forest resources. In this context, temporal changes in forest health were monitored in spruce forests in the Veliköy area of Artvin province, where the pest's impact is intensely observed, using multi-temporal Sentinel-2 satellite images covering the period from July 2022 to August 2023. A deep learning-based semantic segmentation approach was applied to the RGB data obtained from the satellite images to identify different pest impact areas. U-Net, FCN-8, SegNet, and DeepLabV3+ architectures were evaluated comparatively in this study. The results showed that the U-Net and FCN-8 models offered higher accuracy and stronger generalization performance in detecting forest damage. The U-Net model stood out with its more consistent segmentation performance, while the FCN-8 model provided the advantage of producing faster results with lower computational costs. Overall, the findings indicate that deep learning-based approaches offer an effective decision support tool for detecting and spatially demonstrating pest-induced stress in spruce forests. This approach contributes to a better understanding of degradation processes in forest ecosystems, forming an important scientific basis for sustainable forest management and planning processes.

Keywords: *Ips typographus*; Deep learning; Forest health monitoring

Damage and Effects of Bark Beetles on Artvin Forests from a Forest Management Perspective

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Abstract

In Artvin Forest Regional Directorate, numerous trees have been felled due to dieback caused by bark beetles, particularly *Ips typographus*, in forests containing pure spruce or mixed spruce. When extraordinary yield is calculated in managed forests, the final yield that should be calculated in the plan is not taken; it is offset, thus disrupting the plan. In protected areas, tree felling is not normally carried out, but it may be done if the survival of the ecosystem or the country is threatened. The choice of whether to fell or leave to examine depends on the forestry structure of each country. In our country, the approach adopted in protected areas is to cut down and remove infested trees. Fight against bark beetles that began in the 1990s continues today. Tree felling has been/is being carried out in both managed forests and protected areas (national parks, nature reserves, nature parks, etc.) due to the threat to spruce forests/ecosystems. This proceeding, which addresses the impact of bark beetles in Artvin forests, examines: Forest management plan data and stand maps, extraordinary yield assessment records, and tabular data, along with recent on-site inspections and visuals, particularly in protected areas, have been used to demonstrate the extent of the problem. In Artvin's forest management units (e.g., Saçinka Forest Management Unit), the cutting down of dead spruce trees has led to a transformation or change from coniferous to deciduous forests in some units, as evidenced both numerically and visually through stand maps. In two different protected areas (Şavşat Karagöl-Sahara and Hatila National Park), assessments and inspections by relevant experts and technical teams have revealed, through technical reports, that the ecosystem is under threat. Subsequently, approximately 100,000 spruce trees were cut down in both areas. The cutting and removal of dead trees in the management units and in the protected areas faced significant opposition, primarily from local residents and various groups. In protected areas, the number of insect-infested trees has increased due to delays in felling, and the number of trees to be cut has increased approximately tenfold in a few years. At this point, the public has become convinced that the trees should be cut, and they have begun to cooperate by participating in or assisting with the identification and felling efforts to prevent further insect damage.

Keywords: Extraordinary yield; Forest management; Artvin Forest Regional Directorate; Protected forest area; *Ips typographus*

Assessing the *Euwallacea fornicatus*–Fungal Complex: Mycological Investigations and Risk Profiling in Istanbul's Urban Forest

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Abstract

Following the first detection of the invasive ambrosia beetle *Euwallacea fornicatus* (Polyphagous Shot Hole Borer, PSHB) in Istanbul, Türkiye (2024), attention has focused on its associated fungal community and impacts on urban trees. Field surveys were conducted in Gülhane Park, Dolmabahçe, Üsküdar, Kabataş, and Beşiktaş. Infestations were primarily observed on *Acer* spp. and *Platanus* × *acerifolia*, with symptoms including compact frass production, sap exudation, gallery entrance holes, and occasional tree mortality. Adult beetles and infested wood samples were collected from host trees for fungal isolation. Observations indicated that beetles mainly colonize trunk tissues rather than branches, leading to concentrated structural damage. Approximately 60 fungal isolates were obtained and cultured on MEA, PDA, YMEA, and CSMA media. Morphological and microscopic analyses showed that 52% of isolates were consistent with *Fusarium*-like taxa, characterized by rapid growth and white to yellowish colonies. About 25% were *Ophiostoma*-like fungi with variable growth rates and woolly colony morphology. Remaining isolates showed heterogeneous features requiring molecular identification. Ongoing analyses aim to clarify their phylogenetic placement within the *Neocosmospora* and *Ophiostoma* complex, known for vascular pathogenicity. In accordance with EPPO risk alerts, the PSHB–fungus complex represents a significant emerging threat due to its wide host range and lack of effective curative control. Integration of field data with Istanbul urban forestry composition enabled a risk framework. Key reproductive hosts include *Acer*, *Platanus*, *Morus*, *Populus*, *Salix*, *Ulmus*, and *Fraxinus*. Moderately susceptible taxa include *Quercus*, *Aesculus hippocastanum*, *Tilia*, *Olea europaea*, and *Vitis*. Economically important species such as *Prunus* spp. and *Corylus avellana* remain at risk in peri-urban zones. Potential host shifts toward dominant urban taxa highlight the need for integrated monitoring, early detection, and coordinated phytosanitary management.

Keywords: *Euwallacea fornicatus* PSHB; *Neocosmospora*; Urban Forestry; Invasive Species; Risk Assessment

Detection of *Armillaria mellea* (Vahl) P. Kumm. in Oak Stands of the Yumurtatepe Region

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Abstract

This study identified the causal agent of oak dieback observed in a 38.2 ha pure oak (*Quercus* sp.) stand within the "Scientific Function Management Class" of the Yumurtatepe Forest Management Unit (Vize, Kırklareli, Türkiye), as defined by the Functional Forest Management Plan (2013–2032). In areas exhibiting intensive decline, six plots (2,500 m^2 each) were established. From each plot, fungal samples were randomly collected and subjected to comprehensive macroscopic and microscopic analyses. Specimens were dried at 35 °C and examined using stereo and light microscopy. A total of 30 spores obtained from representative samples were measured and compared with literature data. Macromorphological characteristics included honey-coloured basidiocarps (3–15 cm) with dark scales, adnate whitish to yellowish gills, and a fibrous stipe (5–20 cm × 0.5–3.0 cm) featuring a distinct annulus (2–5 mm) and characteristic rhizomorphs (1–3 mm). Microscopic examination revealed elliptical, hyaline spores containing a central oil droplet, measuring 7.0–10.74 × 3.93–7.0 µm. These features were morphologically consistent with *Armillaria mellea* (Vahl) P. Kumm. For molecular identification, fungal DNA was extracted, and the ITS region was amplified using real-time PCR (qPCR). Melting curve analysis and Cq values confirmed amplification specificity. Sequence analysis and BLAST comparison showed 98% similarity with *A. mellea* strains in reference databases, providing sufficient sequence identity for definitive species-level identification. The integration of morphological and molecular data confirms *A. mellea* as the primary causal agent of oak decline in the study area. This integrative

diagnostic approach provides a robust framework for forest pathology, establishing a clear link between field observations and laboratory confirmation. It is recommended that future research utilise multi-gene sequencing to enhance molecular resolution.

Keywords: *Armillaria mellea*; *Quercus*; Oak dieback; Integrative diagnostics

Investigation of Some Chemical Properties of Scots Pine (*Pinus sylvestris* L.) Wood Degraded by White-Rot Fungus *Trametes versicolor*

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Abstract

In this study, the resistance properties of Scots pine (*Pinus sylvestris*) wood against wood-decay fungi were investigated according to the EN 113 standard. Scots pine wood samples were exposed to the white-rot fungus *Trametes versicolor* for 16 weeks. At the end of the incubation period, degradation in the samples was evaluated using mass loss analysis and Fourier transform infrared (FTIR) spectroscopy to characterize changes in the chemical structure. The results showed that *T. versicolor* caused an average mass loss of 28% in Scots pine wood. This loss is a clear indicator of the fungus's ability to metabolize wood polymers. FTIR spectroscopic analyses revealed that significant changes occurred in the molecular structures of lignin, cellulose, and hemicellulose, the main structural components of wood, due to fungal degradation. In particular, significant decreases in peak intensities corresponding to the aromatic ring vibrations of the lignin structure and carbohydrate bonds (C-O and C-H) indicate that the fungus enzymatically degrades both cell wall polysaccharides and lignin, following a simultaneous decay strategy.

Keywords: White rot fungus; FTIR; Biodegradation

Determination of *Trichoderma* Mycobiota in the Yumurtatepe Region

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Abstract

Trichoderma species are recognized as key soil-dwelling fungi with significant potential in biological control and the maintenance of forest ecosystem resilience. This study was conducted in a 38.2 ha pure oak stand (Mbc3) int the Vize district of Kırklareli province, classified under the "Scientific Function Forest Management Class" within the Yumurtatepe Forest Management Unit Functional Forest Management Plan (2013–2032). In stands where dieback symptoms were particularly severe, six plots measuring 2,500 m^2 were established. Each plot was divided into four equal subplotsfrom which representative trees were randomly selected. Soil samples (0.027 m^3 per tree) were collected and transported to the laboratory under cold-chain conditions. The soil samples processed for the isolation of microfungi using standard soil dilution techniques on rose Bengal–streptomycin agar medium. Five Petri dishes were prepared from each soil sample and incubated at 27°C for approximately 7–10 days. At the conclusion of this period, colony-forming units (CFU) were counted to determine the fungal density per gram of oven-dried soil.

Molecular identification of the *Trichoderma* isolates was performed using the elongation factor 1-alpha (EF1-α) gene. Genomic DNA was extracted via a CTAB-based protocol, and target regions were amplified using real-time PCR (qPCR). Following verification by melting curve analysis, the amplicons were sequenced via the Sanger method. As a result of the study conducted in three repetitions in December 2014, December 2016, and August 2020, the following species were isolated from soil samples: *Trichoderma atroviride*, *T. citrinoviride*, *T. euskadiense*, *T. fertile*, *T.*

guizhouense, *T. harzianum*, *T. koningii*, *T. moravicum*, *T. paraviridescens*, *T. semiorbis*, *T. simmonsii*, and *T. subalni*. Based on a comparison with existing checklists of Turkish fungi, eight of these species (*T. euskadiense*, *T. fertile*, *T. guizhouense*, *T. moravicum*, *T. paraviridescens*, *T. semiorbis*, *T. subalni*, and *T. simmonsii*) are reported for the first time in the Turkish mycobiota. These findings significantly expand the knowledge of soil biodiversity in Turkish oak forests and underscore the potential of these species in biological control strategies.

Keywords: *Trichoderma* diversity; *Quercus* stand; Oak forest soil; New records; Turkish mycobiata

Causes of Dieback in Anatolian Black Pine (*Pinus nigra*) Afforestation in Burdur: An Evaluation of Soil, Nutrition and Pathogens

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Abstract

This study investigates the causes of dieback observed in Anatolian black pine (*Pinus nigra*) afforestation areas in the Akçaköy and Yeşilova regions of Burdur, focusing on edaphic characteristics, plant nutritional status, and the presence of pathogens. Soil profiles and needle samples from both healthy and diseased trees were analyzed as part of the research. Soil analyses revealed a texture ranging from clay-loam to clay, with a slightly to moderately alkaline pH. The primary issues identified were "low" phosphorus levels (2.90–5.42 ppm) and zinc levels (0.25–0.65 ppm) at marginal thresholds. Notably, magnesium reached "very high" levels (4.958 ppm), creating a significant edaphic imbalance in the field. The needle analyses were consistent with the soil nutrient imbalance, pointing to a correlation in plant nutrient composition. Nitrogen (6.30 mg/g) and phosphorus (0.58 mg/g) concentrations remained well below the reference lower limits, while magnesium levels exceeded the upper limit (2.19 mg/g), reaching 3.50 mg/g. This disruption of the calcium/magnesium balance is thought to have suppressed physiological processes. Regarding pests, no signs of bark beetles were found. Pathological examinations identified no primary fungal agents; isolated *Alternaria* spp. were evaluated as secondary (opportunistic) microorganisms colonizing weakened tissues. Recent plant pathology studies indicate that *Alternaria* species, typically considered weak or endophytic, can increase their pathogenicity under conditions of increased heat stress and low humidity, transforming into primary destructive agents as plant defense systems fail. In this context, the black pine dieback in Burdur should be evaluated as a synergistic ecophysiological collapse, triggered by magnesium toxicity and nutrient deficiency in the soil combined with "inciting" factors like *Alternaria* spp., which become aggressive under changing climate regimes. To facilitate early diagnosis and understand the spread dynamics of such complex climate-driven dieback processes, monitoring tree nutritional status, physiological stress levels, and pathogen presence is recommended. In conclusion, it is understood that the dieback is not triggered by a direct pathogen invasion, but rather by nutritional disorders—caused by nitrogen, phosphorus, and zinc deficiencies alongside excessive magnesium—merging with environmental stress factors. This physiological stress weakens the trees' defense systems, rendering them susceptible to opportunistic agents.

Keywords: *Pinus nigra*; Dieback; Nutrient imbalance; *Alternaria* spp.; Physiological stress

Synergistic Impacts of Invasive Understory Plants on the Outbreak Dynamics of Forest Insect Pests in Georgia

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Abstract

In forest ecosystems, the understory represents a fundamental structural layer that plays a decisive role in regulating microclimates and maintaining biological equilibrium. The rapid spread and establishment of invasive plant species significantly alter this layer, transforming its structural characteristics and creating complex ecological dynamics. This study examines the structural transformation of the understory driven by invasive flora and analyzes how increased structural complexity affects the outbreak dynamics of the box tree moth (*Cydalima perspectalis*) in Georgian forests. Field surveys were conducted between 2023 and 2025 across 24 *Buxus colchica* stands in the Adjara and Guria regions of western Georgia. Using standard phytosociological methods, we assessed understory density and coverage, focusing primarily on the invasive shrub Amorpha fruticosa, alongside pest damage levels (evaluated on a 0-5 semi-quantitative defoliation scale) and overwintering larval presence. Statistical analysis using Spearman rank correlation and linear regression revealed a strong positive correlation between the density of invasive understory species and the intensity of damage in native *B. colchica* stands. The dense structure created by invasive plants functions as a vital ecological refugium for *C. perspectalis* by stabilizing relative humidity, creating a windbreak barrier, and offering thermal insulation, which significantly increases larval overwintering survival. Furthermore, dense invasive vegetation layers impede access for pest monitoring and biological control interventions. The findings demonstrate that invasive species driven understory alterations are a key driver of pest persistence. Consequently, effective management strategies must integrate invasive understory vegetation control with pest monitoring to support the natural regeneration of boxwood groves and ensure long-term forest resilience.

Keywords: *Cydalima perspectalis*; invasive plants; *Buxus colchica*; understory structure; Georgia.

Pests of Oak Trees in Azerbaijani Forests and The Utilization of Damaged Tree Parts

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Abstract

One of the most important and widely distributed tree groups in the forests of Azerbaijan is the genus *Quercus* (oak), belonging to the Fagaceae family. A total of 12 oak species occur in the country, of which 3 are commonly used for landscaping purposes.

In recent years, the impact of various pest organisms on oak trees has led to noticeable deterioration in tree health, increasing phytosanitary risks. Therefore, within the framework of the National Monitoring Plan (2023–2025), the species diversity of insect pests was investigated in oak plant samples.

Species identification and morphological diagnostics were conducted at the Central Phytosanitary Laboratory of the Azerbaijan Food Safety Institute. As a result, 3 species were identified in 2023 (*Corythucha arcuata*, *Altica quercetorum*, *Neuroterus anthracinus*), 2 species in 2024 (*Corythucha arcuata*, *Myzocallis schreiberi*), and 4 species in 2025 (*Corythucha arcuata*, *Myzocallis schreiberi*, *Aceria ilicis*, *Nidularia pulvinata*). These pests primarily damage leaves, disrupting photosynthesis.

Oak is highly valuable due to its durable wood and the medicinal properties of its leaves and bark. Pest damage limits its utilization potential and causes economic losses. However, insect-damaged plant parts are not entirely unusable and may serve alternative purposes, making selective cutting and preliminary technical assessment essential.

Damaged oak wood can be used as fuel, for charcoal production, and biomass energy. Wood residues may be composted into organic fertilizers, while thermally treated wood can yield tar and other by-products. Damaged leaves can be used for composting and mulching, contributing to soil fertility and nutrient cycling.

In conclusion, effective management of pest impacts and rational utilization of damaged oak materials are crucial for both ecological sustainability and economic efficiency.

Keywords: Monitoring; Oak trees; Pests; Phytosanitary risk; Biomass utilization

Preliminary Results of the 3-year Research on Mechanical Control of Pine Processionary Moth in Turkish Red Pine (*Pinus brutia* Ten.): The Case of Izmir Kâtip Çelebi University Campus

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Abstract

Needle- and leaf-feeding pests cause significant economic losses in forest ecosystems by reducing the photosynthetic capacity, weakening host defense mechanisms, and consequently increasing susceptibility to secondary pests, pathogens, and abiotic stressors such as drought. Since coniferous species account for more than half of the forested areas in Türkiye, needle-feeding pests represent a serious problem to forest productivity and health. The Pine Processionary Moth (PPM) (*Thaumetopoea wilkinsoni*) is one of the most commonly seen defoliators in the country feeding with a particular preference for Turkish red pine (*Pinus brutia* Ten.). This study was conducted within the main campus of İzmir Katip Çelebi University (İzmir, Türkiye), where severe PPM infestations were recorded on Turkish red pine trees during 2022–2023. To control the infestation of PPM on *P. brutia* trees in the campus mechanical control measures were implemented. Plastic funnel traps were installed on the trunks of 44 Turkish red pine trees. PPM populations were systematically monitored between 2024 and 2026 by quantifying nest abundance and assessing activity levels. Nests in the trees were categorized into three size classes (small, medium, and large) and spatially distributed across three crown section (lower, middle, and upper). Pest activity was quantified based on the percentage of needle consumption within these crown sections. The results of the first three years of monitoring indicated that both average number of nest and PPM activity were the highest in 2024 and declined continuously through 2026. A consistent decrease trend was observed in both the average number of PPM nests and defoliation intensity over the study period. For the sustainable management of PPM, studies should be continued to investigate the relative influence of biotic and abiotic factors on population dynamics of the PPM in addition to mechanical control method applied in this study.

Keywords: Pine processionary moth; *Thaumetopoea wilkinsoni*; *Pinus brutia*; İzmir

Bioecology of *Anastatus bifasciatus Geoff. (Eupelmidae)* as an Egg Parasitoid of *Halyomorpha halys Stal.*

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Abstract

Halyomorpha halys is a highly destructive polyphagous quarantine pest with a broad host range, causing significant damage to fruit, berry, vegetable, and cucurbit crops. The species was first recorded in Azerbaijan in 2017 and is included in the A2 quarantine list due to its limited distribution. Despite its invasive nature, no natural population regulation was observed during the initial years; however, since 2024, signs of natural control have emerged. Field surveys conducted in the northwestern regions of Azerbaijan (Zaqatala and Balakan) revealed egg parasitoids (*Anastatus bifasciatus*, *Trissolcus* sp.) and entomopathogens (fungal pathogens and *Nosema* sp.) associated with *H. halys*. Among them, *A. bifasciatus* was identified as the most effective parasitoid. The study was based on field collections from 2024–2025, with laboratory analyses carried out at the Central Phytosanitary Laboratory of the Azerbaijan Food Safety Institute. Results demonstrated that parasitization rates of *A. bifasciatus* strongly depend on host population density. Under low-density conditions in 2024, parasitization reached 98–100% of eggs within egg masses, whereas under high-density conditions in 2025, this rate declined to 20–25%. Laboratory experiments confirmed these findings and showed that increasing the number of egg masses reduced parasitization efficiency, indicating a negative correlation with host density. Behavioral observations revealed that female parasitoids do not respond to freshly laid eggs or newly hatched nymphs; parasitization begins 3–4 days after oviposition. The parasitization of a single egg mass requires approximately 2.5–3 hours and occurs sequentially, resulting in asynchronous adult emergence over a 10–15 days period.

These findings indicate that *A. bifasciatus* exhibits strong ecological adaptability and has significant potential as a biological control agent against *H. halys*, supporting its future integration into integrated pest management (IPM) programs.

Keywords: *Anastatus bifasciatus*; Parasitoid; Egg mass

Integrating Insect-Based Ecosystem Services into Forestry and Wildlife Planning

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Abstract

Forest ecosystems are unique and vulnerable systems that provide a wide range of essential ecosystem services, including carbon sequestration, water regulation, provisioning of economic resources, food supply, and recreational opportunities, while also supporting biodiversity. Given their multifunctional roles and high ecological value, sustainable forest management requires a holistic, long-term planning approach that integrates both biotic and abiotic drivers of ecosystem functioning.

Among biotic components, insects are among the most functionally important groups in forest ecosystems, contributing to all major categories of ecosystem services. They play key roles in processes such as pollination, biological control, decomposition of organic matter, nutrient cycling, and energy transfer across trophic networks. The existing literature is largely dominated by studies on pollinators and agricultural systems, while forest ecosystems and wildlife contexts remain comparatively understudied. Despite this importance, insect-mediated ecosystem services remain underrepresented in forest management and wildlife planning frameworks. The spatial and temporal variability of insect effects across tree, stand, and landscape scales greatly complicates their incorporation into planning processes. As a consequence, the functional roles of insects in forest ecosystems and their contributions to supporting wildlife are frequently overlooked in practice. Insect-based ecosystem service assessments remain limited due to the large spatial extent of study areas, high species diversity, and the extensive sampling requirements. Here, we aim to synthesize current limitations in insect-based ecosystem service assessments and highlight the need for their integration into forestry and wildlife planning. Specifically, we propose extending insect-based assessments beyond agricultural systems to encompass diverse ecosystems. In this context, we emphasize the comprehensive evaluation of insects in terms of ecosystem services across representative habitats and their incorporation into forest and wildlife management strategies. Developing approaches for the adaptive and sustainable integration of the full functional roles of insects within ecosystem processes into forest and wildlife management is of critical importance.

Keywords: Insects; Ecosystem services; Biological control; Pollination; Sustainability

Evaluation of the Chestnut Gall Wasp Damages in Taşlıca and Kafkasör (Artvin) Chestnut Forests

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Abstract

The Asian chestnut gall wasp (ACGW), *Dryocosmus kuriphilus* Yasumatsu (Hymenoptera: Cynipidae), is a pest of chestnut trees (*Castanea* spp.) that is effective on a global scale. In Türkiye, ACGW has been discovered in 2014 in Yalova and subsequently spread to other provinces, and detected in Artvin forests in 2021. In this study, the damage status of ACGW, its impact on abnormal development of vegetative organs, and gall characteristics were evaluated. Field studies were performed at the Taşlıca and Kafkasör areas in Artvin in 2022 and 2024. A total of 114 shoots, each 50 cm long, were cut from 57 damaged trees. By evaluating gall positions and classifying the gall damage on 2775 nodes from the collected shoot samples, the damage status of ACGW and its effect on the development of vegetative organs were assessed. Gall locularity and characteristics were evaluated on 268 galls collected from 30 chestnut trees. The number of chambers per gall was counted, the contents of each chamber were identified, and their dimensions and weight were recorded. Of the studied nodes, 43.71% (n=1213) were damaged. Of these, 67.85% were observed on the shoots, 31.66% on the leaf lamina, and 0.49% on the buds. The frequency of the ACGW damage increased with the severity of the damage on shoots and leaf lamina. Of the examined galls, 202 were unilocular (one larval chamber per gall) and 144 were multilocular (multiple larval chambers per gall). In unilocular galls, average dimensions (length×width) and weight were 16.57×8.88 mm and 0.694 g, respectively. In multilocular galls, these measurements were 17.99×10.28 mm and 0.765 g, respectively.

Keywords: *Dryocosmus kuriphilus*; *Castanea sativa*; Damage; Artvin

Impact of *Cryphonectria parasitica* on Chestnut Trees and its Dissemination via *Dryocosmus kuriphilus*

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Abstract

Cryphonectria parasitica is a bark inhabiting fungus that causes disease in chestnut trees quarantine regulated pathogenic fungus responsible for canker formation. In Azerbaijan, it has been recorded in limited areas of chestnut forests in region for chestnut cultivationand has had a significant negative impact on productivity. Chesnut trees, the first symptoms appear as a discoloration of the outer bark ranging from yellowish brown to reddish brown, with extensive necrosis of the bark. The research was conducted during 2024–2025 using samples collected from chestnut forests in the village of Zakatala district. The collected samples were surface sterilized by immersion in 70% ethanol for a few seconds, followed by rinsing in sterile distilled water. The samples were then aseptically transferred onto PDA and incubated at approximately 22–25°C for 3–5 days. Young mycelium appeared white and gradually changed to light yellow and then to orange-yellow over time. At the same time, the chestnut gall wasp, *Dryocosmus kuriphilus*, recorded in these regions, causes serious damage to chestnut trees by laying its eggs in newly formed galls, thereby reducing productivity. During the research years, uninfected trees were marked however, as the gall wasp population increased, fungal infections were observed in young, previously uninfected chestnut trees. As a result, it was determined that *D. kuriphilus* acts as a vector of *C. parasitica,* spreading the infection to previously unaffected areas. This fungus can also infect chestnut trees through abandoned gall tissues of *D. kuriphilus*, leading to canker formation and ultimately causing the drying and death of shoots.

Keywords: *Cryphonectria parasitica*; Canker; Vector; Chesnut

Advancing Forest Biosecurity Through Regional Collaboration on Forest Invasive Species

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Abstract

Forest invasive species (FIS) are among the most serious threats to forest ecosystems, biodiversity, and forest-based economies worldwide. Addressing this transboundary challenge requires coordinated action at national, regional, and global levels, supported by strong biosecurity frameworks, effective surveillance, and timely information exchange. However, many countries continue to face significant knowledge and capacity gaps related to invasive species pathways, impacts, and management options in the forest sector, limiting their ability to prevent, detect, and respond to emerging threats.

The Food and Agriculture Organization of the United Nations (FAO) addresses threats of forest invasive species through an integrated approach that combines prevention, preparedness, and response. FAO provides assistance to countries for the development and implementation of national FIS strategies, capacity building in invasive species identification and management, support to early warning and monitoring systems, and guidance on control, eradication, and long-term management. To strengthen coherence and consistency in prevention efforts, FAO is developing a forest biosecurity guide to support risk-based, coordinated, and preventive approaches across regions.

FAO also facilitates five regional forest invasive species networks covering over 100 countries. These networks promote information sharing, regional awareness, and cooperation among experts and institutions. Within this framework, countries with demonstrated experience-such as Türkiye, which has successfully completed two biological control projects-are increasingly positioned as regional resources to support other countries. This model of peer-to-peer learning and regional cooperation reflects the movement FAO promotes leveraging proven national expertise to strengthen collective forest biosecurity capacity globally.

Keywords: Forest, Invasive species; Forest biosecurity; Forest health

Integration of Metagenomic and Conventional Diagnostic Methods in The Detection of Phytopathogens

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Abstract

Fungi and oomycetes that cause disease in forest ecosystems have become a greater threat to biosecurity with increasing global trade, the movement of plant material, and climate change. In response to this threat, early detection and accurate species identification are critical not only for disease management, but also for quarantine, surveillance, and the protection of forest health. Diagnostic methods used in forest pathology have historically progressed from classical approaches such as field observation, isolation, culturing, and morphological identification to serological tests, PCR-based molecular methods, qPCR, ddPCR, isothermal amplification systems, and ultimately metagenomic approaches based on high-throughput sequencing. This developmental trajectory is not accidental; each new method emerged from the need to overcome the limitations of preceding approaches in terms of speed, sensitivity, specificity, scope, or field applicability. In this review, the historical progression from classical diagnostic methods to metagenomic approaches is discussed, with particular emphasis on the limitations that led to the development of each method and the reasons why they should now be used in an integrated manner. In addition, a user-oriented decision framework is presented to guide the selection of the most appropriate method according to study objectives, budget, time requirements, and the need for validation.

Keywords: Forest pathology; Fungal pathogens; Oomycetes; Early detection; Metabarcoding; Shotgun metagenomics; Qpcr; ddPCR; CRISPR

Bacterial Wetwood Disease

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Abstract

Bacterial Wetwood is a widespread disease affecting woody plants and is associated with internal bacterial activity leading to tissue degradation and fluid exudation. In 2024, the diagnosis of this disease was investigated at the Central Phytosanitary Laboratory of the Azerbaijan Food Safety Institute using samples obtained from *Platanus orientalis* during monitoring surveys. The aim of this study was to identify the causal agent and characterize it using microbiological and biochemical methods. Plant samples were washed, surface-sterilized with 70% ethanol, and rinsed with sterile distilled water. Concentrated and diluted macerates were inoculated onto nutrient media and incubated at 25°C for 48–72 hours. Colony morphology was examined on King's B and NSA media, revealing distinct characteristics, including fluorescent pigment production on King's B medium. Biochemical identification was performed using LOPAT and additional standard tests. The isolates were determined to be Gram-negative, levan-positive, oxidase-negative, pectinolytic-positive, arginine dihydrolase-positive, motile, and catalase-positive. In contrast, Voges–Proskauer, methyl red, and indole tests yielded negative results. Furthermore, a hypersensitive reaction was observed in tobacco leaves, confirming the pathogenicity of the isolates. In 1977, various bacterial groups—including *Xanthomonas*, *Agrobacterium*, *Acinetobacter*, *Corynebacterium*, and *Erwinia*—were isolated from tissues infected with soft rot disease; additionally, *Enterobacter cloacae*, *Lelliottia nimipressuralis*, *Bacillus megaterium*, and *Pseudomonas fluorescens* were also identified as causative agents. The results demonstrated for the first time that *Pseudomonas* sp. is the causal agent of Bacterial Wetwood in *Platanus orientalis* in Azerbaijan. These findings contribute to the improvement of diagnostic methods and the development of effective plant disease management strategies. Additionally, *Pseudomonas* species are known for their ecological and biotechnological significance, particularly due to their role in the biodegradation of toxic compounds.

Keywords: Bacterial wetwood; *Pseudomonas* sp.; LOPAT; *Platanus orientalis*; Plant pathology

First Record of *Tomicus destruens* (Wollaston, 1865) (Coleoptera: Curculionidae: Scolytinae) from Düzce Province

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Abstract

In this study, a survey was conducted on November 2024 and January to June 2025 on drying and fallen maritime pine and black pine trees located in Düzce Urban Forest and Korugöl Natural Park. During the field studies, adult insect specimens found on the branches and trunks of plants were placed in plastic insect collection containers, labelled with the necessary information, and brought to the laboratory for identification. Log samples also collected from the field were transported to the laboratory. As a result of observations, egg, larvae, pupae, and adult stages of *Tomicus destruens* (Coleoptera: Curculionidae: Scolytinae) were found in both pine species. With this study, the first record of *T. destruens*, one of the main pests of Mediterranean forests, has been made in Düzce province. This new record is significant in terms of the species' spread expansion towards the Western Black Sea region, and it's could be a potential threat to pine forests in the region. The detection of *T. destruens* in urban recreational areas such as the Düzce Urban Forest and Korugöl Natural Park should be considered not only from the perspective of forest health, but also in relation to public health and landscape aesthetics. Therefore, monitoring of the species is strongly recommended.

Keywords: Mediterranean Pine Shoot Beetle; Türkiye; Western Black Sea Region

Mycobiota of Ash Wood in Relation to Tree Health Status in Poland

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Abstract

The European ash (*Fraxinus excelsior*) has experienced a significant decline across Europe in recent decades, mainly due to ash dieback caused by the invasive fungal pathogen *Hymenoscyphus fraxineus*. While the role of this pathogen in tree mortality is well established, the structure of fungal communities inhabiting ash wood at different stages of tree decline remains insufficiently explored. The aim of this study was to characterise the mycobiota of ash wood and to assess its relationship with tree health status. The research was conducted in western Poland (Bolewiny Forest District, Babimost Forest Division), where wood samples were collected in May 2024 from 24 ash trees representing different health classes and forest site types. Samples were obtained using a Pressler increment borer and analysed under laboratory conditions using culture-based methods on malt extract agar, followed by identification based on morphological characteristics. In total, 47 fungal taxa were isolated, including representatives of *Penicillium* (5 species), *Aspergillus*, and *Cladosporium*, which were among the most frequently recorded genera. The most common taxon, *Cladosporium* sp. 2, was detected in 13 samples, followed by *Aspergillus niger* in 10 samples. Notably, 18 taxa remained unidentified and were classified as Fungus sp. 1–18. Additionally, species with potential antagonistic activity against *H. fraxineus*, such as *Aureobasidium pullulans*, were identified in several samples. Fungal diversity was highest in dead trees (health class 4), where 43 out of 47 taxa were recorded, indicating a clear increase in species richness with declining tree health. Characteristic taxa for weakened and dead trees included *Penicillium* spp., *Fusarium* spp., *Chaetomium* sp., and *Trichoderma* spp. Although an increasing trend in fungal diversity was observed with worsening tree condition, statistical analyses did not reveal significant relationships, likely due to the limited sample size. The results highlight the ecological importance of dead and weakened ash wood as reservoirs of fungal diversity and suggest that tree health status plays a role in structuring these communities, with potential implications for understanding interactions within the ash decline process.

Keywords: *Fraxinus excelsior*; Mycobiota; Tree health status; Fungal diversity

Aims and Tools for Aerobiological Monitoring of Forest Tree Pathogens

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Abstract

Aerobiology is a field of biology focused on minute bioparticles passively transported by air masses. Invasive alien fungal pathogens of forest trees are most often disseminated via airborne spores for long distances to invade new hosts in new areas. Therefore, aerobiological monitoring of the airborne fungal inoculum can answer scientists, foresters, phytosanitary agents and other stakeholders' key questions: i) We do not see any symptomatic tree; does the pathogen occur here? ii) We have an infested forest stand; which distance can be naturally overtaken by the pathogen to infect new trees? iii) This year we want to apply a curative treatment to minimize the spread; when exactly should we spray it? iv) Does the pathogen's dispersal depend on weather? There are many solutions how to sample the airborne spores from sticky microscopic slide to GSM module connected digital microcameras assisted by AI. All solutions have particular advantages and disadvantages, making them suitable for a particular range of users, as well as particular pathogens. Our team applied various types of actively sampling spore traps to detect and monitor the seasonal, horizontal and vertical spread of *Hymenoscyphus fraxineus* – the causal agent of the ash dieback, *Cryptostroma corticale* - the sooty bark disease's pathogen, *Fusarium circinatum* – the pine pitch canker fungus, *Heterobasidion annosum* – causal agent of the conifer root and butt rot, *Dothistroma septosporum* and *D. pini* – responsible for the red band needle blight. Aerobiological approach to the tree pathogens' monitoring could facilitate the effort of regular, obligatory monitoring of harmful pathogens named in the EU directives, as well as diminish the overuse of fungicides, which is profitable for both – stakeholder and environment.

Keywords: Spore trap; Air sampling; Airborne inoculum; *Hymenoscyphus fraxineus*; *Cryptostroma corticale*

Towards Sustainable Management of Chestnut Ink Disease: Field Evaluation of a Holistic Approach in *Castanea sativa*

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Abstract

Chestnut ink disease, mainly associated with *Phytophthora cinnamomi*, remains one of the most serious threats to *Castanea sativa* in Mediterranean regions, where recurrent drought and other environmental stresses may further aggravate decline processes. In response to the need for sustainable alternatives to conventional disease control, a holistic management strategy was implemented within the LIFE FAGESOS project to evaluate its applicability under operational field conditions. The approach combined sanitation measures, interventions aimed at lowering pathogen pressure in the soil, the application of beneficial microorganisms, and products intended to stimulate host defence responses. This study presents the first field results obtained in Mediterranean chestnut coppices affected by ink disease. Treatments were applied in several disease foci through a coordinated framework involving local landowners, allowing assessment at a meaningful management scale. Field performance was evaluated using indicators of tree vitality, crown condition, symptom expression, and overall stand health, supported by canopy-based observations and repeated visual monitoring throughout the assessment period. Preliminary results revealed encouraging trends in treated areas, including improved plant condition and a general progressive reduction in decline severity, while also confirming the practical feasibility of applying this integrated protocol in real forestry settings. Rather than relying on a single intervention, the study underlines the value of combining complementary actions adapted to local ecological and operational constraints. These findings support the development of transferable and sustainable management protocols for chestnut ink disease and contribute to broader efforts to enhance the resilience of Mediterranean chestnut ecosystems affected by *Phytophthora*-associated decline.

Keywords: Chestnut ink disease; *Phytophthora cinnamomi*; Integrated management; Mediterranean coppices

Foliar Fungal Endophytes Alter White Spruce Defense Metabolites and Provide Direct Anti-herbivore Resistance Against a Defoliator

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Abstract

Endophytic fungi play critical roles in plant resistance against herbivores, yet their impact on insect herbivore resistance in coniferous trees remains unclear. Therefore, this study looked into how endophytic fungi in white spruce (*Picea glauca*) foliage might help the tree defend against the eastern spruce budworm (ESB), *Choristoneura fumiferana*. Our focus was on understanding whether these fungi could modulate host defense metabolites and provide direct anti-herbivore resistance to ESB. To explore this, we conducted a comprehensive analysis of 30 white spruce genotypes across two progeny locations in Alberta, Canada. We characterized the composition of monoterpenes, sesquiterpenes, and endophytic fungal communities, revealing variations in fungal endophyte abundance and terpene composition among sites and genotypes. We further isolated ten endophytic fungal morphotypes and elucidated their metabolite profiles. The mycelium extracts from these morphotypes had 11 secondary metabolites, and the headspace of the fungus had 13 fungal volatile organic compounds (FVOCs). Subsequent experiments involved assessing the effects of these morphotypes on ESB performance. Direct feeding tests using media amended with fungal mycelium and evaluations of the impact of FVOCs on budworm feeding and attraction revealed diverse effects. Most fungi exhibited harmful effects on budworms, depending on species and doses applied. Greenhouse experiments further demonstrated manipulating foliar fungal communities in white spruce seedlings can lead to changes in their terpene defenses. Our results show that endophytic fungi help white spruce trees fight off ESB by either directly killing the fungi or using volatile organic compounds to keep them away. Additionally, we highlight how endophytes enrich host defenses by enhancing the diversity of secondary metabolites.

Keywords: Endophytic fungi; Plant secondary compounds; Fungal organic compounds; Plant resistance; Plant-microbe-insect coevolution

Integrated Pest Management in Forest Plantations: A Strategic Framework for Risk Reduction

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Abstract

Forest plantations are under increasing pressure from pests and diseases as a result of trade, climate variability, larger plantation areas, and changing environmental conditions. Under these conditions, reactive control is often not enough. By the time damage is visible, the impact on growth, costs, and management can already be significant. This presentation discusses a practical integrated pest management (IPM) approach for forest plantations, with a strong focus on early detection, operational monitoring, risk assessment, and timely action. The goal is to move from isolated responses to a more preventive system that helps technical and operational teams anticipate problems, set priorities, and respond in a more effective way. The approach combines field surveillance, diagnostic support, understanding of pest and disease dynamics, silvicultural measures, and targeted chemical or biological control when required. Special attention is given to monitoring systems that generate useful field information for decision-making, improve response time, and support better use of available resources. Based on examples from plantation forestry in Chile, the presentation outlines the main components of a strong IPM program: prioritization of key pests and diseases, simple and standardized surveillance protocols, clear links between monitoring and action thresholds, coordination between field and technical teams, and regular adjustment based on operational results. Overall, the presentation highlights the value of a more integrated and practical system to strengthen plantation resilience and improve sanitary risk management in a changing environment.

Keywords: Integrated pest management; Forest plantations; Forest health; Phytosanitary risk; Surveillance; Early detection; Risk-based management

Biological Control of the Asian Chestnut Gall Wasp in Albania: Current Status, Risk Assessment and Future Perspectives

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Abstract

The Asian chestnut gall wasp (*Dryocosmus kuriphilus*) is among the most destructive invasive insect pests affecting chestnut trees worldwide. To evaluate its distribution and the natural presence of its specific larval parasitoid, *Torymus sinensis*, comprehensive field surveys and laboratory analyses were conducted across the primary chestnut-producing regions of Albania between 2023 and 2026. In order to monitor the distribution of *D. kuriphilus*, we visited 17 localities and searched for the presence of chestnut galls. Once detected, 2000 galls were sampled per locality and transferred to the laboratory to monitor the presence and parasitism rate of *T. sinensis*. The results demonstrate that the pest has rapidly spread throughout the chestnut forests of northern Albania, resulting in severe levels of gall infestation. Concurrently, it was identified that *T. sinensis* has naturally entered Albania alongside its host, forming stable biological control populations in the infested areas. Laboratory analyses of gall samples collected in 2023 showed an average parasitism rate of 12.5%. Risk assessments confirmed that the release of *T. sinensis* carries no adverse economic, environmental, or social impacts. Classical biological control utilizing local populations is identified as the most effective management strategy for preserving chestnut yields. Consequently, future initiatives aim to establish laboratory infrastructure in several Albanian localities and expand the biological control program to support a sustainable chestnut value chain in Albania.

Keywords: Asian chestnut gall wasp, Biological control, Albania

Modeling the Potential Distribution of *Hyphantria cunea* in Türkiye under Climate Change

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Abstract

The fall webworm, *Hyphantria cunea* (Drury, 1773), is one of the most important polyphagous invasive pests of Türkiye, causing substantial damage in both agricultural and forest ecosystems. Its high reproductive capacity and adaptability allow it to exploit a wide range of host plants, making it a significant threat to crop production and forest health. Climate change is expected to influence its distribution and population dynamics further, highlighting the need for proactive monitoring and management strategies. In this study, we aimed to assess the current and potential future distribution of *H. cunea* in Türkiye under various climate change scenarios.

Species occurrence data were compiled from GBIF, iNaturalist, and literature sources, and bioclimatic variables were incorporated into the analysis. Maximum Entropy (MaxEnt) modeling was used to estimate habitat suitability, while Geographic Information Systems (GIS) techniques were applied to visualize spatial distribution patterns. Future climate projections for the study region were obtained from the WorldClim database, based on the BCC-CSM2-MR global climate model for future periods 2021–2040, 2041–2060, 2061–2080, and 2081–2100 under the SSP1-2.6 and SSP5-8.5 scenarios, and potential habitat suitability for the species was categorized into four classes: highly suitable, suitable, low suitability, and unsuitable.

The habitat suitability of *H. cunea* is primarily determined by climatic variables BIO14 (precipitation of driest month), BIO4 (temperature seasonality), and BIO1 (annual mean temperature), which consistently showed the highest contribution across all scenarios and time periods. MaxEnt modeling of *H. cunea* indicates that areas of high and moderate suitability remain largely stable under both optimistic and pessimistic climate scenarios, with only minor increases in moderately suitable regions. Low suitability and unsuitable areas show little change, while the sea limits the northern distribution, and no significant southward expansion is predicted. These findings suggest that the species' potential distribution will remain relatively stable, reflecting its current climatic adaptability and geographic constraints.

Keywords: Invasive species; MaxEnt modeling; Future projections; Habitat suitability; Ecological risk

Drought and Bark Beetle Induced Dieback in the Coniferous Forests of Southwestern Anatolia

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Abstract

Climate change–induced prolonged and/or more severe droughts pose a significant risk to forest ecosystems by amplifying the impacts of pest insects and pathogens. Drought not only directly affects tree growth and survival but may also lead to more frequent and severe outbreaks of forest insects. Trees are highly sensitive to drought stress and prolonged high temperatures; when combined with reduced precipitation, these conditions can result in water deficits, physiological stress, and ultimately mortality. Extreme weather events associated with anthropogenic climate change have increased the frequency and severity of bark beetle damage, contributing to widespread forest mortality worldwide in recent years. Elevated temperatures can accelerate host tree susceptibility to bark beetle attacks by impairing defense mechanisms. High temperatures influence physiological and biochemical processes in many tree species; for instance, they may increase the emission of volatile organic compounds—perceived by bark beetles as stress signals—enhance evapotranspiration and reduce photosynthetic activity. Drought stress, often occurring in conjunction with high temperatures, further compromises host resistance. Severe and/or prolonged drought leads to stomatal closure to reduce transpiration, which in turn decreases photosynthesis and carbon assimilation, ultimately depleting carbohydrate reserves. Consequently, limitations in water and carbon availability jeopardize both growth and the production of secondary metabolites, resulting in slow-growing trees with insufficient defensive capacity to withstand bark beetle attacks and associated fungal pathogens. Water stress also reduces tree resistance to bark beetle infestations by impairing structural defense mechanisms such as resin flow. Drought frequently acts as a catalyst for bark beetle outbreaks, as trees under water stress exhibit reduced growth and carbon assimilation rates, thereby weakening host defenses and potentially leading to large-scale tree mortality within relatively short periods. The forests of Southwestern Anatolia are located within the Mediterranean Basin, a region experiencing warming at a rate above the global average. Increasing drought and irregular precipitation regimes have not only intensified the frequency and spatial extent of forest fires but have also directly contributed to dieback and tree mortality through bark beetle outbreaks. In recent years, both individual and large-scale tree mortality events have become increasingly common in the region.

Keywords: Climate change; Epidemic; Dieback; Stress; Scolytinae

Habitat Suitability Modeling of *Formica rufa* Using Ensemble Machine Learning

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Abstract

The *Formica rufa*, commonly known as the red wood ant, is a keystone species that significantly influences its surroundings. This group of predatory species influences various ecological processes, making them ecologically significant. Ants may serve as bioindicators of ecological balance in fragmented habitats. Assessing the habitat preferences of these species and determining the factors that influence these choices is essential for sustainable forest management. This study utilized a hybrid (ensemble) machine learning approach to estimate and map the habitat suitability of *F. rufa*.

A field survey was performed in the forests of the Kastamonu Regional Directorate of Forestry during 2024 and 2025, resulting in the identification of 358 active *F. rufa* nests. Active nest sites were examined with topographic, stand characteristic, and meteorological parameters. To mitigate model overfitting, the correlation structure across variables was analyzed, leading to the exclusion of variables with correlations exceeding 0.9. The habitat suitability of *F. rufa* was modeled using common machine learning techniques, including Random Forest, XGBoost, Generalized Additive Model (GAM), Support Vector Machine (SVM), and their hybrids. Spatial thinning and block cross-validation were employed to reduce spatial sampling bias. The significant levels of the parameters included in the models were also determined. The models' accuracy was assessed using both threshold-independent (ROC) and threshold-dependent (TSS, Kappa, sensitivity, specificity) performance metrics. A conclusive habitat suitability map was generated.

Keywords: Red wood ant; Forest; Habitat suitability; Machine learning

MaxEnt-Based Habitat Suitability Modeling of the Predator *Calosoma sycophanta* L. in Pine Processionary Moth-Affected Turkish Red Pine (*Pinus brutia* Ten.) Forests (A Case Study of the Western Mediterranean Region)

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Abstract

This study was conducted to investigate the relationships between the pine processionary moth (PPM) (*Thaumetopoea pityocampa* Denis & Schiffermüller, 1775 and *T. wilkinsoni* Tams, 1926; Lepidoptera: Thaumetopoeidae) and its predator *Calosoma sycophanta* Linnaeus, 1758 (Coleoptera: Carabidae) with environmental variables, and to generate habitat suitability maps based on these variables. The study area was divided into 2×2 km grid cells for systematic sampling, and field surveys were conducted in 191 sampling plots to collect presence/absence data for *C. sycophanta* A statistically sufficient number of presence data points was reached. The relationships between the environmental variables and species presence were analyzed and mapped using the Maxent method.

To select the most suitable species distribution model for *C. sycophanta* species, the standard deviation between the AUC values of the training and test datasets was taken into consideration. The model with the lowest standard deviation was selected as the optimal model. In the habitat suitability model obtained for *C. sycophanta* (AUC: 0.917–0.916), the environmental factors affecting the species'distribution were identified as aok_ibreli, Bio17, Bio4, Bio7, slope_class, jeo, AYSİ, ri, and elevation. Moreover, the generated data may serve as a guide for predicting the potential distribution of *C. sycophanta* in other regions and for planning future biological control strategies.

Keywords: Antalya, *Calosoma sycophanta*, Habitat suitability mapping, Maxent, Pine processionary moth

Climate Change–Related Tree Mortality and Entomological Risks in Protected Areas of the Western Mediterranean Region

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Abstract

Climate change can substantially affect tree health and biotic interactions in sensitive forest ecosystems, particularly within protected areas. Increasing temperatures, reduced and irregular precipitation, lower humidity, and prolonged drought periods impose physiological stress on trees, weakening their resistance to insect damage. This study investigates the drivers of tree mortality observed in protected areas located in Elmalı (Antalya), Yeşilova (Burdur), and Kemer (Antalya) in the Western Mediterranean Region of Türkiye. Field observations were conducted in 2023 in Çığlıkara Nature Reserve (Elmalı), and in 2025 in Salda Lake Special Environmental Protection Area (Yeşilova) and Beydağları Coastal National Park (Kemer). Stands of *Cedrus libani*, *Pinus brutia*, and *Pinus nigra* subsp. *pallasiana* were examined. Climate data obtained from the Turkish State Meteorological Service were used to evaluate temperature, humidity, and precipitation patterns corresponding to the periods of observed mortality. The findings indicate that drought stress is the primary driver of tree mortality, while secondary pests, particularly bark beetles, have contributed to increased damage through population outbreaks. Widespread mortality was recorded across all sites; however, insect-related damage was relatively limited in *C. libani* stands in Elmalı, whereas higher bark beetle activity was observed in *P. nigra* subsp. *pallasiana* in Yeşilova and *P. brutia* in Kemer. Climate data further revealed decreased precipitation and elevated mean temperatures during the winter and spring periods of 2023–2025. Due to regulatory constraints associated with protected area status, management interventions remain limited, complicating the control of pest populations. In particular, the lack of pheromone-based control options for certain bark beetle species and restrictions on the removal of infested trees hinder effective management. These findings suggest that passive conservation alone may be insufficient under increasing climatic stress. Therefore, regular monitoring of entomological risks, the development of early warning systems, and the implementation of low-impact, ecosystem-based management strategies are recommended.

Keywords: Climate change, Protected areas, Tree mortality, Forest pests, Bark beetles, Western Mediterranean

Application of Entomological Bioindicators for Environmental Pollution Assessment

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Abstract

Rapid industrialization, intensive urbanization, and unsustainable agricultural practices have triggered a process of environmental degradation that threatens ecosystem integrity on a global scale. Although conventional physicochemical analyses can provide instantaneous measurements of pollution levels, they remain insufficient to elucidate the cumulative and long-term impacts of contaminants on biological systems. In this context, the present study constitutes a comprehensive review that examines the effectiveness of entomological bioindicators in assessing the health of aquatic, terrestrial, and atmospheric ecosystems, as well as their current position in the scientific literature. Based on a systematic literature survey, this research synthesizes the morphological, ecological, and physiological responses of different insect taxa to anthropogenic stressors. The findings confirm that insects serve as highly sensitive, cost-effective, and versatile biomonitors of environmental change. In particular, the reliability of the EPT (*Ephemeroptera*, *Plecoptera*, *Trichoptera*) index in aquatic systems, the effectiveness of Coleoptera and Hymenoptera in monitoring soil toxicity in terrestrial environments, and the sentinel role of pollinators such as *Apis mellifera* in detecting atmospheric heavy metal pollution are supported by extensive literature evidence. Furthermore, this review discusses the current status and future potential of modern technological tools, including DNA barcoding and enzyme-based analyses, alongside traditional observational methods. In conclusion, the study identifies existing gaps in the literature and highlights the necessity of formally integrating insect-based monitoring systems into international environmental protection protocols from a scientific perspective.

Keywords: Entomology; Heavy metals; Biomonitoring; Bioindicators

Comparative Analysis of Three Invasive Ambrosia Beetles in Türkiye: Distribution, Host Susceptibility and Management Perspectives

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Abstract

Ambrosia beetles are critical forest pests that cultivate symbiotic fungi within woody tissues causing significant ecological and economic losses. While their invasive capacity is largely driven by international trade and climate change, their impact varies significantly based on species-specific colonization strategies. Due to their invasive characteristics, the absence of natural enemies in newly colonized ecosystems often leads to rapid population increases. This study presents a comparative analysis of the current status of three invasive ambrosia beetles in Türkiye: *Xylosandrus compactus*, *Xylosandrus germanus*, and *Euwallacea fornicatus*.

Recent field surveys confirm that *E. fornicatus* is established across both the European and Asian sides of İstanbul. Furthermore, *X. compactus*, originally recorded in İstanbul, has now been identified in Yalova, where it causes damage to thin branches of *Magnolia grandiflora*. Regarding the distribution of *X. germanus*, existing literature reports indicate a widespread presence extending from Düzce to Ordu, covering the Western and Central Black Sea regions.

These species are notable for their broad host range, high reproductive capacity, and their preference for stressed or weakened trees. Ecological observations indicate *X. compactus* primarily damages thinner branches, whereas *X. germanus* poses a significant threat to saplings and thin stems. In contrast, the *E. fornicatus* complex induces systemic vascular wilt and dieback in host plants via pathogenic fungal symbionts, particularly in urban environments. Although these species rely on mutualistic fungal associations for larval development—primarily *Ambrosiella* spp. for *Xylosandrus* species and the *Fusarium*/*Neocosmospora* complex for *E. fornicatus*—their varying host preferences and colonization mechanisms necessitate tailored management strategies.

As emphasized in EPPO phytosanitary guidelines, the proliferation of these species is primarily facilitated by international trade and the movement of untreated wood, underscoring the urgent need for enhanced border biosecurity. By characterizing the unique biology, damage dynamics, and spatial distribution of these three invasive beetles, this study provides a comprehensive framework for developing regional early-detection and integrated pest management (IPM) protocols aimed at mitigating long-term ecological and economic damage.

Keywords: *Xylosandrus compactus*; *Xylosandrus germanus*; *Euwallacea fornicatus*; *Ambrosiella* spp.; *Neocosmospora* spp.; Integrated pest management (IPM)

Bark Beetle Damages and Silvicultural Management Strategies in Protected Areas: The Case of Karagöl-Sahara and Hatila Valley National Parks

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Abstract

This study aims to emphasize the importance of proactive silvicultural interventions in preventing entomological (insect) damages that lead to serious economic and ecological losses in protected areas. Nature conservation areas in Turkiye are separated into absolute protection statuses such as national parks, nature parks, nature monuments, and wildlife development areas, as well as partial protection statuses (conservation forests, soil protection, etc.) determined by forest management plans. In literature and practice, there is an ongoing paradigm between the approach advocating for leaving absolute protection areas entirely to natural succession processes (passive conservation) and the active ecosystem management approach, which foresees taking necessary precautions against elements threatening ecosystem continuity.

Hatila Valley and Karagöl-Sahara National Parks, located in the Artvin province of Turkiye, stand out with the rare Oriental spruce (*Picea orientalis* (L.) Link.) climax forest ecosystems they harbor. Having a thin bark structure, the Oriental spruce shows high susceptibility to biotic pests, especially bark beetles. In recent years, populations of the eight-toothed bark beetle (*Ips typographus* L.), twelve-toothed bark beetle *Ips sexdentatus* (Boern.), and the great spruce bark beetle (*Dendroctonus micans* Kug.) have reached the epidemic stage in the aforementioned national parks, causing mass tree mortality and habitat destruction. The reaching of the epidemic stage by the mentioned beetle populations in the Oriental spruce stands in Hatila Valley and Karagöl-Sahara National Parks gained momentum following the isolation of both ecosystems from silvicultural interventions after being declared "absolute protection areas." In this paper, the consequences of the passive conservation strategy and active ecosystem management approaches applied in absolute protected areas on the population dynamics and forest health of the mentioned national parks are comparatively analysed. Consequently, silvicultural intervention timing and silvicultural techniques are proposed to keep the population dynamics of biotic pests threatening the ecosystem integrity of protected areas at a controllable level. Furthermore, to ensure ecosystem continuity in absolute protected areas, the necessity of "weak and moderate" (low-medium intensity) proactive silvicultural interventions that enhance stand resistance before potential epidemics occur is opened for discussion.

Keywords: Silviculture; Protected Area Management; Oriental Spruce (*Picea orientalis*); Bark Beetles; Forest Health

Origin of Pine Processionary Moth Populations in Austria: A Genetic Approach

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Abstract

The pine processionary moth (PPM), *Thaumetopoea pityocampa*, is expanding its range in the European Alps, particularly in the southern regions of Carinthia (Austria), likely driven by increasing winter temperatures. Following the distinct outbreaks observed at Dobratsch mountain in 2016/17, the question arose from where this population originates. Therefore, we investigated the genetic structure of the populations in Carinthia (Buchrigl and Arnoldstein), along with those in Italy (Friuli) and Slovenia (Bovec), using mitochondrial DNA and microsatellite data.

Mitochondrial DNA analyses showed that the Austrian populations are genetically highly homogeneous, and a common haplotype from eastern France and Italy is also dominant at Dobratsch mountain. According to microsatellite data, no significant difference between observed and expected heterozygosity was found, indicating that the populations are generally outcrossing. However, PCA and STRUCTURE (K=3) analyses revealed that the Austrian populations form distinct clusters clearly separated from the Italian and Slovenian populations. Furthermore, negative F_{ST} values among the intra-Austrian populations indicated low gene flow among these subpopulations and further genetic differentiation within themselves.

The genetic findings suggest that the PPM populations in Austria did not establish in the region through long-distance dispersal events. The observed genetic structure is consistent with either a gradual natural expansion from southern regions or a local demographic expansion of pre-existing, isolated populations facilitated by warming climate conditions. Further demographic inferences and scenario comparisons are required to conclusively distinguish between these expansion models. As a next step, more detailed genetic analyses will be conducted by incorporating additional genetic data from across Europe.

Keywords: *Thaumetopoea pityocampa*; Population genetics; Range expansion; Mitochondrial DNA; Microsatellites

Insect Pests of Fir Forests: Species, Damage, and Management Perspectives

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Abstract

Fir trees (*Abies* spp.), members of the Pinaceae family, are ecologically and economically important conifers widely distributed across Türkiye, including Nordmann fir, Uludağ fir, Kazdağı fir, and Taurus fir. Their dense foliage, erect cones, and high-quality wood make them essential components of forest ecosystems and valuable resources for construction, furniture production, and the paper industry. Despite their importance, fir forests are increasingly threatened by several bark beetle species (Coleoptera: Curculionidae), which typically exploit weakened or stressed trees and can cause extensive mortality. Among these, *Pityokteines curvidens* (large fir bark beetle) is the most destructive species, responsible for widespread decline in European and Turkish fir stands. It primarily attacks drought-stressed trees, producing resin exudation and characteristic gallery systems beneath the bark. Another significant pest, *Cryphalus piceae* (small fir bark beetle), targets thin-barked branches and crowns, forming star-shaped larval galleries that lead to crown discoloration and dieback. *Pityokteines marketae*, an endemic Mediterranean species, predominantly infests Taurus fir (*Abies cilicica*), often in association with mistletoe (*Viscum album*), thereby disrupting water transport and accelerating tree mortality. Additionally, *Pissodes piceae* (fir weevil) damages the bark and cambial tissues; its larval feeding creates distinct star-like galleries, often accompanied by resin flow and increased woodpecker activity. These beetles typically produce one or two generations annually, with flight activity occurring in spring and summer. Their population dynamics are closely linked to abiotic stress factors such as drought, storm damage, and inadequate silvicultural practices. Infestations result in progressive crown discoloration, needle loss, and eventual tree death. Effective management therefore depends on continuous monitoring, a thorough understanding of pest life cycles, and the implementation of appropriate silvicultural strategies to enhance forest resilience.

Keywords: Fir bark beetles; *Pityokteines curvidens*; *Cryphalus piceae*; Forest pest management; *Abies* spp.

Monitoring Forest Health in Terms of Forest Pests and Diseases Under ICP Forests

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Abstract

This study aims to monitor the diseases and pests observed on tree species in Turkish forests within the framework of the ICP Forests (International Cooperative Programme on Assessment and Monitoring of Air Pollution Effects on Forests) methodology, and to reveal the effects of forest pests on tree species as a result of these monitoring activities. ICP Forests has been implemented for approximately 40 years in European countries and for 20 years in Türkiye, with monitoring activities carried out at two levels (Level I and Level II programs). Based on the data obtained in this context, the status of various harmful organisms, particularly insect and fungal agents, on tree species has been evaluated. The findings indicate that the ICP Forests monitoring network plays a critical role in early warning systems and the development of pest and disease management strategies for the sustainability of forest health.

Keywords: ICP forests; Monitoring; Pests; Diseases; General directorate of forestry

First Record of *Neopachygaster admiranda* Krivosheina & Freidberg, 2004 (Diptera: Stratiomyidae: Pachygastrinae) from Türkiye with Ecological and Zoogeographical Notes

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Abstract

This study reports the first occurrence of the soldier fly species *Neopachygaster admiranda* Krivosheina & Freidberg, 2004 from Türkiye, significantly extending its known distribution range from the eastern Mediterranean (Israel) region into the southern Black Sea (Samsun) biogeographical zone. The material was collected from Samsun Province, Vezirköprü District, Oymaağaç Village, a locality characterized by a unique intersection of riparian forest ecosystems and steppe vegetation, and also known for its archaeological significance associated with the ancient Hittite city of Nerik. Larval specimens were discovered beneath the bark of *Populus nigra* and were successfully reared under controlled laboratory conditions to obtain adult individuals, allowing precise morphological confirmation. The study integrates field sampling, larval rearing, and morphological examination based on diagnostic characters of the genus *Neopachygaster* within the subfamily Pachygastrinae. Ecological observations indicate that the species is strictly associated with saproxylic microhabitats, particularly decaying wood environments with high humidity and stable microclimatic conditions. The locality exhibits a continental-microclimatic transition with moderate summer temperatures, high solar exposure, and riparian vegetation dominated by *Populus* and *Salix* species. The emergence of adults in mid-August suggests a synchronized developmental cycle aligned with summer thermal peaks. This record not only fills a major gap in the distributional knowledge of the species but also highlights the importance of underexplored riparian and saproxylic habitats in Anatolia for dipteran biodiversity. Furthermore, it emphasizes the biogeographical significance of Türkiye as a faunal bridge between Palearctic subregions. The findings contribute to the understanding of the ecological requirements and distribution dynamics of Pachygastrinae flies and underscore the necessity of further faunistic surveys in the region.

Keywords: *Neopachygaster admiranda*; Stratiomyidae; Pachygastrinae; *Populus nigra*, Saproxylic insects; Türkiye

Behavioral Patterns of Egg-Laying and Nest Placement in Pine Processionary Moth

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Abstract

This study investigates the distribution of nests and egg batches of the pine processionary moth, *Thaumetopoea wilkinsoni* Tams, 1926 (Lepidoptera: Notodontidae), in relation to cardinal directions and crown positions, and examines their association with several tree characteristics. The research was conducted in a young forest stand in Dinar (Afyonkarahisar, Türkiye). Data were collected from 15 sample trees, and tree height, crown base height, crown length, and crown diameter were measured. The number and height of nests and egg batches were recorded for four cardinal directions. To account for variations in tree size, height measurements were standardized to calculate relative tree and crown heights to determine vertical positions of infestations within the tree crown. Statistical analyses were conducted using SPSS and Python. A total of 85 nests and 250 egg batches were identified. Mean heights were recorded as 2.48m for nests and 2.17m for egg batches. Vertical distribution showed that 4.6% of nests were in the lower, 40.23% in the middle, and 55.17% in the upper crown. For egg batches, 9.6% were in the lower, 35.2% in the middle, and 55.2% in the upper crown. Regarding directions, nests were distributed as 69.0% south, 12.6% east, 16.1% west, and 2.3% north. Egg batches were distributed as 17.6% south, 28.4% east, 16.4% west, and 37.6% north. Positive correlations were found between the total number of nests and south-facing nests, tree height ($p<0.01$), crown length, and crown diameter ($p<0.05$). For egg variables, positive correlations were determined between the total number of egg batches and those on the east and north ($p<0.01$), and south ($p<0.05$) aspects. No significant relationships were found among other variables. A significant difference in nests and egg batches was observed among crown positions, increasing from the lower to the upper crown, whereas no significant differences were detected among cardinal directions ($p>0.05$).

Keywords: Egg laying; Nest formation; Pine trees; *Thaumetopoea wilkinsoni*

Effects of Silvicultural Practices on Forest Insect Damage

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Abstract

Forest insect pests are among the principal biotic agents determining the structure, continuity, and regeneration success of forest ecosystems. A growing body of research demonstrates that silvicultural practices play a critical role in shaping forest susceptibility to insect damage by altering stand structure, host tree physiology, and ecological interactions. In this context, silvicultural interventions should be regarded not only as production and maintenance activities, but also as key ecological tools that influence pest population dynamics. Practices such as site preparation, species selection, regeneration methods, and tending operations can exert both direct and indirect effects on pest populations through the regulation of tree vigor and modification of microclimatic conditions. In particular, appropriate stand density management can enhance the physiological resistance of trees and reduce pest pressure, whereas improper or delayed interventions may trigger pest outbreaks. Furthermore, increasing tree species diversity is recognized as an effective strategy, as it limits host continuity and supports biological control processes. Silvicultural decisions made during the stand tending and regeneration phase directly affect pest colonization processes and population development, thereby exerting long-term influences on stand dynamics. Harvesting practices and the management of logging residues can alter the spatial distribution of habitat and food resources for insect pests, either increasing or reducing associated risks. The growing impact of pest pressures necessitates a more strategic planning of silvicultural interventions across temporal and spatial scales, requiring management approaches tailored to the stages of pest invasion, establishment, and spread. In this process, intensive and localized silvicultural interventions become particularly important in the early stages, whereas at later stages, approaches based on the regulation of stand structure and species composition gain prominence. Overall, these evidence indicate that effective management of forest insect pests depends on the implementation of silvicultural practices within a holistic framework that accounts for ecosystem dynamics, rather than relying on isolated interventions.

Keywords: Silvicultural practices; Forest insect pests; Stand structure; Pest management

Biology and Anatomical Impact of the Invasive Box Tree Moth (*Cydalima perspectalis* (Walker)) on *Buxus sempervirens* in Kastamonu (Türkiye)

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Abstract

Forest ecosystems are subject to multiple stressors that threaten their continuity and sustainable development. Among the most critical drivers are forest fires, illegal anthropogenic interventions, diseases, and insect outbreaks often referred to as "smokeless fires." In particular, insect pests can cause severe ecological and economic losses in forest ecosystems. Türkiye occupies a key position in terms of biodiversity, hosting a wide range of plant species and habitats. The Anatolian boxwood, *Buxus sempervirens*, is widely used in landscaping due to its evergreen habit and compact growth form; it is also preferred as a potted ornamental plant and as filler material in floral arrangements. However, an invasive Lepidoptera species damaging *Buxus* spp. in Europe has been identified *as Cydalima perspectalis* (Walker, 1859; Lepidoptera: Crambidae). Native to the humid subtropical regions of East Asia, this species was first recorded in southwestern Germany and has rapidly spread across Europe over the past decade, primarily through the trade of ornamental boxwood plants. The main objective of this study is to investigate the biology of *C. perspectalis* and to determine its impact on the anatomical structure of boxwood in Kastamonu Province (Pınarbaşı and Azdavay districts), where the pest has become particularly prevalent. Field and laboratory investigations were conducted with a focus on areas exhibiting high infestation levels. The biological characteristics of the species were documented under natural conditions, and damage assessments were performed at both morphological and anatomical levels. The results revealed that the pest is present throughout all boxwood stands in the study area and causes extensive damage. These findings highlight the invasive potential of *C. perspectalis* and underline the need for integrated pest management strategies to protect boxwood populations and associated forest ecosystem functions.

Keywords: *Cydalima perspectalis*; Box tree moth; *Buxus sempervirens*; Biological cycle, Forest pests; Kastamonu; Anatomical effects

Impacts of Biotic Agents on the Morphological and Anatomical Structure of Economically Important Tree Species in Kastamonu (Türkiye)

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Abstract

Forests in Kastamonu (Türkiye) are increasingly exposed to interacting biotic stressors that alter tree growth, vitality, and wood structure. This study provides an integrated evaluation of fungal pathogens and saproxylic insects using dendroecological, morphological, and wood anatomical approaches in sweet chestnut (*Castanea sativa*) and Kazdağı fir (*Abies nordmanniana* subsp. *equi-trojani*) ecosystems. Chestnut blight caused by *Cryphonectria parasitica* revealed that infection intensity and host response vary across environmental gradients. While conventional growth parameters such as stem height and diameter (DBH) remain relatively stable between healthy and infected individuals, radial growth and xylem characteristics exhibit strong sensitivity. Healthy trees are characterized by greater fibre dimensions and lumen widths, whereas infected individuals develop larger vessel diameters. These anatomical adjustments indicate a pathogen induced shift in hydraulic architecture, reflecting a trade-off between hydraulic efficiency and safety under stress conditions. In Kazdağı fir ecosystems, infection by *Melampsorella caryophyllacearum* reduces host vitality and induces structural abnormalities such as witches' broom formation. These weakened tissues create suitable substrates for saproxylic colonization. The detection of *Cossonus parallelepipedus* in infected wood highlights cascading interactions between fungal pathogens and insect communities, accelerating wood decomposition and influencing nutrient cycling processes. Overall, the results demonstrate that fungal pathogens not only directly affect tree growth and xylem organization but also facilitate secondary insect colonization. This integrative perspective underscores the importance of combining forest pathology, wood anatomy, and entomology to better understand and manage forest resilience under changing environmental conditions.

Keywords: Chestnut blight; Forest pathology; Fir broom rust; Wood anatomy; Saproxylic insect-fungus interactions

Assessment of Termite Resistance and Performance Enhancement of Wood Reinforced with Multi-Walled Carbon Nanotubes

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Abstract

In this study, the effects of multi-walled carbon nanotube (MWCNT) impregnation on the termite resistance of Scots pine (*Pinus sylvestris* L.) wood were investigated. The impregnation process was carried out using the full-cell method at 0.25%, 0.5%, and 1% concentrations. Termite resistance tests revealed that the biological durability of the wood improved significantly depending on the impregnation concentration. The highest mass loss was observed in the control group (12.41±1.76%), whereas all MWCNT-treated samples exhibited lower values. In particular, the mass loss decreased to 4.79±2.86% at 1.0% concentration. A consistent decreasing trend in mass loss was observed with increasing concentration, with values of 7.46%, 6.97%, and 4.79% for 0.25%, 0.50%, and 1.0% concentrations, respectively. These results clearly indicate that higher MWCNT retention enhances resistance against termite-induced degradation. In addition, termite mortality rates increased with increasing MWCNT concentration. The highest mortality rate was recorded at 1.0% concentration (97.24±16.89%), followed by 0.50% (83.93±11.16%) and 0.25% (64.60±9.77%), while the control group showed a mortality rate of 60.86±19.38%. These findings suggest that MWCNT treatment may exert toxic or behaviour-modifying effects on termites. Visual assessment results indicated moderate attack levels across all groups (3.00–3.66), with the highest damage observed in the control samples. Overall, MWCNT-impregnated wood demonstrated enhanced resistance to termite attack, and this effect became more pronounced with increasing concentration.

Keywords: Multi-walled carbon nanotubes (MWCNTs); Termite resistance; Scots pine; Biological durability; Wood impregnation

Bats and Forest Health: Ecosystem Services in Biological Control of Pests

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Abstract

Biodiversity is a fundamental component of ecosystem functioning and sustainability, and interactions among species play a critical role in maintaining this balance. Populations of species we consider harmful—whether due to human impacts or natural processes—occasionally increase. This increase can lead to a decline in crop yields. In the process of pest control, methods that do not harm the environment should be prioritized. Insectivorous bats are effective organisms in suppressing pest insect populations due to their high prey consumption capacity. The literature indicates that a bat can consume an amount of insects nearly equal to its own body weight in a single night. Thanks to these characteristics, bats provide an important ecosystem service in controlling pest insects, particularly in forest ecosystems.

The role of bats in pest control is not limited to forests. In forest-agricultural transition zones, particularly in monoculture farming systems, high pest pressure increases the use of chemical pesticides. However, the effective presence of bats in these areas offers a natural solution that could reduce pesticide use. Recent studies have shown that bat populations can be supported through the use of bat boxes, thereby enhancing the potential for biological control. Especially in regions where natural roosting sites are limited, providing artificial roosting sites increases bat habitat use and supports the continuity of ecosystem services. This study will present preliminary assessments of the first monitoring study on roosting ecology and diet based on bat boxes in hazelnut farms adjacent to forest areas in the provinces of Düzce and Bolu. The potential of bats as a biological control agent against the increasing insect pests in monoculture hazelnut fields in recent years will be highlighted.

Keywords: Bats; Pest management; Hazelnut farms

Overlooked Forest Health Risks of *Diplodia sapinea* in Türkiye

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Abstract

Diplodia sapinea, the causal agent of Diplodia shoot blight, is a globally important opportunistic pathogen of pines. It can damage seeds and seedlings in nurseries, and cause shoot blight, crown dieback, cankers, blue stain, and reduced growth in forests, and can cause tree mortality especially in plantations. The pathogen may persist latently in asymptomatic pine tissues, but disease expression is strongly favoured by host stress. Among the stress factors involved, drought and heat-related water limitation are now recognized as major drivers of symptom development, outbreak severity, and climate-related disease emergence. This is particularly relevant for Türkiye, where more frequent and severe drought events are projected and many pine forests already occur near climatic or edaphic stress limits.

In this review, we synthesize current knowledge on the biology, host range, epidemiology, and climate sensitivity of *D. sapinea*, and discuss its relevance for pine forests and plantations in Türkiye. We also use a relatively recent *D. sapinea* detection from symptomatic pine material in the Kırklareli–Edirne region, confirmed through field observations, laboratory examinations, and molecular characterization including ITS sequencing and species-specific primers, as an illustrative case to highlight that the pathogen may be more widespread or more important in Türkiye than currently recognized. This regional case does not by itself demonstrate a national-scale epidemic, but it supports the need to reconsider overlooked disease records, decline events, and plantation failures in which drought stress, poor site matching, or bark beetle activity may have masked the contribution of fungal pathogens.

We argue that *D. sapinea* should not be treated as a climate-sensitive forest health risk with implications for pine regeneration, plantation stability, particularly *Pinus nigra* adaptation, provenance transfer, assisted migration, and future forestry planning. Integrated field surveys, molecular diagnostics, population studies, host susceptibility assessments, and climate-based risk modelling are needed to clarify its present distribution and future risk in Türkiye.

Keywords: *Diplodia sapinea*; Pine decline; Climate change; Latent pathogen; Black pine; Forest health; Türkiye; Disease monitoring

Seed-Associated Fungal Colonization in Pine Species: Implications for Seed Health Management and Forest Regeneration

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Abstract

Forest ecosystem sustainability is closely linked to the success of natural regeneration and afforestation efforts. In this process, the microbial health status of seeds, together with their physiological quality, may play a decisive role in seedling development and early survival. Fungal organisms on seed surfaces or within seed tissues can reduce germination rates, impair seedling development, and contribute to deterioration of seed quality during storage under favorable environmental conditions. In pine species, which are widely used in forestry practices, the detection and monitoring of seed-associated fungal contamination is therefore important for the safe and effective use of forest reproductive material. This paper discusses the general importance of fungal colonization in forest tree seeds within the context of seed health management. It also evaluates the potential effects of host species identity and seed source on seed mycobiota and emphasizes the role of seed health analyses in afforestation and restoration practices. In this regard, early monitoring of fungal contamination, species-based evaluation, and careful management of seed storage conditions are essential steps for obtaining healthy, sustainable forest reproductive material.

Keywords: Seed health; Seed-borne fungi; Pine seeds; Forest regeneration; Seed mycobiota; Forest reproductive material

Biological Control Studies Against Native and Invasive Insect Species Damaging Forests in the Eastern Black Sea Region

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Abstract

Temporary and permanent biological control laboratories were established between 1985 and 1987 under the authority of the Artvin Regional Directorate of Forestry to implement biological control strategies against forest pest species in the Eastern Black Sea Region. Since 1985, mass rearing of predatory species and their alternative host organisms has been conducted under laboratory conditions. Within the framework of the biological control program against *Dendroctonus micans*, which entered the country via spruce forests of Georgia in 1966, a total of 4282624 individuals of *Rhizophagus grandis* were reared and released, contributing to the restoration of ecological balance. In addition, against the invasive species *Ips typographus*, which entered regional spruce forests in 1984 and is regarded as one of the most destructive bark beetles in the region, as well as the native species *Ips sexdentatus*, the following predatory species were mass-produced and released: 114707 individuals of *Thanasimus formicarius*, 3548 of *Clerus mutillarius*, 34430 of *Rhizophagus depressus*, 14150 of *Rhizophagus dispar*, and 7,905 individuals of *Temnochila caerulea* and *T. virescens*. For other significant forest pests, 7616 individuals of *Bracon hebetor* were produced for *Cydalima perspectalis* in boxwood ecosystems, 10926 individuals of *Torymus sinensis* for *Dryocosmus kuriphilus* (chestnut gall wasp), and 32420 individuals of *Trissolcus japonicus* for *Halyomorpha halys*. The mass production and field release of these beneficial organisms are ongoing. Experimental studies are also being conducted on the egg parasitoids *Trissolcus japonicus* and *Anastatus bifasciatus* using eggs of alternative laboratory-reared hosts, including *Leptoglossus occidentalis*, *Halyomorpha halys*, *Nezara viridula*, *Palomena prasina*, and *Rhaphigaster nebulosa*. Furthermore, in order to sustain laboratory colonies of predatory species such as *Thanasimus formicarius*, *Temnochila virescens*, *Temnochila caerulea*, and *Clerus mutillarius*, alternative feeding regimes have been developed using the late larval instars of *Plodia interpunctella* and *Ephestia kuehniella*, which are mass-reared as substitute hosts. These production processes are being maintained successfully without disruption.

Keywords: Biological control; *Thanasimus formicarius*; *Ephestia kuehniella*; *Rhizophagus grandis*; *Trissolcus japonicus*

A Synergistic Study on Drying in Tree Species of the Western Black Sea Region (Kastamonu-Sinop): Heavy Metals and Secondary Pests

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Abstract

This study examined the forests of sessile oak (*Quercus petraea* (Matt.) Liebl), black pine (*Pinus nigra* Arnold), and boxelder (*Acer negundo* L.) in the Kastamonu region, as well as in oriental beech (*Fagus orientalis* Lipsky) forests in the Sinop region, examining the phenomenon of physiological desiccation, which has been increasing in recent years, within the context of the combined effects of abiotic and biotic stress factors. In particular, the adverse effects of heavy metals (Cr, Ni, Co, etc.) accumulating in the soil on the trees have been evaluated. High concentrations of heavy metals in the soil inhibit root development, thereby limiting water and nutrient uptake, leading to chronic water stress in the trees and, consequently, triggering the physiological drying-out process. Subsequently, weakened trees become vulnerable targets for secondary pests (bark beetles, fungal pathogens, etc.) that the tree could normally eliminate. Reduced stomatal conductance and disrupted osmotic balance in trees under heavy metal stress create a suitable microhabitat for the proliferation of insect pests. The synergistic interaction between these two factors accelerates the drying process, leading to mass tree mortality. The data obtained indicate that, in forest health monitoring studies, not only biotic factors but also environmental stressors, such as soil contamination, must be evaluated simultaneously.

Keywords: Physiological drying; Heavy metals; Secondary pests; Abiotic stress

Understanding *Leptoglossus occidentalis* (Hemiptera: Coreidae) in Türkiye Through Morphology and The Effect of Low Temperature on The Nymphal Molting Success

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Abstract

The *Leptoglossus occidentalis* Heideman, 1910 (Hemiptera: Coreidae), also known as the western conifer seed bug (WCSB), native to North America and has received increased attention due to its nature, an invasive pest and its rapid distribution to different countries. This species feeds on pine nuts—which have substantial economic importance, especially in Türkiye. In this paper, we presented the morphological characteristics of adult *L. occidentalis.* The adult *L. occidentalis* population of Türkiye shares the same characteristics as overseas WCSB populations, from its antennomeres, body coloration, and appendages, down to its species-specific characteristic—a zigzag line on its coria. The adult *L. occidentalis* population of Türkiye has measurements of body length at 16.39 mm and 18.41 mm, and body width at 5.05 mm and 5.92 mm for male and female, respectively, showing dimorphism. Furthermore, the nymphal stages of *L. occidentalis* include the first instar with a mean body length of 2.98 mm and a mean weight of 0.24 mg. The second instar exhibits a mean length of 5.38 mm and a mean weight of 0.40 mg. The third instar has a mean length of 7.48 mm and a mean weight of 2.00 mg. The fourth instar's body length is 9.35 mm, with a mean weight of 13.61 mg. Finally, the fifth instar reaches a length of 11.59 mm and a weight of 29.12 mg. Additionally, our testing found molting success of *L. occidentalis* nymphs had a negative correlation with temperature, $r = -0.195$, $p = 0.165$, suggesting molting decreases temperature declines.

Keywords: Invasive; Pest; Morphological characteristics; Dimorphism; Pine

Determination of the Biology and Some Morphological Characteristics of *Orthotomicus tridentatus* Eggers, 1921 (Coleoptera: Curculionidae: Scolytinae) in the Eastern Mediterranean Region of Türkiye

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Abstract

Orthotomicus tridentatus, is one of major pests of *Cedrus libani*. It is an endemic species that can cause substantial economic and ecological losses in *C. libani* forests. This study was conducted to determine the biology of *O. tridentatus* in the Eastern Mediterranean region between 2021 and 2024. The biology of the pest was investigated in *Cedrus libani* forests located at an elevation range of 1100 (±50), 1350 (±50), and 1650 (±50) m in Pozantı district of Adana province. In each elevation zone, three replicate trap logs and pheromone traps were placed horizontally. Both the trap logs and pheromone traps were checked every 10 days. The life stages of the pest and other findings in the trap logs were recorded in Field Observation Sheets. In pheromone traps, the specimens that fell into the collection chamber were transferred into jars and labeled for transport to the laboratory. Larvae, pupae, and adult specimens of the species were collected, and their morphological characteristics were examined.

As a result of the study, it was determined that *O. tridentatus* has three generations per year at an elevation of 1100 m under the conditions of the Pozantı region. At elevations of 1350 m and 1650 m, this species has two generations per year. This study is the first to identify that the cedar bark beetle population at 1100 m has three generations per year. The adult length was measured to range 3.38±0.17 mm. The larval length, depending on its developmental stage, varied from 0.47 to 7.38 mm, while the pupal length ranged between 4.95 and 6.05 mm. The main gallery average length was measured 4.2±1.35 cm. It has been determined that a single female lays between 22 and 87 eggs. On the other hand, it was observed that the spring pioneer flights and autumn adult flights of *O. tridentatus* varied from year to year depending on climatic conditions. It has been determined that the summer generation of the pest develops faster than the spring and autumn generations. Adult flights vary both from year to year and depending on elevation.

Keywords: Cedar bark beetle; Adult flight period; Eastern mediterranean region; Multiple generation; Türkiye

Identification of Insect Species Causing Damage in Honduran Forests and Control Studies

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Abstract

In Central America, *Dendroctonus frontalis* Zimmermann is widely regarded as the most dangerous bark beetle affecting pine forests. In an effort to investigate effective control methods against this pest, a biological control and diagnostic laboratory was established in Tegucigalpa, the capital of the Republic of Honduras, with the support of the Turkish Cooperation and Coordination Agency (TİKA). This initiative aimed not only to develop sustainable management approaches but also to identify the key factors that trigger *D. frontalis* outbreaks and the secondary pests that predispose pine forests to infestations. Research has revealed that several secondary bark beetle species, including *D. valens*, *D. approximatus*, *D. adjunctus*, *Ips apache*, *Ips lecontei*, *Ips grandicollis*, *Ips cribricollis* and *Ips calligraphus* play a facilitative role in *D. frontalis* outbreaks by weakening host trees. Within the galleries of these species, predatory beetles such as *Temnoscheila virescens, T. acuta* and *Enoclerus sphegeus* have been identified. Efforts have been made to collect adults and larvae of these natural enemies and to rear them under laboratory conditions for potential use in biological control programs. Due to consistently high temperatures in Honduras, where average air temperatures rarely fall below 20°C throughout the year, bark beetle populations remain active year-round. As a result, continuous management interventions are necessary. Moreover, climate change has been identified as a significant factor exacerbating bark beetle outbreaks, not only by increasing population growth rates but also by enabling these pests to attack otherwise healthy pine trees. Consequently, elevated tree mortality is expected to heighten the risk of forest fires, adding another layer of urgency to integrated pest management efforts.

Keywords: *D. frontalis*; Laboratory; Honduras; *Ips apache*; *Temnoscheila virescens*

Assessment of Tree Mortality Induced by *Pissodes castaneus* (Coleoptera: Curculionidae) in an Anatolian Black Pine (*Pinus nigra* subsp. *pallasiana*) Plantation (Ankara)

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Abstract

Climate change and the associated increase in environmental stress factors can weaken the resistance of coniferous species to biotic agents, particularly in plantation ecosystems. This situation enhances the outbreak potential of certain insect species, especially those considered secondary pests. This study aimed to identify the primary cause of widespread tree mortality observed in an Anatolian black pine (*Pinus nigra* subsp. *pallasiana*) plantation covering approximately 300 hectares within the campus of Başkent University (Ankara). Field surveys were conducted in May 2024, during which trees exhibiting decline symptoms were examined, and damage characteristics and infestation levels were assessed. The results indicated that the main cause of tree mortality was *Pissodes castaneus* (De Geer, 1775) (Coleoptera: Curculionidae). Characteristic emergence holes, feeding galleries, and pupal chambers beneath the bark were observed. The pest was found to damage both shoot and stem tissues, disrupting vascular structures and leading to rapid tree mortality. Data from the Turkish State Meteorological Service revealed reduced precipitation and increased mean temperatures during the winter and spring of 2024. The higher mortality rates compared to previous years suggest a potential link with climatic factors such as drought and elevated temperatures. In addition, the relatively low site quality of the plantation, located under the semi-arid conditions of Central Anatolia, may have facilitated pest development and spread. These findings indicate that *P. castaneus* can reach significant damage levels under favorable environmental conditions. Regular monitoring, particularly in low-quality plantation sites, combined with early detection, mechanical control, and appropriate silvicultural practices, is essential to mitigate such impacts.

Keywords: Small banded pine weevil; *Pinus nigra* subsp. *Pallasiana*; Tree mortality; Plantation

Spatial and Silvicultural Indicators of Stand Susceptibility to *Orthotomicus tridentatus* in *Cedrus libani* Forests: A Case Study from Elmalı Research Forest

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Abstract

As forest ecosystems in the Mediterranean region are increasingly exposed to various environmental stressors. Among these, bark beetle activity has become an important component of forest disturbance dynamics. In this context, this studyinvestigates the spatial and stand-level characteristics associated with the 2025 infestation of *Orthotomicus tridentatus* Eggers, 1921 in *Cedrus libani* A. Rich. forests located in the Elmalı Research Forest, Antalya, Türkiye. The study was conducted across 75 forest compartments using georeferenced forest management data combined with 30-meter resolution digital elevation model (DEM) data. Topographic variables were derived using Horn's gradient algorithm and evaluated alongside silvicultural stand attributes to characterize potential differences between infested and non-infested compartments. Statistical analysis indicated a significant association between crown closure class and the occurrence of infestation (χ^2=5.195, *df*=2, p<0.05). All compartments where infestation was recorded were classified as crown closure Class 3. However, this complete separation limited the ability to reliably estimate comparative effect sizes between density classes. Topographic assessments indicated that infested compartments were more frequently located on southerly and easterly aspects. Variation in the presence of infestation was also observed across elevation gradients. Spatial analysis using Haversine distance suggested that infested compartments were geographically clustered between 300 and 800 meters, aligning with dispersal distances previously reported for *O. tridentatus*. A weighted composite index was developed to classify compartments according to relative risk levels based on stand structure and topographic variables. This index was used to identify compartments that may represent potential susceptibility zones, even in the absence of observed infestation. Overall, the findings suggest that stand density and topographic conditions may be associated with differences in infestation occurrence at the compartment scale. The results are intended to support further monitoring efforts and to provide a basis for more detailed studies on bark beetle–host interactions in *Cedrus libani* ecosystems.

Keywords: Topographic factors; Infestation risk; Spatial clustering

Mistletoe and Bark Beetle Problem in the Scots Pine Forests of the Erzurum Region

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Abstract

In the Erzurum Forest Regional Directorate, the areas where Scots pine (*Pinus sylvestris*) forests exhibit the best growth are north-facing mountain slopes above 2000 m. In the region, the tree line reaches elevations of up to 2700 m. Site quality in these areas is generally classified as Class I and II. However, at lower elevations (1300–1850 m), widespread dieback has been identified in the forests of Oltu, Tortum, Narman, and Şenkaya due to lower site quality.

Field studies revealed a high presence of mistletoe along with significant infestations of bark beetles in standing dead trees, declining individuals, and fallen logs. It was determined that bark beetle populations increased markedly in trees weakened by mistletoe damage. The identified bark beetle species include *Ips sexdentatus*, *Ips acuminatus*, *Orthotomicus erosus*, *Orthotomicus longicollis*, and *Tomicus minor*. Mistletoe occurrence was found to be almost negligible above 2000 m, while it was present between 1850–2000 m but did not cause dieback in these zones.

Analysis of meteorological data indicates that areas experiencing dieback were subjected to exceptionally severe and severe drought conditions, particularly during the period from June 2019 to May 2021. Dieback was observed to decrease gradually from lower elevations up to approximately 1850 m, while it was minimal or absent at higher elevations.

With increasing elevation, climatic conditions improve lower temperatures, higher humidity, and increased precipitation mitigate drought effects. In such environments, trees exhibit healthy growth, and mistletoe and bark beetle presence is either absent or minimal, resulting in negligible dieback. In contrast, drought was identified as the primary factor influencing dieback at lower elevations. Trees weakened and stressed under drought conditions were more susceptible to combined mistletoe and bark beetle damage, leading to both individual and mass mortality events. Furthermore, climate change–induced warming and increasing aridity are expected to exert greater impacts on forest health in the future, potentially intensifying both biotic and abiotic stress factors on forest ecosystems.

Keywords: Drought, *Pinus sylvestris*; *Viscum album*; Scolytinae; Damage

Population Dynamics of *Ips sexdentatus* and Its Predator *Thanasimus formicarius* in Forest Depots in Zonguldak, Bartın and Karabük Provinces

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Abstract

Forest product storage areas can provide suitable ecological conditions for the development and population increase of bark beetles, leading to significant economic losses. This study aims to determine the presence and population dynamics of *Ips sexdentatus* (Börner), an important secondary pest species, and its natural predator *Thanasimus formicarius* (Linnaeus) in forest depots. The research was conducted between April and July 2024 in the Western Black Sea Region of Türkiye, within the jurisdiction of the Zonguldak Regional Directorate of Forestry, in Zonguldak (6), Bartın (3), and Karabük (5) provinces. A total of 14 forest depots were included in the study, of which 11 belong to the General Directorate of Forestry and 3 to private sector companies engaged in forest product trade. Periodic observations and counts were carried out in the selected depots, and the numbers of pest and predator individuals were systematically recorded. Within the scope of the study, a total of 167,239 individuals of *I. sexdentatus* and 876 individuals of *T. formicarius* were detected. The findings indicated that the population of *I. sexdentatus* increased markedly with rising temperatures, reaching peak levels in late spring and early summer. In contrast, the abundance of *T. formicarius* remained relatively low throughout the study period and did not show a proportional increase in response to the growth of the pest population. This suggests that natural predation pressure under depot conditions is insufficient to effectively control the pest population. The results demonstrate that forest depots may act as important reservoirs for bark beetle populations when favorable conditions occur. The novelty of this study lies in its focus on depot environments, which are often overlooked in favor of natural forest ecosystems. These findings highlight the importance of integrating biological control with other pest management strategies to reduce pest risks in stored forest products and to support sustainable forest management.

Keywords: *Ips sexdentatus*, *Thanasimus formicarius*, Forest depots, Bark beetles, Biological control

Influence of Vapor Pressure Deficit on the Radial Growth of Scots Pine (*Pinus sylvestris* L.) Infected by Pine Mistletoe (*Viscum album* subsp. *austriacum* (Wiesb.) Vollm.): A Preliminary Assessment

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Abstract

Vapor Pressure Deficit (VPD), defined as the difference between saturated and actual atmospheric water vapor pressure, is a critical indicator of transpiration potential and environmental stress and plays a decisive role in plant physiology. This study investigated the effects of pine mistletoe (*Viscum album* subsp. *austriacum* (Wiesb.) Vollm.) and VPD on the radial growth of Scots pine (*Pinus sylvestris* L.) stands in the Gümüşhane–Şiran region of Türkiye. A sample plot was established, and the severity of mistletoe infection was evaluated using the Dwarf Mistletoe Rating System (DMRS). A total of 30 trees with similar dendrometric characteristics were selected to ensure homogeneity: 7 trees each from the low and moderate infection classes, and 8 trees each from the high infection and non-infected classes. Increment cores were extracted at breast height from two perpendicular directions of each tree. In the laboratory, the cores were mounted, progressively sanded for improved clarity, and scanned at high resolution to obtain precise annual ring width measurements. Radial growth increments were measured for the 30-year period (1992–2021) using Digimizer software. Final analyses were conducted based on the mean values derived from the two directional measurements for each tree. The results indicated that increasing levels of infection led to severe radial growth losses. Total increment losses were calculated as 19.6%, 58.8%, and 67.7% for the three respective infection levels compared to non-infected trees over the 30-year period. Correlation analysis revealed a significant negative relationship between VPD and all groups (non-infected, low, moderate, and high infection) ($p < 0.05$), indicating that increasing VPD levels significantly suppress radial growth across all tree categories.

Keywords: Dwarf mistletoe rating system; Radial growth loss; Vapor pressure deficit; *Viscum album*; *Pinus sylvestris*

One of the Forest Resources: Edible Insects

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Abstract

Edible insects comprise numerous species belonging to various orders, including Coleoptera, Hymenoptera, Orthoptera, Lepidoptera, Hemiptera, Isoptera, Odonata, Diptera, Neuroptera, Trichoptera, Thysanura, Anoplura, and Ephemeroptera. The egg, larval, pupal, nymphal, and adult stages of insects can be utilized as food in different cultures around the world. Owing to their high protein, fat, vitamin, and mineral contents, they constitute a highly nutritious food source. In addition to their direct inclusion in human diets, edible insects are commonly prepared in baked, boiled, roasted, or fried forms. They may also be used as additives or protein sources in various food products such as chips, pasta, cakes, and confectionery. Furthermore, they are utilized in the production of animal and fish feed, which broadens their role in food systems. Their nutritional value, their ability to reproduce rapidly in a short time, and diversity of use make edible insects a promising alternative for sustainable food and feed production. The aim of this study is to reveal the uses of edible insects that can be regarded as one of the forest resources and to evaluate their relationship with sustainable forest management. Within this scope, national and international literature on the subject was reviewed, and the nutritional characteristics, forms of use, status of edible insects within non-wood forest products, and their connection with forest ecosystems were assessed. The findings indicate that edible insects can be considered non-wood forest products, have considerable potential to contribute to sustainable food and feed production, and should be recognized as biological resources that deserve attention in terms of forest ecosystem conservation and sustainable forest management

Keywords: Food; Forestry; Edible insects; Nature conservation; Non-wood forest products

Poster Presentations

Identification of *Pestalotiopsis caudata* Associated with Tip Blight of Arborvitae (*Thuja plicata*) in Yalova, Türkiye

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Abstract

Thuja plicata (western red cedar) is an important ornamental plant widely used in landscaping and nursery production in Türkiye. In recent years, symptoms such as shoot dieback and browning of scale leaves have been increasingly observed in arborvitae plants in nurseries and landscape areas. In this study, symptomatic arborvitae samples collected from Yalova Province were investigated. Fungal isolates obtained from diseased plant tissues were examined based on colony morphology and microscopic characteristics. On potato dextrose agar (PDA), the fungus produced white mycelium with black acervuli forming as dot-like structures. Microscopic observations revealed that the conidia were five-celled, with the median cells being darkly pigmented and possessing 2–3 septa (typically 3). Conidial dimensions were measured as 18.7–25.1 (22.3 ± 2.5) × 4.3–6.5 (5.5 ± 0.1) µm, with apical appendages measuring 19.9–28.8 (± 8.9) µm and basal appendages 3.5–11.18 (± 2.9) µm. These morphological characteristics were consistent with the diagnostic criteria reported for *Pestalotiopsis* species in the literature. For molecular identification, genomic DNA was extracted from the isolates and PCR amplification was performed using ITS primers. Samples yielding bands after electrophoresis were subjected to sequence analysis, and the obtained sequences were compared with those in the NCBI database. Sequence analysis confirmed the pathogen as *Pestalotiopsis caudata*. Species of *Pestalotiopsis* are known as important fungal pathogens capable of causing needle blight and shoot dieback. Although the presence of *Pestalotiopsis* species on various hosts has been previously reported in Türkiye, records associated with arborvitae are very limited. The results indicate that this pathogen should also be considered in the diagnosis of shoot dieback problems, particularly in nursery production systems and landscape plantings. This study provides the first evidence of the presence of *Pestalotiopsis caudata* on arborvitae in Yalova Province and offers baseline data for future studies on the distribution and epidemiology of the disease.

Keywords: *Pestalotiopsis* sp.; *Thuja plicata*; Arborvitae; Tip blight

Diversity and Occurrence of Powdery Mildew Fungi Associated with Woody Plants Across Urban and Peri-urban Habitats in Çankırı

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Abstract

Urban and peri-urban green spaces provide important ecological and aesthetic benefits, yet trees and woody ornamentals in these habitats are exposed to abiotic stress, human disturbance and introduced plant material, all of which may facilitate the establishment and spread of pathogens. Powdery mildew fungi, members of the Erysiphales, are common biotrophic pathogens of woody plants in urban areas. However, their diversity, distribution and invasive potential in Turkish urban and peri-urban ecosystems remain poorly documented.

This study investigated powdery mildew fungi associated with woody plants across different habitat types in Çankırı, including urban areas, surrounding settlements, urban–rural transition zones, rural areas and forest habitats. Symptomatic leaves were collected from trees, shrubs and woody ornamentals. Selected specimens were further evaluated using DNA sequence data to improve taxonomic resolution.

Our findings revealed several host–fungus associations, including *Sawadaea negundinis* on *Acer negundo*, *Erysiphe platani* on *Platanus orientalis*, *E. flexuosa* on *Aesculus hippocastanum*, *E. quercicola* and *E. alphitoides* on oaks, *E. berberidis* on *Mahonia aquifolium* and *Berberis thunbergii*, *Phyllactinia* spp. on *Fraxinus angustifolia* and *Cornus mas*, *Podosphaera* sp. on *Cydonia oblonga*, and *Leveillula* sp. on *Zygophyllum fabago*. Several of these fungi were observed across multiple habitat types, indicating that powdery mildew fungi are not restricted to urban plantings but may occur along broader urban–rural–forest gradients. Among the detected taxa, *E. platani*, *E. flexuosa* and *S. negundinis* are of particular interest because of their alien or potentially invasive status in Europe and Türkiye. The molecular confirmation of *S. negundinis* on *A. negundo* suggests that some earlier morphology-based records of maple powdery mildews in Türkiye may require re-evaluation. Ongoing studies in Çankırı also examine the prevalence, infection severity and seasonal development of powdery mildew diseases on *A. negundo*, *P. orientalis* and *A. hippocastanum*. Overall, these studies are important not only as fungal inventories, but also for understanding the biodiversity, distribution patterns, ecological drivers and invasive potential of powdery mildew fungi in urban and peri-urban landscapes.

Keywords: Erysiphales; urban trees; Uban–rural gradient; Woody plants; Alien fungal pathogens; *Sawadaea negundinis*

Younger Generations' Perspectives on Urban Trees and Forests Biosecurity: The Case Study of University Students in Türkiye

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Abstract

Urban green spaces (UGSs) play a key role in supporting citizens' daily lives while sustaining urban biodiversity and environmental quality. Within the framework of COST Action CA20132 UB3Guard (https://ub3guard.eu/), this study investigates young generations' perception of urban trees biosecurity and management strategies for major insect pests and pathogens. Three insect pests (Asian longhorn beetle, emerald ash borer, pine processionary moth) and three pathogens (ash dieback, *Phytophthora* spp., canker stain of plane) were considered. Here we present results from the Turkish case study of a broader European survey. A semi-structured questionnaire of 37 questions was administered via the EUsurvey platform, collecting approximately 150 responses from students at Turkish universities. Results indicate a generally low awareness of urban tree biosecurity, with just 39% of respondents reporting familiarity with the concept. Across background, most respondents felt involved in the topic (73%) and interested in further investigation (78%). Knowledge of specific pests and pathogens is also limited, with canker stain of plane being the most recognised organism (49%), while invasive insects remain largely unknown. A "healthy tree" is primarily associated with vigour, abundant foliage and absence of pests/pathogens rather than aesthetic or structural attributes. Management preferences strongly reject no-intervention strategies and favour localized treatments (e.g. soil-based approaches, biological control, and innovative techniques) and, when necessary, replacement with resistant species. The choices are mainly driven by environmental motivations, while aesthetic value and management costs are considered less important. Accordingly, respondents perceive UGSs as providers of ecosystem services and favour scenarios with higher species and structural diversity enhancing system resilience. In Türkiye, these patterns reflect a context of increasing public sensitivity towards urban trees, shaped by long-term urbanisation and green space loss.

Keywords: Urban green spaces; Environmental awareness; Urban forest management; Ecosystem services; Forest pests and pathogens

Post-Fire Insect and Terrestrial Arthropod Community Dynamics in Türkiye: A Systematic Review

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Abstract

This study aims to examine the changes occurring in insect communities following forest fires in Türkiye through a systematic literature review approach. In the forest ecosystems of Türkiye, located within the Mediterranean climatic zone, fire is a fundamental disturbance factor shaping ecosystem dynamics and has significant effects on insect communities, particularly in *Pinus brutia* ecosystems. The literature indicates that the effects of fire on insect populations vary depending on species, trophic group, and successional stage.

Within the scope of this review, studies published in Web of Science, Scopus, and Google Scholar databases were systematically analyzed and evaluated in terms of species richness, abundance, community composition, and functional group changes. Previous studies show that during early post-fire successional stages, increases are observed in certain insect groups (especially saproxylic Coleoptera and some Hymenoptera species), while declines occur in habitat specialists and shade-dependent species. In the long term, it has been determined that insect communities gradually recover in parallel with vegetation regeneration, and distinct community structures emerge at different successional stages.

The limited number of studies conducted in Türkiye and their predominantly regional scale make generalizations difficult; moreover, methodological differences (sampling methods, temporal scales, and taxonomic scope) restrict the comparability of results. Nevertheless, existing findings demonstrate that the effects of fire on insect biodiversity are not unidirectional; rather, fire can create a mosaic habitat structure that provides opportunities for certain groups.

In conclusion, this systematic review presents the current knowledge on post-fire insect community dynamics in Türkiye within a holistic framework and highlights the necessity for standardized methodologies and long-term monitoring studies for future research.

Keywords: Forest fire; Insect communities; Succession; Türkiye

Species Distribution Modeling of the Pine Processionary Moth in the Coniferous Forests of Kastamonu and Sinop under Current and Future Climate Scenarios

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Abstract

The pine processionary moth (*Thaumetopoea pityocampa* and *Thaumetopoea wilkinsoni*, Notodontidae, Lepidoptera) is an significant herbivorous species that damages coniferous forests and plantations, particularly in the Mediterranean region and Türkiye. Global climate change is altering the distribution ranges of forest defoliators, often facilitating their expansion into previously unsuitable habitats.

This study aimed to assess changes in the potential distribution of the pine processionary moth in Kastamonu and Sinop, two major forested regions of the western and central Black Sea region, under projected climate change scenarios. Habitat suitability modeling was conducted using MaxEnt 3.4.1, which implements the maximum entropy approach. Future climate projections for the study region were obtained from the WorldClim database, based on the HadGEM3-GC31-LL global climate model for future periods 2021–2040, 2041–2060, 2061–2080, and 2081–2100 under SSP1-2.6 and SSP5-8.5 scenarios, while current conditions were represented using the baseline WorldClim layers. Habitat suitability was classified into four categories: highly suitable, suitable, low suitability, and unsuitable.

Evaluation of the model results indicates that temperature seasonality (BIO4), precipitation of driest month (BIO14), and precipitation of warmest quarter (BIO18) are the most influential climatic variables shaping the species' distribution. Although some fluctuations in distribution areas are projected under future climate scenarios, highly suitable and suitable habitats are generally expected to expand over time, while low suitability and unsuitable areas are likely to remain largely stable or decrease slightly. These findings highlight the potential risk of range expansion under climate change and emphasize the need for targeted monitoring and management in regions predicted to become increasingly suitable.

Keywords: *Thaumetopoea wilkinsoni / Thaumetopoea pityocampa*; MaxEnt modelling; Habitat suitability; Climate change effects; Forest pest management

The Potential of Wood-decay Fungi in Bio-fabrication and Sustainable Material Production

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Abstract

White and brown rot fungi (*Pleurotus ostreatus*, *Ganoderma lucidum*), which maintain the carbon cycle in nature, have the ability to degrade wood through the enzymes they secrete. This mechanism, viewed for years in traditional forest pathology as a "wood defect" or a cause of disease, is actually at the center of innovative bio-fabrication processes today. This review study addresses this fundamental shift in approach within forest pathology and examines the potential of mycelium as a structural biological binder.

In this production process, which is based on controlled solid-state fermentation (substrate preparation, sterilization, inoculation, incubation, and thermal inactivation), the performance of the resulting mycelium composites directly depends on the selected lignocellulosic framework. For example, sawdust, acting as the main framework, provides the material with high compressive strength, while hemp fibers act as a reinforcing element, significantly increasing the flexural strength of the material. When this biomechanical synergy created by sawdust and hemp is combined with the natural water-repellent and porous structure of mycelium, it results in ultra-lightweight composites with highly successful thermal and acoustic insulation. On the other hand, the collagen-like structure of the mycelial network also offers a strong and eco-friendly "mycelium leather" alternative to animal or synthetic leathers in the textile industry.

Providing an eco-friendly alternative to non-biodegradable synthetic foams like Expanded Polystyrene (EPS) foam, these compostable materials directly serve the circular economy through the upcycling of low-economic-value forest waste. Consequently, forest pathologists, who have the best command of fungal wood degradation dynamics and pathogen-substrate relationships, are expected to take on a much more active and pioneering role in these new bio-engineering processes.

Keywords: White-rot fungi; Mycelium biocomposites; Mycelium leather; Solid-state fermentation; Lignocellulosic biomass; Enzymatic degradation

Seasonal Occurrence and Urban Habitat use of the European Starling (*Sturnus vulgaris*) in Kastamonu City Center: A Review on its Potential Role in Biological Control

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Abstract

Biological control plays a significant role in sustainable pest management in both forest and urban ecosystems. While predatory arthropods are prominent in biological control efforts, the role of insectivorous birds is also quite important. European starling (*Sturnus vulgaris*) is a widely distributed and highly adaptable bird species frequently found in large flocks in urban environments. Previous studies have shown that European starlings consume insects predominantly belonging to the taxa of Coleoptera, Diptera, Lepidoptera (larval stages), and Hemiptera. This feeding range suggests that the species may exert a natural suppressive effect on populations of soil-dwelling and plant-associated insect pests. Local observations indicate that *S. vulgaris* is found in large swarms in the city center of Kastamonu, mainly in autumn, occupying urban green spaces such as parks and street tree plantings. The species typically uses the area as a temporary resting place and migrates in November and December. In particular, the frequent gathering of starlings on plane trees (*Platanus* spp.) has led to public complaints due to the heavy defecation. However, these sycamore trees are also frequently affected by the sycamore lace bug (*Corythucha ciliata*), a significant urban tree pest. Although direct feeding analyses have not been conducted, the known feeding behavior of *S. vulgaris* suggests a possible trophic interaction with insect pests associated with urban trees. Therefore, the presence of European starlings in urban environments should be evaluated not only as a management issue but also within the framework of urban biological control and ecosystem services. This review aims to assess the seasonal presence of *Sturnus vulgaris* in Kastamonu city center, its urban habitat use, and its potential role in biological control, based on published literature and local ecological observations.

Keywords: European Starling; Biological control; Pest control; Urban ecology; Kastamonu; Türkiye

Entomological Effects of Wildlife Damage in Forest Ecosystems

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Abstract

Wildlife plays a fundamental role in shaping forest ecosystems; however, excessive or unbalanced wildlife activity can lead to significant ecological disturbances with important entomological consequences. This study examines the multifaceted impacts of wildlife-induced damage on insect communities and their functional roles within forest ecosystems. Large herbivores such as deer and wild boar, along with smaller mammals and birds, cause physical damage through browsing, bark stripping, trampling, and soil disturbance. These disturbances weaken trees, reduce regeneration success, and alter habitat structure and microclimatic conditions. Such changes create new ecological niches that directly influence insect diversity, abundance, and behavior. On one hand, damaged and stressed trees become highly susceptible to colonization by secondary insect pests, particularly bark beetles and wood-boring species, which can initiate population outbreaks and accelerate tree mortality. On the other hand, the accumulation of deadwood and altered vegetation structure can enhance habitats for saproxylic insects and other decomposer communities, thereby increasing biodiversity in certain contexts. The entomological effects of wildlife damage are therefore not unidirectional but involve complex interactions among herbivores, host plants, and insect assemblages. These interactions can shift ecosystem processes such as decomposition, nutrient cycling, and energy flow. Furthermore, ongoing climate change may intensify both wildlife pressure and insect population dynamics, amplifying their combined impacts on forest health. This study highlights the need for an integrated perspective that considers wildlife–insect–plant interactions in forest management strategies. Understanding these linkages is crucial for predicting ecosystem responses, mitigating pest outbreaks, and maintaining the resilience and sustainability of forest ecosystems under increasing environmental pressures.

Keywords: Forest ecosystems; Wildlife damage; Bark beetles; Forest health; Biotic interaction

DNA Barcoding of Predatory Neuroptera Species with Biological Control Potential in Forest-associated Habitats of Eskişehir, Türkiye

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Abstract

Neuroptera includes many predatory insect species that feed on aphids, psyllids, mites and other soft-bodied arthropods. Due to these feeding habits, predatory Neuroptera species are considered important natural enemies with potential roles in biological control. Accurate identification of these taxa is essential for evaluating their ecological importance and possible contribution to sustainable pest management. However, morphological identification may be difficult in closely related or morphologically similar species; therefore, DNA barcoding provides a useful complementary approach for reliable species identification. In this study, adult Neuroptera specimens collected by light traps from semi-natural green habitats in Eskişehir, Türkiye, were identified using DNA barcoding. The mitochondrial cytochrome oxidase I gene region was used for molecular identification. DNA extraction, PCR amplification, gel electrophoresis and sequence evaluation were carried out following standard DNA barcoding protocols. The obtained sequences were compared with reference databases and evaluated for species-level identification. As a result, four species belonging to the genera *Helicoconis*, *Coniopteryx* and *Nemoptera* were identified, and a total of 24 sequences were obtained. Sequence lengths were approximately 657–658 bp, and nucleotide composition showed a high A+T ratio. These findings indicate that DNA barcoding is an effective tool for supporting the identification of predatory Neuroptera species. The study contributes to the molecular documentation of Neuroptera diversity in Eskişehir and provides baseline data for future taxonomic, ecological and biological control studies. In this context, the results may support the recognition of predatory Neuroptera as potential natural enemies in forest-associated habitats.

Keywords: DNA barcoding; COI gene; Neuroptera; Biological control; Forest entomology

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Proceeding

Forest Health Monitoring with Remote Sensing: A Preliminary Study on Multi-Term Analysis of Pine Processionary Moth Damage

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Abstract

The pine processionary moth (*Thaumetopoea* spp.) is one of the main pest species commonly found in coniferous forest ecosystems in Turkiye, causing significant needle loss. Particularly active in early spring, this species reduces the photosynthetic capacity of trees, leading to growth losses and posing a significant threat to forest health through defoliation and physiological stress in the long term. In this context, an analysis application has been developed on the cloud-based Google Earth Engine platform to monitor pest-induced stress temporally and spatially. Within the scope of the application, NDVI, NDMI, and NBR plant indices for the March-April period, when the pest's impact was particularly pronounced, were calculated and analyzed using Sentinel-2 satellite data obtained from Corum, Samsun, Sinop, and Kastamonu provinces, where field studies were conducted, and damage was detected. Multi-year time series were obtained from buffer zones around the selected sample points to minimize phenological effects and more accurately capture pest-related changes. In analyses covering the years 2021–2026, anomaly analysis based on interannual differences was performed, and Z-scores were calculated using long-term mean and standard deviation values to assess statistical deviations. The results show that Z-scores mostly range between -0.5 and -1.0, corresponding to low to moderate stress levels, while severe stress situations ($Z < -1.5$) have not yet been observed. Additionally, while NDVI shows relatively moderate or near-normal variations in some locations, NDMI and NBR indices exhibit more pronounced negative anomalies in the same areas, suggesting moisture-related and structural vegetation stress that may not be fully captured by greenness-based indicators alone. This developed approach offers a feasible and innovative decision support tool for the early detection, monitoring, and planning of effective control strategies for pine processionary moth damage.

Keywords: *Thaumetopoea* spp.; Google Earth Engine; Remote Sensing; Türkiye

INTRODUCTION

Climate change and global warming increase abiotic stresses on forest ecosystems, directly affecting the population dynamics, distribution, and damage thresholds of biotic pests (Ayres and Lombardero, 2000; Netherer and Schopf, 2010). One of the most important primary pests causing mass defoliation in coniferous forest areas is the pine processionary moth (*Thaumetopoea* spp.) (Avcı, 2000). This phytophagous insect species dramatically reduces photosynthetic capacity by consuming needles, the assimilation organs of trees, especially in early spring, through larval feeding. Although pine species produce new shoots in the following months, repeated defoliations in successive years weaken the physiological resistance of the

trees, lead to radial growth losses, and create a breeding ground for secondary pest infestations, thus threatening forest health and ecosystem sustainability in the long term (Jacquet et al., 2012).

Traditional forest health monitoring methods rely heavily on human-based field inventories, local trap data, and visual observations. However, these approaches present logistical challenges in large and rugged terrains, require high costs, and are insufficient in terms of temporal resolution for capturing the initial stages of damage (Wulder et al., 2006). Satellite remote sensing technologies, especially with the accessibility of multispectral data such as Sentinel-2, have played a major role in the dynamic and effective monitoring of forest health (Drusch et al., 2012). In addition, cloud-based geographic data processing platforms such as Google Earth Engine (GEE) enable processing of petabytes of satellite archives with pixel-level time-series analysis without the limitations of local computer hardware (Gorelick et al., 2017).

Although the Normalized Difference Vegetation Index (NDVI) is commonly used in the literature for monitoring forest pests and defoliation (Rouse et al., 1974), this index, which is based only on visible red (Red) and near infrared (NIR) bands, may experience saturation problems against early microscopic changes in dense canopy structure and needle leaf moisture content. In this study, based on the March-April period when the insect is most active and its damage becomes visible; In addition to the chlorophyll-sensitive NDVI, the Normalized Difference Moisture Index (NDMI) (Gao, 1996), which includes short-wave infrared (SWIR) bands and is sensitive to plant water stress, and the Normalized Burn Rate (NBR) (Key and Benson, 2006), which is sensitive to changes in canopy openings and lies between fire and structural degradation indices, were evaluated together.

The aim of the study is to process multi-temporal Sentinel-2 data from 2021 to 2026 in sample areas determined in Çorum, Samsun, Sinop, and Kastamonu provinces on GEE, to reveal deviations in plant indices using Z-score-based anomaly analysis, and to evaluate the advantages of the multi-index approach in early diagnosis.

MATERIALS AND METHODS

Study Area and Data Set

This study covers pure and mixed coniferous forest areas in Çorum, Samsun, Sinop, and Kastamonu provinces, located in the Black Sea Region and Central Anatolian transition zone of Türkiye, where pine processionary moth (*Thaumetopoea* spp.) damage is frequently observed, and reference points were collected through field studies (Figure 1).

Figure 1. Study area

The analyses utilized Sentinel-2 MultiSpectral Instrument (MSI) Level-2A reflectance data provided by the European Space Agency (ESA). From this atmospherically corrected data, images from March and April, when pest feeding activity peaks and needle loss is visible, were filtered. Cloud, shadow, and snow masking algorithms were applied to clean the pixels, and median composite images were generated for each year.

Calculation of Plant Indices

To comprehensively investigate the spectral effects of the pine processionary moth on plant health, moisture content, and canopy structure, three key spectral indices were calculated. The formulas for these indices are given below:

Normalized Difference Vegetation Index (NDVI): Used to determine cellular structure and chlorophyll activity.

$$NDVI = (NIR - RED) / (NIR + RED)$$

Normalized Difference Moisture Index (NDMI): Calculated to capture water content in needles and canopy moisture stress.

$$NDMI = (NIR - SWIR1) / (NIR + SWIR1)$$

Normalized Burn Rate (NBR): Integrated to monitor structural damage and biomass changes caused by defoliation.

$$NDVI = (NIR - SWIR2) / (NIR + SWIR2)$$

Time Series, Buffer Analysis and Z-Score Based Anomaly Analysis

Buffer zones were created around verified damage points from field observations to minimize positional errors and phenological effects arising from local geographic and topographic variations and pixel shifts. Temporal statistics of pixels within these buffer zones were extracted using regional statistic functions in the GEE environment.

In the time series covering the period 2021–2026, long-term pixel-based mean (μ) and standard deviation (σ) values were calculated for each index. Then, Z-Score analysis was applied to statistically determine how much the relevant year (x) deviated from these historical norms:

$$Z = \frac{x-\mu}{\sigma}$$

The stress levels in forest areas were classified using calculated Z-scores. Negative Z-scores indicate a lower-than-normal plant stress condition.

RESULTS AND DISCUSSION

As a result of multi-temporal analyses conducted between 2021 and 2026, the spectral reflections of pine processionary moth damage in the examined sample areas were clearly mapped and graphed.

When the spatial and temporal distributions of the calculated Z-scores were examined, the general stress level in the study areas was predominantly concentrated between -0.5 and -1.0. According to the literature, these values are considered mild to moderate vegetation stress. Very severe stress situations (Z < -1.5), which are widespread and indicate sudden collapses, were observed relatively less frequently during the study period. This suggests that the pest population has not yet reached epidemic levels or that the biological/mechanical control measures of the forest management directorates are effective.

The most striking finding of the study is the behavioral difference in the sensitivities of the indices. While NDVI values exhibited normal or near-normal variations (Z ≈ 0 or slightly negative) in some localized damage foci; NDMI and NBR indices showed significantly higher negative anomalies (negative Z-scores) in the same coordinate and time period (Figure 2).

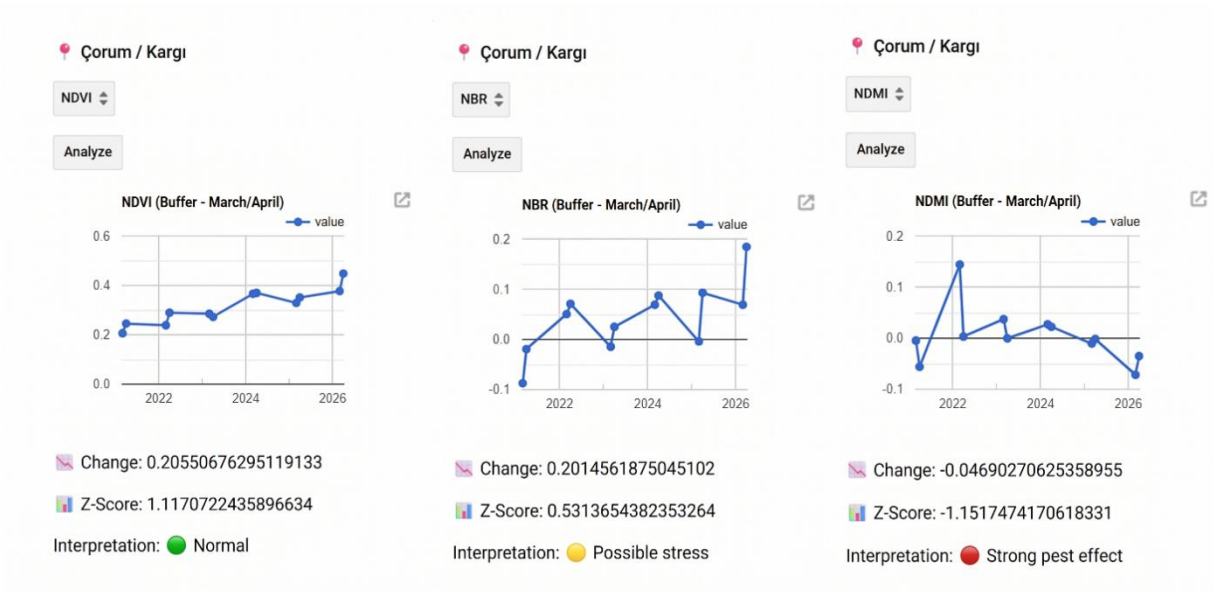

Figure 2. Multiple spectral index trends and anomaly classifications for a selected damage focus (Çorum/Kargı)

The primary reason for this is that during the process of pine processionary moth larvae consuming needles, the initial damage in the tree is not so much foliage loss as a decrease in cellular water content (detected by NDMI) and disruption of canopy geometry (detected by NBR). It has been shown that relying solely on the foliage-focused NDVI index can miss early-stage insect damage in pine forests, whereas integrating SWIR-based NDMI and NBR provides a much more sensitive early-warning mechanism for detecting anomalies.

CONCLUSION

This preliminary study successfully monitored pine processionary moth damage in the Western and Central Black Sea transition zone using multispectral index anomaly analysis on the cloud computing platform Google Earth Engine on the cloud computing platform Google Earth Engine. The high temporal resolution of Sentinel-2 data and the high sensitivity of SWIR bands to vegetation stress increased the accuracy in forest health monitoring studies.

This developed approach offers an innovative, dynamic, and low-cost decision support tool for the General Directorate of Forestry (OGM) and relevant decision-makers in early diagnosis, determination of the extent of damage, and planning of localized control strategies.

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Climate Change, *Ips typographus* Dynamics and Biological Control by *Thanasimus formicarius* in the Republic of Georgia

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Abstract

Climate change is increasingly influencing forest ecosystems by altering temperature and precipitation patterns, thereby affecting the population dynamics of forest pests. In Georgia, these changes have contributed to the expansion and increased outbreak frequency of *Ips typographus*, a major pest of *Picea orientalis* L. Warmer temperatures and prolonged drought periods weaken host trees, making them more susceptible to beetle colonization and facilitating rapid population growth and multivoltine development. Recent observations indicate that *I. typographus* has expanded its distribution in mountainous regions of Georgia, causing significant ecological and economic damage, with infestation levels reaching up to 70–80% of standing spruce trees in some areas. Increased overwinter survival and accelerated life cycles further enhance outbreak potential.

The aim of this study was to determine the abundance of *I. typographus* under different temperature conditions using pheromone traps placed on spruce trees in the Borjomi region and to compare population dynamics between two locations. The number of attracted insects varied, and an increase in temperature was associated with an increase in pest abundance. At 21–23°C, 247 and 391 adults were captured; at 24–26°C, 366 and 404; at 28–30°C, 580 and 520; and at 32–35°C, 668 and 565 individuals at the two respective sites.

Control of bark beetles is challenging because *I. typographus* spends most of its life cycle beneath the bark. A promising approach is biological control using natural enemies, particularly the predatory beetle *Thanasimus formicarius*. This predator feeds on both adult and larval stages, reducing pest populations. In both study sites, *T. formicarius* was detected at temperatures above 26°C, coinciding with peak pest abundance. Field and laboratory studies support its role in regulating bark beetle populations.

In conclusion, climate change is expected to exacerbate the impact of *I. typographus* in Georgia; however, biological control by *T. formicarius*, combined with integrated forest management, offers a promising and environmentally friendly strategy for mitigating future outbreaks. Further research is needed under changing climatic conditions.

Keywords: Pest; *Ips typographus;* Climate change

INTRODUCTION

Climate change has become one of the most significant drivers of ecological transformation in forestecosystems worldwide. Rising temperatures, altered precipitation regimes, and the increased frequency of extreme weather events are reshaping interactions between trees and insect pests.

It is widely recognized that climate change can alter both the frequency and intensity of forest pest outbreaks (Volney & Fleming, 2000); however, these effects are not uniform, as outbreaks may be either enhanced or reduced depending on specific climatic conditions (Lehmann *et al.*, 2020). The response of insect pests largely depends on the intensity of climatic stressors as well as species specific ecological traits (Bracalini *et al.,* 2024).

Bark beetles, in particular, have shown strong responses to climate variability due to their sensitivity to temperature and host tree condition. Climate change can positively influence bark beetle populations by shortening generation time, increasing survival, and facilitating their spread, which may lead to outbreaks of native populations. Elevated temperatures accelerate metabolic rates, enhancing development and dispersal capacity while reducing mortality, ultimately resulting in higher population densities (Nardi, *et al*., 2002; Nordlander, et al., 2003; Juhász, *et al*., 2020;)

Climate change also affects interactions between insect pests and their host plants. For example, specialist insects that are closely synchronized with host plant phenology may be negatively affected by shifts in plant development stages (Bracalini *et al.,* 2024). At the same time, drought stress and other environmental pressures can weaken host trees, reducing their defense mechanisms and increasing their susceptibility to pest colonization.

To mitigate the negative impacts of forest pests, various management strategies have been developed, including monitoring systems and early detection techniques aimed at minimizing damage (Abdullah, *et al.,* 2018; Bentz, *et al.,* 2015;). However, these approaches often do not fully consider long-term ecological consequences or the well-being of non-target organisms, such as parasitoids and other arthropods (Khanday, *et al.,* 2019;). Because pest population dynamics are also regulated by natural enemies, it is essential to consider how these beneficial organisms respond to changing climatic conditions.

Among forest insect, bark beetles are the most dangerous pests. *Ips typographus* (L.), commonly known as the European spruce bark beetle, is one of the most destructive pests of spruce forests across Eurasia. Under favorable climatic conditions, *I. typographus* populations can increase rapidly, leading to large-scale outbreaks and extensive tree mortality. It is an economically important insect not only in Europe but in the Caucasus as well. In Georgia, it primarily attacks Oriental spruce, *Picea orientalis* L., one of the dominant forest-forming species in Georgia and economically important species in mountainous forest ecosystems, while in Central and Northern Europe, it attacks mainly Norway spruce, *P. abies* LINNAEUS. During the XX century, between 1.2 and 22 million cubic metres of spruce trees were regularly killed by the pest during outbreaks in various parts of Europe (CAB International, 2004).

Recent climatic trends in Georgia, including rising average temperatures and prolonged drought periods, have created favorable conditions for bark beetles, especially for *I. typographus* development. These changes weaken host trees, reduce their defensive capacity, and enable the

pest to complete multiple generations per year. Therefore, understanding the relationship between temperature and pest population dynamics is essential for developing effective forest protection strategies.

Within Integrated Pest Management biological control represents a sustainable and environmentally friendly alternative to chemical methods. Among the natural enemies of bark beetles, the predatory beetle *Thanasimus formicarius* (L.) plays a significant role in regulating *I. typographus* populations by feeding on both adult and larval stages.

Therefore, the aim of this study was to investigate the effect of temperature on the abundance of *I. typographus* and to evaluate the potential role of *T. formicarius* as a biological control agent under the climatic conditions of the Republic of Georgia.

MATERIALS AND METHODS

Study Area

The study was conducted in the Borjomi region of Georgia, characterized by mountainous terrain and dominated by *Picea orientalis* forests. Two study sites with similar forest composition but slightly different microclimatic conditions were selected for comparative analysis.

Insect Monitoring

Population dynamics of *Ips typographus* were monitored using aggregation pheromone traps Ipsowit- a widely used aggregation pheromones designed by Witasek. Traps were checked regularly, and the number of captured individuals was recorded. Temperature data were simultaneously collected to assess the relationship between climatic conditions and beetle activity.

Data Analysis

Captured insect numbers were grouped according to temperature intervals (21–23°C, 24–26°C, 28–30°C, and 32–35°C). Comparative analysis between the two study sites was performed to evaluate spatial variation in population dynamics. Observations of *Thanasimus formicarius* presence were also recorded.

RESULTS

Temperature and Ips typographus Abundance

The results demonstrated a clear positive relationship between temperature and beetle abundance. At lower temperatures (21–23°C), captures were relatively moderate, with 247 and 391 individuals recorded at the two sites (Table 1).

As temperatures increased to 24–26°C, the number of beetles rose to 366 and 404 individuals. A substantial increase was observed at 28–30°C, with 580 and 520 individuals captured. The highest abundance occurred at 32–35°C, where 668 and 565 individuals were recorded.

These findings indicate that higher temperatures significantly enhance beetle activity and population growth.

Table 1. Abundance of *Ips typographus* captured in pheromone traps under different temperature conditions at two study sites

Temperature (°C)	Site 1	Site 2	Mean Abundance
21–23	247	391	319
24–26	366	404	385
28–30	580	520	550
32–35	668	565	616.5

A clear positive relationship between temperature and *Ips typographus* abundance was observed at both study sites. Beetle captures increased steadily with rising temperature, reaching maximum values at 32–35°C. Mean abundance increased from 319 individuals at 21–23°C to 616.5 individuals at 32–35°C. Differences between the two sites were relatively small, with total captures of 1861 and 1880 individuals, respectively, indicating similar population dynamics across locations.

Occurrence of Thanasimus formicarius

The predatory beetle *T. formicarius* was detected at both study sites at temperatures above 26°C. Its presence coincided with peak populations of *I. typographus*, suggesting a potential density-dependent response.

So, the analysis revealed a clear increasing trend in *I. typographus* abundance with rising temperature. The effect of temperature approached statistical significance ($F = 6.38$, $p \approx 0.08$), indicating a strong influence on beetle population levels, although it did not reach the conventional significance threshold of $\alpha = 0.05$. Nevertheless, the consistent increase in mean abundance from 319 individuals at 21–23°C to 616.5 individuals at 32–35°C suggests a biologically meaningful relationship between temperature and pest activity.

DISCUSSION

There is currently a lack of knowledge regarding the impact of climate change on *Ips typographus* population outbreaks in Georgia. The present study, conducted in the Borjomi region, demonstrates that higher temperatures significantly enhance beetle activity and population growth. In addition, the predatory beetle *Thanasimus formicarius* was detected at both study sites at temperatures above 26°C, and its presence coincided with peak populations of *I. typographus*. This finding suggests a potential density-dependent response of the predator *T. formicarius*.

Historically, in Georgia, *I. typographus* primarily attacked trees weakened by *Dendroctonus micans* Kugel (Shavliashvili & Zharkov, 1985). The first occurrence of *I. typographus* in Georgia was reported by Linderman in 1881 (cited in Zaitsev, 1950). Since then, the species has spread across various regions, either through natural migration or via timber transport (Lozovoi, 1965). However, it was not considered a major forest pest until favorable ecological conditions triggered a large-scale outbreak around the year 2000 (Kereselidze et al., 2010). Currently, infestation levels reaching up to 70–80% in some areas highlight the severity of the problem. These processes are particularly concerning given the vulnerability of *Picea orientalis* forests in Georgia.

At present, it remains unclear how *I. typographus* outbreaks will develop in the future. In the mountainous Borjomi region, 61% of forests (approximately 22,400 hectares) consist of conifers, of which the majority (18,000 hectares) is dominated by spruce (*Picea orientalis*). Bark beetle populations are known to increase continuously and establish new foci of attack, particularly in structurally weakened spruce stands. These dynamics are influenced by vertical temperature variation and local water stress conditions. However, pest prevalence and population growth may vary significantly across different geographical regions (Girits, 1975).

The results of the present study emphasize the importance of continued investigation into bark beetle outbreaks, particularly those of *I. typographus*, as well as the occurrence and ecological role of *T. formicarius* under varying temperature conditions and across different geographical zones. Extensive research has already been conducted on the assemblages of natural enemies associated with bark beetles, both in Georgia and internationally (Wegensteiner & Weiser, 1995; Wegensteiner, 2004; Kereselidze et al., 2007; Yaman, 2006).

The present study highlights the need for further research on natural enemies, especially *T. formicarius*. Biological control using this predator represents a promising approach for mitigating bark beetle outbreaks. As a specialized predator, it targets both larval and adult stages of *I. typographus*. Its synchronized occurrence with high pest densities suggests that it may play a significant role in natural population regulation.

However, biological control alone may not be sufficient. Integrated forest management strategies—including sanitation cutting, monitoring, and habitat management—are essential for effectively controlling outbreaks under changing climatic conditions.

CONCLUSIONS

Overall, our study supports the conclusion that increasing temperature is associated with higher *Ips typographus* abundance. Warmer conditions accelerate development, increase reproductive rates, and enable the species to produce multiple generations within a single season. These findings are consistent with the hypothesis that rising temperatures under climate change scenarios may enhance bark beetle population growth and outbreak potential.

Furthermore, the increase in *I. typographus* populations was accompanied by a corresponding increase in *Thanasimus formicarius* at the same locations. Among the natural enemies of bark beetles, *T. formicarius* may play a significant role in regulating *I. typographus* populations.

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Identification of Insect Species Damaging the Acorns of Selected Oak (*Quercus* spp.) in the Aegean Region of Turkiye

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Abstract

This study aimed to identify insect species causing damage to the acorns of *Quercus ithaburensis* Decne. subsp. Macrolepis (Kotschy) Hedge & Yaltırık, *Quercus cerris* var. *Cerris* (Willd.) and *Quercus aucheri* Jaub. & Spach in the Aegean Region of Türkiye.

For each oak species, three sampling sites were selected. At each site, 20 mature trees were randomly chosen, and their geographic coordinates, elevation and aspect were recorded. Acorns were collected from the field were transferred to rearing containers under laboratory conditions to allow insect emergence.

As a result of the study, five insect species belonging to Lepidoptera were identified as acorn pests: *Apomyelois ceratoniae* (Zeller, 1839) (Pyralidae), *Cydia amplana* (Hübner, 1799), *Cydia fagiglandana* (Zeller, 1841), *Cydia splendana* (Hübner, 1799), and *Pammene gallicolana* (Lienig & Zeller, 1846) (Tortricidae). These species are considered to pose a significant risk to acorn viability and natural regeneration of oak forests in the region.

Keywords: *Quercus ithaburensis*; *Quercus cerris*; *Quercus aucheri*; acorn pests

INTRODUCTION

Global climate change is expected to increase the average global temperature by up to 6.4 °C by the end of the 21st century (2090–2099) relative to the 1980–1999 baseline period, primarily due to anthropogenic greenhouse gas emissions. Rising temperatures and changing precipitation patterns are projected to intensify drought stress, particularly in continental regions. The Mediterranean Basin is considered one of the areas most vulnerable to climate change, and Türkiye is expected to experience more frequent droughts and reduced annual precipitation (Gao & Giorgi, 2008). These changes highlight the importance of conserving drought-tolerant tree species and ensuring their successful regeneration.

The genus *Quercus* (Fagaceae) comprises approximately 600 species worldwide, including 18 species and 22 taxa in Türkiye (Davis, 1965; Seçmen et al., 1989). Oaks are ecologically and economically important because of their adaptability, longevity, and contribution to biodiversity.

However, successful regeneration depends largely on healthy acorn production, which is often reduced by seed-feeding insects. Although acorn-associated insects have been studied in several European oak species, information on Turkish oaks remains limited.

Among Turkish oaks, *Quercus cerris* var. *cerris* is valued for its drought tolerance, adaptability to various soil types, and strong coppicing and germination capacity (Rigo et al., 2016). *Quercus ithaburensis* subsp. *macrolepis* is economically important because its acorn cups are used in the tanning and dye industries, while its acorns also represent a valuable natural resource (Seçmen et al., 1989; Öztürk et al., 1990; Baytop, 1991; Zeybek, 1994; Bainbridge, 2001). *Quercus aucheri*, an endemic species of southwestern Anatolia, has limited natural regeneration, making the identification of acorn-damaging insects important for its conservation.

Despite the ecological and economic importance of these oak taxa, information on their acorn-associated insect fauna is still scarce. The aim of this study was to identify the insect species associated with the acorns of *Quercus cerris* var. *cerris*, *Quercus ithaburensis* subsp. *macrolepis*, and *Quercus aucheri*, and to provide baseline information that will support future conservation, regeneration, and sustainable forest management practices.

MATERIALS AND METHODS

This study was conducted on three oak species naturally distributed in the Aegean Region of Türkiye: *Quercus ithaburensis* Decne., *Quercus cerris* var. *cerris* (Willd.), and *Quercus aucheri* Jaub. & Spach.

To ensure adequate representation of each species' ecological distribution range, five sampling sites were selected per species based on their known natural occurrence. Site selection considered geographic distribution patterns and habitat heterogeneity. A total of 13 sampling sites were established across İzmir, Manisa, Uşak, Muğla, and Aydın provinces (Table 1).

Table 1. Sampling locations, host *Quercus* species, altitude, and geographic coordinates of the study sites

Serial number	Tree species	Location	Altitude (m)	Latitude and longitude
1	*Quercus ithaburensis*	İzmir-Seferihisar	65	38 10 00-26 50 26,7
2	*Quercus ithaburensis*	Uşak-Banaz	921	38 41 29,8-29 44 58,1
3	*Quercus ithaburensis*	Manisa-Selendi	459	38 44 14,1-29 52 32,4
4	*Quercus ithaburensis*	Manisa-Kula	459	38 36 52,6-28 28 30,2
5	*Quercus ithaburensis*	Manisa-Gördes	722	38 50 39,8-28 18 56,9
6	*Quercus aucheri*	Muğla-Bodrum-Ortakent	77	37 02 69,6-27 20 14,2
7	*Quercus aucheri*	Muğla-Bodrum-Trafo	144	37 03 59,9-27 21 08,8
8	*Quercus aucheri*	Muğla-Marmaris-Bozburun 1	46	36 36 04,2-28 03 77,6
9	*Quercus aucheri*	Muğla-Marmaris-Bozburun 2	31	36 35 54,0-28 03 16,3
10	*Quercus cerris*	İzmir-Ovacık 1	1125	38 21 48,6-27 42 07,1
11	*Quercus cerris*	İzmir-Ovacık 2	1094	38 21 45,4-27 42 43,4
12	*Quercus cerris*	İzmir-Ödemiş	913	38 20 14,3-27 56 91,9
13	*Quercus cerris*	Uşak-Banaz	939	38 41 49,7-29 45 32,4

At each sampling site, twenty mature and healthy trees were selected as sampling units. For each individual tree, geographic coordinates (GPS-based), elevation, and aspect were recorded to characterize site conditions and enable spatial analysis.

Seed sampling was conducted during the fruiting season (October–November 2017). In the first sampling year (2017), acorns were collected separately from the northern and southern aspects of each tree crown (20 acorns per aspect) to explore the possible influence of crown orientation and associated microclimatic conditions on insect infestation. Crown orientation was initially considered a potentially important factor because differences in solar radiation, temperature, and humidity may influence insect oviposition behaviour and larval development. However, preliminary evaluation of the 2017 material indicated that the number of infested acorns and emerged adults was insufficient to provide statistically reliable comparisons between crown aspects. Furthermore, infestation levels varied considerably among host species and localities, reducing the statistical power of aspect-based analyses. Therefore, the aspect variable was not included in the final analyses, and subsequent sampling (2018–2019) focused on increasing the number of sampled acorns per tree regardless of crown orientation in order to improve the reliability of species detection and infestation estimates.

In the subsequent sampling years (2018 and 2019), fifty seeds per tree were collected without consideration of crown orientation, in order to increase sample size.

All collected seeds were labeled according to species, site, tree number, and sampling year to ensure traceability and data integrity throughout subsequent laboratory analyses.

For infestation assessments, a standardized subsample consisting of 400 acorns was used for each host–insect association. These acorns originated from a single representative locality where the respective insect species was consistently detected and where adult emergence was sufficient for quantitative evaluation. The subsample comprised 20 acorns collected from each of 20 randomly selected trees (20 × 20 = 400). The remaining acorns collected during the survey were primarily used for species identification, confirmation of host associations, and distributional records. Standardizing the sample size to 400 acorns allowed direct comparison of infestation rates among insect species while minimizing bias arising from unequal sample sizes among years, localities, and host species.

Seeds collected from the field were transferred into observation containers filled with sterilized soil at a depth of 2 cm and maintained under controlled monitoring conditions. The containers were regularly inspected to monitor insect emergence.

Emerging insects were collected, preserved appropriately, and subsequently identified to the lowest possible taxonomic level using standard morphological diagnostic keys.

Specimens collected during field surveys were first relaxed in specially prepared humidification chambers to prevent structural damage during preparation. Subsequently, the wings were carefully spread on stretching boards and dried in an incubator at 50 °C for four days to ensure proper preservation. After drying, each specimen was pinned and labeled with locality data including collection site, date, and relevant sampling information.

For taxonomic identification, when external morphological characters were insufficient for reliable determination, male and female genitalia dissections were performed.

During genitalia preparation, the abdomen was detached using fine forceps. In smaller specimens, the abdomen was removed entirely at the junction with the thorax, whereas in larger

specimens, it was separated at the level of the 4th–5th abdominal segments. The detached abdominal portion was boiled in a 10% potassium hydroxide (KOH) solution until the soft tissues were sufficiently macerated. The material was then transferred to distilled water, and the genital structures were carefully dissected and cleaned from surrounding tissues.

Following dehydration in 96% ethyl alcohol, the genitalia were cleared in creosote and mounted as permanent slides using Entellan mounting medium. The preparation techniques followed the methodologies described by Pierce (1960), Kornoşor (1982), and Fernandez (1986).

Species identification was conducted after completion of all necessary preparations. Determinations were based on external morphological characters and, where required, on the structural characteristics of male and female genitalia. Relevant taxonomic literature and comparative reference material were consulted. Identifications were carried out by Dr. Mustafa Özdemir (Plant Protection Central Research Institute, Ankara). Primary references included Razowski (2002, 2003), Kuznetsov (1987), and Slamka (2010).

Identification of oak species was performed under the supervision of Dr. Nihal Özel (Aegean Forestry Research Institute Directorate), following the diagnostic criteria provided in Türkiye Meşeleri Teşhis Kılavuzu (Yaltırık, 1984). The determinations were conducted by Dr. Fazıl Selek. Initially, the distribution areas of the three target oak species within the Aegean Region were examined. Leaf, twig, and seed samples were collected from representative trees in these areas, and photographs documenting trunk morphology and general tree habitus were taken. Species identification was completed according to the diagnostic keys and descriptions provided in the reference guide.

Climatic data were obtained from the nearest meteorological stations, including Seferihisar, Uşak, Selendi, Kula, Gördes, Bodrum, Marmaris (Bozburun), İzmir (Kemalpaşa), and Ödemiş. Parameters evaluated included average annual temperature, temperature extremes, relative humidity, and total annual precipitation, providing a climatic framework for interpreting insect distribution patterns.

Table 2. Climatic characteristics of the meteorological stations representing the study sites, including elevation, temperature, relative humidity, and annual precipitation

Station name	Elevation (m)	Mean Temperature of the Warmest Month (°C)	Mean Temperature of the Coldest Month (°C)	Annual Thermal Amplitude	Mean Annual Temperature (°C)	Mean Relative Humidity (%)	Mean Annual Precipitation (mm)
Seferihisar	22	26,8	8,4	18,4	17,1	65,0	640,94
Uşak	919	23,4	2,3	21,1	12,5	63,6	557,60
Selendi	475	27,2	5,0	22,2	15,9	59,7	528,17
Kula	720	25,7	4,1	21,6	14,8	62,0	463,17
Gördes	622	25,3	4,4	20,9	14,8	64,0	534,27
Bodrum	26	28,3	11,3	17,0	19,2	61,8	749,1
Marmaris (Bozburun)	50	27,9	11,5	16,4	19,3	57,4	777,3
İzmir (Kemalpaşa)	208	27,5	5,8	21,7	16,2	65,1	722,52
Ödemiş	111	27,3	7,1	20,2	16,7	65,0	619,8

(*) Based on the official correspondence of the Turkish State Meteorological Service (dated 8 September 2020, No. 72308)

RESULTS

Consequently, a total of five species belonging to the families *Pyralidae* and *Tortricidae* (order *Lepidoptera*) were recorded.

Table 3. Taxonomic classification of the Lepidopteran species identified in the present study

Order	**Family**	**Genus**
Lepidoptera	Pyralidae	*Apomyelois ceratoniae* (Zeller, 1839)
	Tortricidae	*Cydia amplana* (Hübner, 1799)
		Cydia fagiglandana (Zeller, 1841)
		Cydia splendana (Hübner, 1799)
		Pammene gallicolana (Lienig & Zeller, 1846)

The host associations of the identified Lepidopteran species are summarized in Table 4. The results demonstrate that each insect species exhibited a distinct host range. *Apomyelois ceratoniae* was associated with *Quercus cerris* and *Q. ithaburensis***,** whereas *Cydia amplana* was recorded exclusively from *Q. aucheri***.** *Cydia fagiglandana* occurred on both *Q. cerris* and *Q. aucheri***,** while *Cydia splendana* and *Pammene gallicolana* were found only on *Q. ithaburensis***.** Adult emergence data and infestation rates for each host species are presented in Table 5. Among the recorded species, *C. fagiglandana* showed the highest infestation rates, reaching 27.50% in *Q. cerris* and 24.25% in *Q. aucheri*, whereas *C. amplana* exhibited the lowest infestation rate (10.50%). *Apomyelois ceratoniae* caused an intermediate infestation level (16.75%) in *Q. cerris*.

Table 4. Host associations of the acorn-feeding Lepidoptera recorded during the study

Lepidopteran species	*Q. ithaburensis*	*Q. cerris*	*Q. aucheri*
Apomyelois ceratoniae	✓	✓	-
Cydia amplana	-	-	✓
Cydia fagiglandana	-	✓	✓
Cydia splendana	✓	-	-
Pammene gallicolana	✓	-	-

Table 5. Adult emergence and infestation rates of acorn-feeding Lepidoptera

Species	Host oak	Adults emerged	Acorns examined	Infestation (%)
A. ceratoniae	*Q. cerris*	67	400	16,75
C. amplana	*Q. aucheri*	42	400	10,50
C. fagiglandana	*Q. cerris*	110	400	27,50
C. fagiglandana	*Q. aucheri*	97	400	24,25

Order Lepidoptera
Family Pyralidae
Apomyelois ceratoniae **(Zeller, 1839)**
Apomyelois ceratoniae is a cosmopolitan pest species widely distributed across tropical and subtropical regions. It is known to infest a broad range of nut and fruit crops. Major host plants include *Ceratonia* spp. (carob), *Prunus* spp. (almond), and *Phoenix* spp. (date palm).

The species has expanded into new geographic regions over recent decades. For instance, it is considered one of the most significant pests of date palms in desert valleys of Southern California (USA) and poses a serious threat to extensive almond (*Prunus* spp.) and pistachio

plantations in the San Joaquin Valley (Noorbakhsh, 2017, Gothilf, 1984; Warner, 1988; Cosse et al., 1994).

Figure 1. *Apomyelois ceratoniae* (Zeller, 1839)

Acorns of *Quercus cerris* collected from the Ovacık 1 locality were placed under observation on 16 February 2019. Adult emergence occurred on 25 March, 27 March, 2 April, 10 April, 22 April, and 30 April 2019. Of the 20 jars monitored, 10 yielded adult emergence. From a total of 400 acorns collected from *Quercus cerris* trees, 67 adults of *Apomyelois ceratoniae* (Zeller, 1839) emerged. The overall infestation rate was calculated as 16.75%.

Under standard laboratory conditions, four adults of this moth species emerged on 7 October 2019 from acorns collected on 23 October 2018 from *Quercus ithaburensis* trees in Seferihisar.

***Cydia amplana* (Hübner, 1799)**

In Türkiye, the species has thus far been documented only from the provinces of Bolu (Göynük and Mudurnu), İstanbul, and Kırıkkale. More broadly, it exhibits a wide western Palaearctic distribution, extending from Western and Central Europe through Russia and Türkiye to Syria and the Transcaucasian region (Özdemir et al., 2005; Kuznetsov, 1987).

Figure 2. *Cydia amplana* (Hübner, 1799)

The species exhibits a broad host range and has been reported to infest several economically and ecologically important tree species, including *Quercus pedunculata*, *Q. rubra*, *Q. petraea*, and members of the genera *Juglans*, *Corylus*, *Fagus*, and *Castanea* (Avcı, 1997; Postner, 1978; Çanakçıoğlu, 1963; Escherich, 1931).

To determine adult emergence, acorns of *Quercus aucheri* collected from the Bodrum–Ortakent region were maintained under controlled laboratory conditions from 16 February 2019 onwards. Adults of *Cydia amplana* (Hübner, 1799) emerged between 3 and 10 May 2019, with emergence recorded in 8 of the 20 rearing containers. In total, 42 adults emerged from 400 acorns, corresponding to an infestation rate of 10.5%. These findings confirm that *Q. aucheri* acorns from the study area constitute a suitable developmental host for *C. amplana*.

***Cydia fagiglandana* (Zeller, 1841)**

Within Türkiye, *Cydia fagiglandana* has been documented from Bolu (Göynük, Mengen, Mudurnu, and Yeniçağa), Düzce (Yığılca and Taşdibek), İstanbul, Kahramanmaraş, and Kırıkkale. The species exhibits a broad Palearctic distribution, occurring throughout Europe, northwestern Africa, Türkiye, Iran, Syria, southwestern Russia, the Caucasus and Transcaucasia, Central Asia, and Japan (Özdemir et al., 2005; Razowski, 2001; Kuznetsov, 1987; Bradley et al., 1979; Çanakçıoğlu, 1963).

Figure 3. *Cydia fagiglandana* (Zeller, 1841)

Larvae develop within the fruits and seeds of several deciduous forest tree species, including *Fagus orientalis* and members of the genera *Corylus*, *Castanea*, and *Quercus*, reflecting the species' relatively broad host range within temperate broadleaved forests (Razowski, 2001; Avcı, 1997; Bradley et al., 1979; Çanakçıoğlu, 1963).

Acorns of *Quercus aucheri* collected from the Bodrum–Ortakent region were maintained under controlled climatic conditions from 27 February 2019 to monitor adult emergence. Adults of *Cydia fagiglandana* (Zeller, 1841) emerged over an extended emergence period spanning 22 April to 12 June 2019, with successful emergence documented in 12 of the 20 rearing containers. In total, 97 adults emerged from 400 acorns examined, corresponding to an infestation rate of 24.25%.

For *Quercus cerris*, acorns collected from the Ovacık 2 locality were maintained in soil-filled rearing containers between 16 and 18 February 2019. Adult emergence occurred between 10

April and 18 May 2019 and was recorded in 10 of the 20 rearing containers. A total of 110 adults emerged from 400 examined acorns, yielding an overall infestation rate of 27.50%. These findings demonstrate that both *Q. aucheri* and *Q. cerris* provide suitable developmental hosts for *C. fagiglandana*, although infestation was slightly higher in *Q. cerris* under the conditions investigated.

***Cydia splendana* (Hübner, 1799)**

Within Türkiye, *Cydia splendana* has been recorded from Bolu (Göynük and Mudurnu), Düzce, Bursa, İstanbul, İzmir, Konya, Kırıkkale, and Kocaeli. More broadly, the species is widely distributed across the western Palearctic region, encompassing Europe, Russia, and the Caucasus-Transcaucasian region (Özdemir et al., 2005; Razowski, 2001; Kuznetsov, 1987; Seçkin, 1981; Escherich, 1931).

Figure 4. *Cydia splendana* (Hübner, 1799)

An oligophagous tortricid, *C. splendana* is associated primarily with broadleaved forest trees, where its larvae infest and develop within the fruits and seeds of species belonging to *Quercus*, *Fagus*, *Castanea*, *Juglans*, and *Prunus* (*P. amygdalus*) (Çanakçıoğlu, 1982; Seçkin, 1981).

To monitor adult emergence, acorns of *Quercus ithaburensis* collected from the Uşak–Banaz locality were maintained under standardized climate-controlled laboratory conditions from 28 February 2019 onwards. Adults of *Cydia splendana* (Hübner, 1799) successfully emerged on 2 April 2019.

***Pammene gallicolana* (Lienig & Zeller, 1846)**

Within Türkiye, the occurrence of *Pammene gallicolana* (Lienig & Zeller, 1846) has been confirmed from Kırıkkale, Van, and Çanakkale (Koçak and Kemal, 2009; Kemal and Koçak, 2010; Atay et al., 2018). More broadly, the species is widely distributed across the western Palearctic region, encompassing Great Britain, Austria, Portugal, Lithuania, the Czech Republic, Slovakia, Germany, the Netherlands, Italy, Hungary, Romania, Greece, and Eastern Europe, with additional records from South Africa (Gaedike, 2014; Habeler, 2014; Corley et al., 2016; Karsholt and Razowski, 1996; Razowski, 2003).

Figure 5. *Pammene gallicolana* (Lienig & Zeller, 1846)

Acorns of *Quercus ithaburensis* collected from the Manisa–Selendi locality were maintained under standardized climate-controlled laboratory conditions to monitor adult emergence. The first adults of *P. gallicolona* emerged on 25 February 2019, providing evidence of successful completion of larval development within acorns collected from the study area.

DISCUSSION

The present study expands current knowledge of the Lepidopteran fauna associated with acorns of *Quercus ithaburensis*, *Q. cerris* var. *cerris*, and *Q. aucheri* in the Aegean Region of Türkiye. Five seed-infesting species belonging to the families Pyralidae and Tortricidae were identified, confirming that these oak species support a diverse assemblage of acorn-feeding Lepidoptera. The occurrence of multiple insect species on different oak hosts is consistent with previous studies demonstrating that acorns constitute important resources for specialized seed-feeding insects.

A noteworthy finding of the present study is the detection of *Apomyelois ceratoniae* (Zeller, 1839) in the acorns of *Q. ithaburensis* and *Q. cerris*. Although this species has previously been reported from several economically important hosts, including carob, almond, date palm, pistachio, and pomegranate (Noorbakhsh, 2017; Mamay, 2016), no previous record of its association with oak acorns was found during the present literature review. The results therefore represent the first documented record of *A. ceratoniae* infesting oak acorns, extending the known host range of this species.

The study also contributes new distributional data for two tortricid species. *Cydia fagiglandana*, previously reported from northwestern Türkiye (Özdemir et al., 2005), was recorded from İzmir (Kemalpaşa–Ovacık) and Muğla (Bodrum–Ortakent), considerably extending its known distribution in western Anatolia. Likewise, *Pammene gallicolana*, previously reported as a first record for Çanakkale by Atay et al. (2018), is herein recorded for the first time from the Manisa–Selendi locality. These records improve our understanding of the geographical distribution of acorn-feeding Tortricidae in Türkiye.

Field observations indicated that none of the five Lepidopteran species caused infestation levels sufficient to produce visible reductions in tree vitality, foliage density, or seed production.

Nevertheless, Yüksel (2016) reported that oak forests in Türkiye host 1,097 pest and disease species, highlighting the ecological importance of continuous monitoring. Although the seed pests identified in the present study did not appear to threaten tree health directly, their potential effects on acorn quality, seed viability, and natural regeneration warrant further investigation. Consequently, long-term monitoring and quantitative assessments of seed loss and germination reduction would provide valuable information for the sustainable management and conservation of native oak forests.

Although crown aspect was initially considered as a potential explanatory factor affecting insect infestation, the available data did not provide sufficient statistical power to evaluate this effect reliably. Therefore, crown orientation was excluded from the final analyses. Future studies based on larger and more balanced datasets should further investigate the influence of crown aspect and associated microclimatic conditions on acorn infestation in different oak species.

CONCLUSIONS

This study provides new information on the Lepidopteran species associated with acorns of *Quercus ithaburensis*, *Q. cerris* var. *cerris*, and *Q. aucheri* in the Aegean Region of Türkiye. The discovery of *Apomyelois ceratoniae* infesting oak acorns represents a novel host association, while the records of *Cydia fagiglandana* and *Pammene gallicolana* extend the known geographical distribution of these species in western Türkiye. These findings contribute to a better understanding of the diversity, host associations, and distribution of acorn-feeding Lepidoptera in Mediterranean oak ecosystems.

Although no evidence of severe damage to tree vitality was observed during the present study, acorn-infesting insects may adversely affect seed quality and the availability of viable planting material, particularly in years of high infestation. Regular monitoring of seed pests should therefore be incorporated into oak seed collection programmes and forest regeneration practices, especially in seed stands and conservation areas.

Future studies should quantify the effects of these insects on acorn viability, germination, and seedling establishment, while also investigating their population dynamics, host preferences, and responses to environmental conditions. Such information will provide a scientific basis for developing sustainable monitoring and management strategies aimed at conserving the genetic resources and ensuring the successful natural regeneration of native oak forests in Türkiye.

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Biology and Seasonal Population Dynamics of *Ips sexdentatus* (Börner) (Coleoptera: Curculionidae) in Çankırı Castle, Türkiye

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Abstract

This study was conducted in 2025 to determine the biology and population dynamics of the six-toothed bark beetle, *Ips sexdentatus* (Börner) (Coleoptera: Curculionidae: Scolytinae), which infests *Pinus nigra* trees within the Çankırı Castle recreation area. Three Scandinavian-type pheromone traps were utilized for weekly monitoring from April 20 to September 21, 2025. The life stages of the pest were investigated by examining the subcortical regions of infested trees. The number of generations was estimated using the Sum of Effective Temperatures (SET) method, utilizing a lower developmental threshold of 10.9°C and a thermal constant of 506 degree-days.

A total of 236 *I. sexdentatus* adults were captured during the study period, indicating three distinct flight periods in May, June, and August. Flight activity was associated with unusually high temperatures in 2025, which were 2.1°C above the long-term average. The Sum of Effective Temperatures reached 1965.2 degree-days, indicating the potential for approximately 3.88 generations—comprising three complete generations and one partial fourth generation—throughout the vegetation period. The lower trap catches, compared to previous records from 2009 and 2010, may reflect the effects of recent forest maintenance activities at Çankırı Castle. Furthermore, the capture of only one natural predator, *Thanasimus formicarius* (L.) (Coleoptera: Cleridae) suggests that natural biological control may currently be limited in the study area.

Keywords: *Ips sexdentatus*, *Pinus nigra*, Pheromone trap, Çankırı Castle, Population dynamics, Sum of effective temperatures.

INTRODUCTION

Çankırı Castle, which is in the central district, is a significant area because of its natural and cultural values, and people frequently visit it for recreational purposes. As one of our historically important cultural heritages and an archeological site, the castle was constructed on a small hill in the north part of the city. Its walls are built using rubble stones and bricks. The castle area also includes the tomb of Karatekin Bey, who is a Seljuk Commander. After the landscaping projects carried out by Çankırı Municipality in 2012, the castle area also served as a recreational site and viewing terrace. This makes it one of the most visited places in the city (Yiğit, 2019; Tülek & Atik, 2021).

Although there are several tree species in the area, it is mostly dominated by *Pinus nigra* Arnold. In recent years, these trees have suffered from severe dieback and mortalities because of infestation by the six-toothed bark beetle, *Ips sexdentatus* (Börner) (Coleoptera: Curculionidae: Scolytinae). A previous study showed that *I. sexdentatus* was studied in Çankırı Castle during the 2009-2010 outbreak, and it sometimes caused tree deaths (Şimşek et al., 2011).

The distribution of *I. sexdentatus* has been recorded in numerous regions across Europe. This pest exists from Europe to Asia, covering Transcaucasia, Siberia, Georgia, Korea, and Japan (Yüksel & Akbulut, 2005; Şimşek et al., 2011, 2017). The distribution area in Türkiye covers the distribution areas of its host tree species, such as *Pinus nigra*, *P. sylvestris*, *P. brutia*, *Picea orientalis*, *Abies nordmanniana*, and *A. bornmülleriana*. Low-level populations of *I. sexdentatus* prefer attacking weakened, damaged, or fallen trees. However, larger populations become aggressive and can also attack healthy trees (Şimşek et al., 2010b; Özcan et al., 2022).

Pest management in an area with such historical and urban importance requires safe and sustainable management approaches. Therefore, this study focuses on Çankırı Castle to examine the biology of *I. sexdentatus*, which is actively infesting the site, and to monitor its flight activity by using pheromone traps.

MATERIALS AND METHODS

The Study Area and the Materials

This study was carried out at Çankırı Castle in Çankırı Province. The study area covers an area of approximately 0.19 ha (1,900 m^2) (Figure 1). The main materials of the research consisted of black pine (*Pinus nigra*) trees aged between 25 and 50 years and infested with *I. sexdentatus*; species-specific pheromone dispensers (IPSSEX [60 mg Ipsdienol] pheromone dispensers obtained from Tripheron Company through VİT-VERİM Company); and Scandinavian-type (3-funnel) traps.

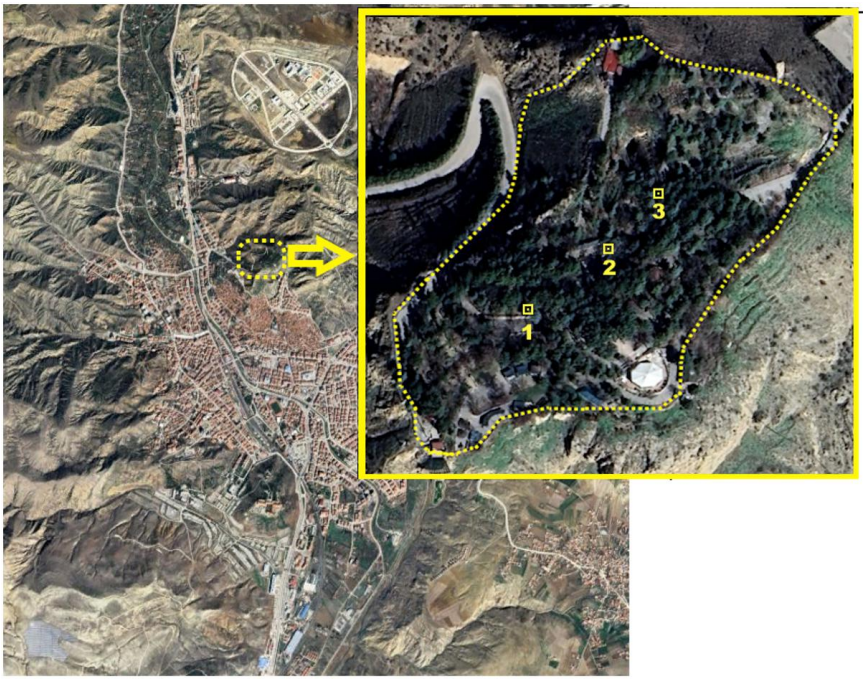

Figure 1. Location of Çankırı Castle in the satellite image

Methods

The field studies were initiated on April 20, 2025. Considering the distribution of black pine trees in the research area, three pheromone traps were placed on the southern aspects at a

height of 1.5 m above the ground, with a minimum distance of 50 m between them (Şimşek et al., 2010a, 2017; Erdoğan, 2024).

During the field observations, the bark of the trees which were identified as being damaged by *I. sexdentatus* was peeled to investigate the various life stages of the pest under the bark. Pheromone traps were checked weekly. The captured insects were transferred into labeled plastic containers, taken to the laboratory in an icebox, and kept in a deep freezer at −17°C for at least 12 hours (McNee et al., 2000; Şimşek et al., 2017). Non-target insects, especially natural enemies, were counted, recorded, and released into the environment.

Other insects captured in the pheromone traps and identified as the natural enemies of bark beetles were separated for subsequent release into the field after being counted and recorded in the laboratory. Both the field studies and laboratory counting procedures were continued for two more weeks after the last *I. sexdentatus* was caught in the pheromone traps.

The lower developmental threshold of 10.9°C and a thermal constant of 506±7 degree-days (Pineau et al., 2016; Erdoğan, 2024) were used to estimate the number of generations. The daily mean temperatures were calculated by taking the average of daily maximum and minimum temperatures (1). Degree-days were accumulated only when the daily mean temperature exceeded the threshold value (2 and 3), and the obtained sum of effective temperatures was divided by the thermal constant value (506 degree-days). The days on which the daily mean temperature was higher than 36°C were not included in the evaluation (Pineau et al., 2016; Erdoğan, 2024).

$$T_{mean} = (T_{min} + T_{max}) / 2 \quad (1)$$

$$ET = 0, \quad \text{if } T_{mean} < 10.9 \text{ or } T_{mean} > 36.0 \quad (2)$$
$$ET = T_{mean} - 10.9, \quad \text{if } 10.9 \leq T_{mean} \leq 36.0$$

$$SET = \sum ET \quad (3)$$

The required data to calculate the sum of daily effective temperatures, including daily minimum, maximum, and mean temperatures (°C), relative humidity (%), and precipitation amount (mm), were obtained from the Turkish State Meteorological Service, Çankırı Meteorology Directorate. Data analysis and graphical representations were performed using Python (Python Software Foundation, v3.14) with pandas, matplotlib and numpy libraries, which were used for processing the meteorological datasets and calculating the flight period indices and figures throughout the study.

RESULTS

Biological Observations

During the initial bark examinations conducted by peeling the bark of the trees at Çankırı Castle, it was determined that both the dark brown to black overwintered adults of *I. sexdentatus* and the light brown new-generation adults feeding in the galleries were found under the bark (Figure 2A, B). The adults have a total of 12 spines, with 6 located on each side of the elytra (Figure 2C).

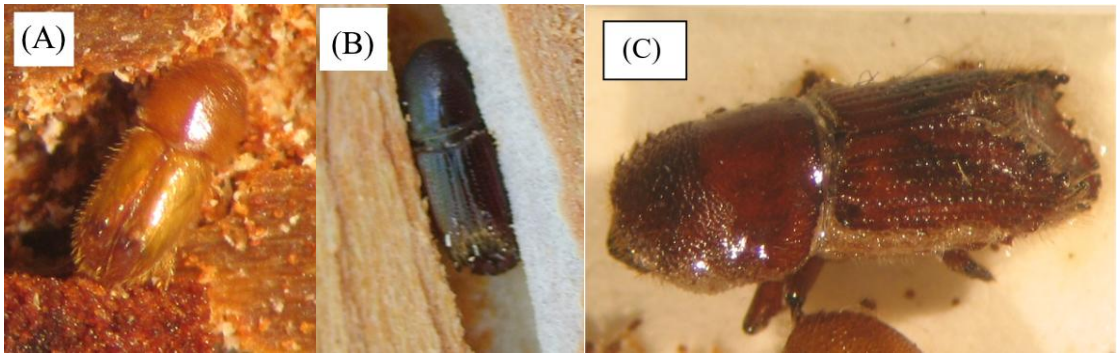

Figure 2. Young adult (A), mature adult (B) of *Ips sexdentatus* (Börner), and the spines on the elytral declivity of the adults (C)

During subsequent examinations and observations conducted in the following periods, the larvae and pupae of the pest were also encountered. It was observed that the *I. sexdentatus* larvae detected under the bark were cream-colored and of the apodous (legless) larval type, while their pupae were white (Figure 3).

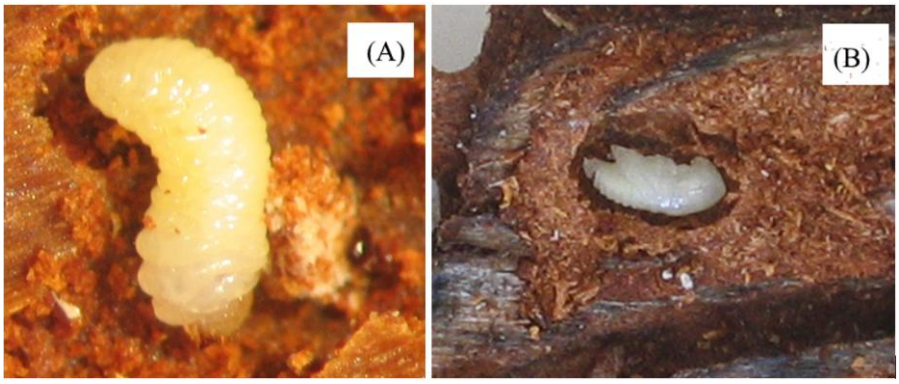

Figure 3. Larva (A) and pupa (B) of *Ips sexdentatus* (Börner)

Pheromone Trap Captures

A total of 236 *I. sexdentatus* adults were captured during the study period (Figure 4). The first adults were caught on May 4, 2025. Peak catches were observed on May 11 (average 19.7 adults/trap), May 25 (10.3 adults/trap), June 29 (13.0 adults/trap), and August 24 (13.0 adults/trap). The last capture was recorded on September 7, 2025.

Three distinct flight periods of *I. sexdentatus* were identified during the study. The first, second, and third flight periods occurred during May 4–25 (118 adults, 50%), June 15–July 6 (63 adults, 26.7%), and August 17–September 7, 2025 (55 adults, 23.3%), respectively.

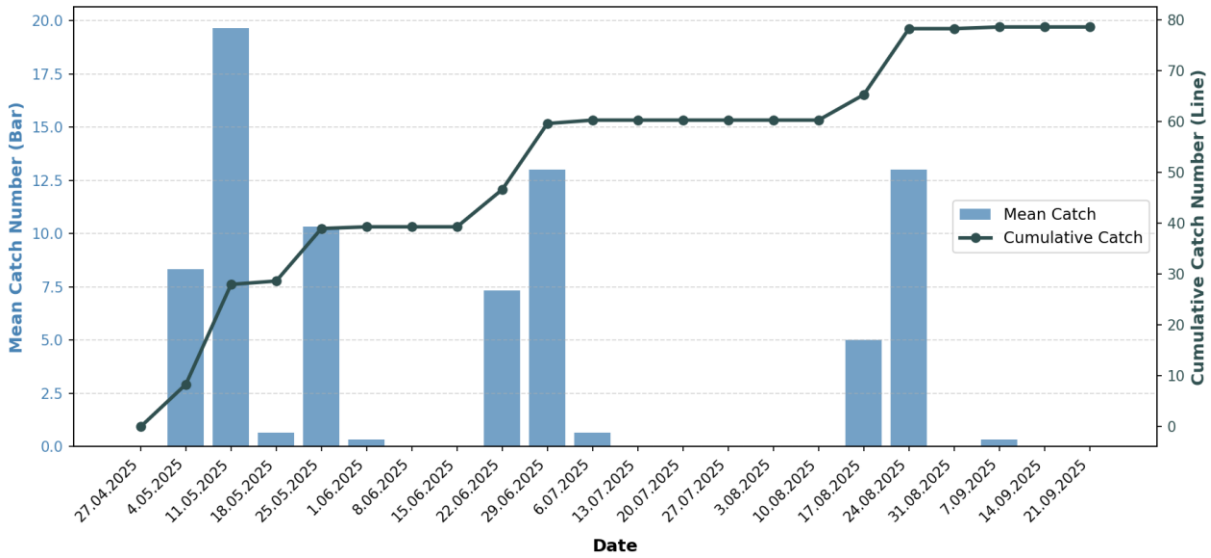

Figure 4. Mean number of adults (individuals) captured on different dates in *Ips sexdentatus* (Börner) pheromone traps installed at Çankırı Castle

Figure 4 shows that *I. sexdentatus* adults were first captured in the pheromone traps placed at Çankırı Castle on May 4, 2025 (with 2, 1, and 22 individuals in the traps, respectively, and an average of 8.3 individuals/trap). On the following monitoring date (05/11/2025), the trap catches increased (mean: 19.7 individuals/trap). Although the catches decreased on 05/18/2025, they increased to a mean of 10.3 individuals/trap on 05/25/2025, followed by a mean catch of 0.3 individuals/trap on 06/01/2025. After this date, no captures were recorded until 06/22/2025. On the same date, the captures started again (mean: 7.3 individuals/trap), and after reaching a new peak on 06/29/2025 (13.0 individuals/trap), they declined to 0.7 individuals/trap on 07/06/2025. In the following period, the captures occurred again on 08/17/2025 (mean: 5.0 individuals/trap) and increased to a mean of 13.0 individuals/trap by 08/24/2025. The final capture in the pheromone traps was recorded on 09/07/2025, with a mean of 0.3 individuals/trap.

The findings indicated that three distinct flight periods of *I. sexdentatus* adults were recorded at Çankırı Castle (Figure 4). According to the study results, the first flight period of *I. sexdentatus* occurred between May 4 and May 25, 2025 (118 individuals), whereas the second flight period was observed between June 15 and July 6, 2025 (63 individuals), and the third flight period was recorded between August 17 and September 7, 2025 (55 individuals), resulting in a total of 236 captured adults.

Relationship Between Captured Ips sexdentatus Adults and Meteorological Data

The minimum, maximum, and mean values of temperature (°C), together with the 7-day moving average temperature, relative humidity (%), and precipitation (mm) recorded in Çankırı between April and September 2025, are presented graphically in Figure 5.

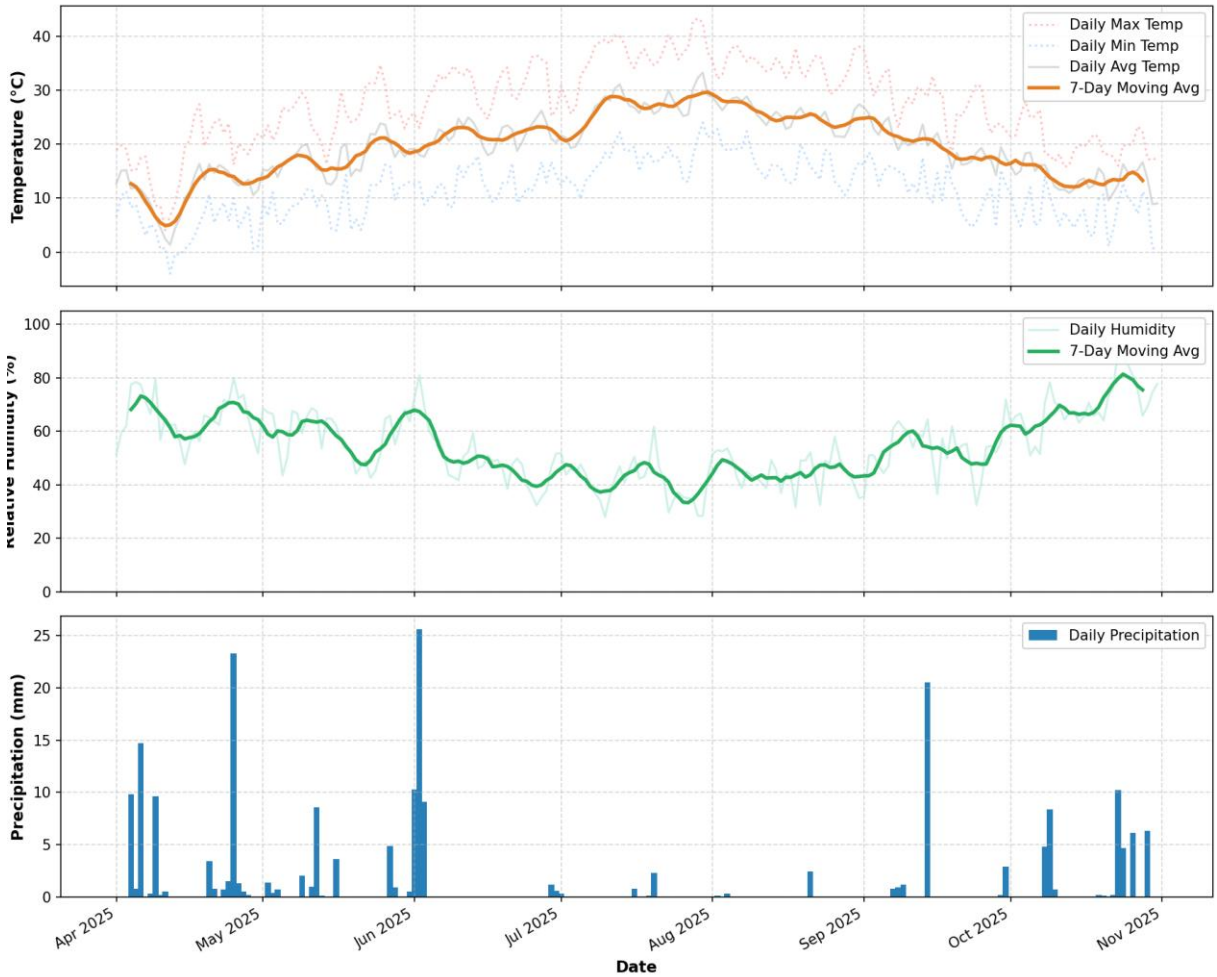

Figure 5. The minimum, maximum, mean and 7-day moving average temperature (°C), relative humidity (%), and precipitation (mm) values recorded in Çankırı between April and September 2025

The number of *I. sexdentatus* individuals captured in the pheromone traps (Figure 4) and the meteorological data (Figure 5) indicate that, during the first period of trap captures (05/04/2025–06/01/2025), the mean air temperature ranged between 11.5°C and 23.9°C, whereas the mean relative humidity varied between 42.5% and 72.4%. A total of 31.9 mm of precipitation was recorded throughout this period. It is considered that the rainy conditions during the 10-day period preceding May 18, 2025, a date on which low capture rates were recorded, combined with the mean air temperatures ranging from 0.6°C to 10.2°C, might have influenced this decline. Conversely, during the second capture period (06/22/2025–07/06/2025), the mean air temperature ranged from 19.5°C to 27.0°C, and the mean relative humidity varied between 32.2% and 51.8%. The total precipitation during this second period was 2.1 mm. Finally, during the third period (08/17/2025–09/07/2025), the mean air temperature ranged between 21.2°C and 28.2°C, while the mean relative humidity varied from 31.6% to 61.2%. The total precipitation during this final flight period was 3.2 mm.

The meteorological data and the trap catch numbers on the dates when the peak captures occurred during the three flight periods of *I. sexdentatus* are summarized below. In the first flight

period, the peak capture occurred on May 11, 2025; on this date, the mean air temperature was 17.3°C, the mean relative humidity was 68.6%, and 8.6 mm of precipitation was recorded. Regarding the second flight period, the peak capture was recorded on June 29, 2025, with a mean air temperature of 21.1°C, a mean relative humidity of 46.6%, and a total precipitation of 1.2 mm. Finally, in the third flight period, the peak capture was observed on August 24, 2025, during which the mean air temperature was 25.6°C and the mean relative humidity was 49.0%.

Generation Numbers

It has been reported by many researchers (e.g., Tosun, 1975; Yüksel, 1997; Yüksel et al., 2000; Yüksel & Akbulut, 2005; Toper Kaygın, 2007; Şimşek et al., 2011, 2017) that the number of generations in bark beetles can increase depending on elevation and climatic conditions (Şimşek et al., 2010a,b; Pineau et al., 2016; Ünal et al., 2023).

The higher number of flight periods recorded in this study compared to the findings of a previous study conducted in the same area (Şimşek et al., 2011) is considered to stem from the fact that air temperatures throughout the summer of 2025 were higher than those in previous years. Supporting this assumption, when the long-term mean temperature data and the 2025 temperature data are evaluated together, it is observed that the mean air temperature in 2025 was 2.1°C warmer than the 1929-2024 average (Table 1).

Table 1. Monthly mean temperatures (°C) and long-term averages for Çankırı Province

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
2025	2.9	1.1	10.4	11.0	17.2	21.9	27.0	25.7	19.6	13.2	8.6	4.3
1929-2024	-0.4	1.3	5.7	11.2	15.9	19.8	23.1	23.0	18.1	12.2	5.9	1.7
Temp. Increase	3.3	-0.2	4.7	-0.2	1.3	2.1	3.9	2.7	1.5	1.0	2.7	2.6

The accumulated sum of effective temperatures (SET) in 2025 reached 1965.2 degree-days, which corresponds to 3.88 generations. This value indicates the completion of three full generations and one partial (incomplete) fourth generation. For comparison, the number of generations was calculated as 2.87 in 2009 and 3.45 in 2010 using the same method (based on data from Şimşek et al., 2011).

Natural Enemies and Biological Control Potential

During the trap monitoring process, a single adult individual of *Thanasimus formicarius* (L.)(Coleoptera: Cleridae), which is known to be a predator of I. *sexdentatus*, was also captured. Although the pheromone traps are not designed to monitor predator populations specifically, the capture of only a single *T. formicarius* individual throughout the entire monitoring period may suggest a low predator presence in the study area. However, this finding should be interpreted with caution, as trap catches alone do not provide a comprehensive measure of predator abundance in the field.

DISCUSSION

This study revealed three distinct flight periods of *I. sexdentatus* at Çankırı Castle in 2025. Several recent studies (Bracalini et al. 2021, Erdoğan 2024, Özcan et al. 2026) have reported that *I. sexdentatus* has three distinct flight periods, which is consistent with our findings. Erdoğan (2024) reported three generations in Ankara, with the first flight occurring in mid-April and the second in early July. Similarly, Hlavkova et al. (2024) observed the first flights in early May and peak activity between late June and mid-July in the Czech Republic.

The fact that the 2025 temperature data remained approximately 2.1°C higher than the long-term average suggests that elevated temperatures may have contributed to the observed flight intensity and the estimated number of generations of *I. sexdentatus*. In this context, Özcan et al. (2022) emphasized that maximum temperature is one of the key factors affecting *I. sexdentatus* outbreaks, while Ünal et al. (2023) highlighted that the effects of climate change on bark beetle population dynamics are expected to become increasingly important in the future. According to Şimşek et al. (2011), during the 2009–2010 outbreak period in Çankırı, *I. sexdentatus* produced 2.87 and 3.45 generations, respectively.

In contrast, the total number of 236 adults captured during the present study was considerably lower than the values reported for the same area during the outbreak years. Lower capture numbers suggest that recent maintenance and management practices implemented around Çankırı Castle, including the removal of dead trees and regular monitoring activities, may have contributed to the suppression of the pest population. Accordingly, the relatively low number of beetles captured in pheromone traps during 2025 indicates that the population currently remains in an endemic phase. Nevertheless, the 2025 temperature data revealed that thermal accumulation was approximately 220 degree-days higher than that recorded in 2010, resulting in an estimated 3.88 generations in 2025. Erdoğan (2024) also reported a third generation of *I. sexdentatus* in Ankara while other researchers (e.g., Yüksel and Akbulut 2005, Özcan et al. 2011, Lopez and Goldarazena 2012, Dong and Hulcr 2024) reported that a third generation is possible depending on climatic conditions and elevation. However, despite the low trap captures, the increased thermal potential observed in 2025 indicates that the beetle may initiate much faster and more destructive outbreaks than before under possible future drought conditions or host stress. Therefore, low population levels should not create a false sense of security; instead, the increasing thermal potential should be considered a potential ecological risk.

Although three distinct flight periods were observed, the thermal accumulation model indicated 3.88 generations. Therefore, flight periods should not be interpreted as direct evidence of the number of generations, since overlapping generations and sister broods may occur in *Ips* species.

The capture of only one *T. formicarius* indicates that natural biological control is currently lacking in the area, highlighting the delicate relationship between *I. sexdentatus* and its specialized predators. Natural population regulation relies heavily on the phenological synchronization of *T. formicarius* with its prey (Schroeder, 1999; Warzée et al., 2006). Unfortunately, capturing beneficial predators in pheromone traps may reduce their availability in the field and could potentially affect their contribution to natural biological control. Several previous studies have also reported the capture of *T. formicarius* adults at *I. sexdentatus* pheromone traps (Özcan et al. 2011, 2026, Etxebeste et al. 2012, Özcan 2017, Akkuzu et al. 2018, 2021, Bracalini et al. 2021, Erdoğan 2024). Since removing predatory species can trigger larger pest populations in subsequent generations (Bracalini et al., 2021), it is vital to carefully sort and immediately release beneficial insects during routine inspections.

CONCLUSIONS

Within the framework of integrated pest management (IPM), the following recommendations are proposed for historically and recreationally important sites such as Çankırı Castle:

- Set up pheromone traps before the emergence of overwintered adults (before the mean temperature reaches 10.9°C),
- Sort and immediately release beneficial insects during weekly monitoring,
- Replace pheromone dispensers within the recommended period (6 weeks),
- Focus intensive management efforts between early May and late June, and in mid-August,
- Implement mass trapping and remove infested trees during population peaks,
- Develop an early warning system that integrates pheromone traps with remote sensing (satellite or drone imagery) and acoustic monitoring devices.

Ultimately, the findings of this study provide valuable data for sustainable management strategies, helping to safeguard Çankırı Castle as a cultural heritage site.

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Introduction of the Hosts of *Coccinella septempunctata* (L.), a Biological Control Agent, on Forest Trees

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Abstract

In this study, the host species of *Coccinella septempunctata* (L.), an important predator of forest pests, were compiled based on literature data. The aim of the study is to contribute to the wider use of *C. septempunctata* (L.) in the biological control of forest pests.

Within this scope, previous national and international studies were examined; it was determined that *C. septempunctata* (L.) feeds on pest species belonging to the order Hemiptera, including Aphididae such as *Aphis craccivora*, *Chaitophorus leucomelas*, *C. populialbae*, *Cinara cedri*, *C. laportei*, *C. obscura*, *C. orientalis*, *Eulachnus nigricola*, *Myzocallis boerneri*, *M. castanicola*, *Pemphigus immunis*, *Lachnus roboris*, and *Phloeomyzus passerinii*; Diaspididae such as *Carulaspis juniperi* and *Leucaspis pusilla*; and Marchalinidae such as *Marchalina hellenica*. It was concluded that this species acts as an effective predator on these pests.

The findings indicate that *C. septempunctata* (L.) has a broad feeding range. Based on the reviewed studies, it plays an important role in keeping pest populations below the economic threshold on various forest tree species, including *Pinus nigra*, *Pinus nigra* Arnold subsp. *pallasiana*, *P. brutia*, *P. silvestris*, *Cedrus libani*, *Cupressus sempervirens*, *Juniperus excelsa*, *J. sabina*, *J. virginiana*, *Quercus robur*, *Q. cerris*, *Q. ilex*, *Q. petraea*, *Q. pubescens*, *Q. suberi*, *Q. coccifera*, *Q. ithaburensis*, *Robinia pseudoacacia*, *Populus nigra*, *P. canadensis*, *P. alba*, *P. tremula*, *Castanea sativa*, *Platycladus orientalis*, *Thuja occidentalis*, and *T. orientalis*.

In conclusion, in line with the objectives of the Twelfth Development Plan (2024–2028), which emphasizes increasing supervision and training on the misuse of pesticides and promoting alternative biological and biotechnical control methods, it is recommended to enhance awareness of *C. septempunctata* (L.), support related projects, conserve its populations in forest ecosystems, and promote its mass production in Biological Control Laboratories within Regional Directorates of Forestry to ensure its more effective use in biological control.

Keywords: *Coccinella septempunctata*, Biological control, Hemiptera

INTRODUCTION

Biological control stands as a fundamental strategy in the management of forest pests. The most comprehensive definition of biological control was established in the 1996 FAO Code of Conduct for the Import and Release of Exotic Biological Control Agents, which describes it as "the use of living natural enemies, antagonists, competitors, and other self-replicating biological entities for pest management strategies" (Uygun et al., 2010).

The primary objective of biological control is to protect human, environmental, and animal health by reducing reliance on chemical pesticides, while simultaneously conserving natural enemies that suppress harmful organisms (Kırışık & Erler, 2017).

Biological control agents are classified into parasitoids, predators, entomopathogens, and antagonists (Uygun et al., 2010). Among these groups, predatory insects represent the most widely utilized agents in biological control programs (Kılınçer et al., 2010). Within the order Coleoptera, members of the family Coccinellidae are frequently employed in such efforts (Toper Kaygın & Sobutay Kaptan, 2017).

Coccinellids undergo complete metamorphosis (holometabolism), passing through egg, four larval instars, prepupa, and pupal stages before reaching adulthood. Their bodies are typically hemispherical, though some groups exhibit an oval morphology. They are small insects, with body lengths ranging from 1.5 to 10 mm (Uygun & Karabüyük, 2013).

Coccinella septempunctata (L.), a prominent member of the Coccinellidae family and a significant predator of numerous aphid species, possesses a cosmopolitan distribution (Gençer & Altın, 2015). Due to this widespread occurrence, *C. septempunctata* has garnered substantial interest from the scientific community and has been the subject of numerous studies across various disciplines.

The adults of *C. septempunctata*, measuring 6–8 mm in length, are characterized by a black head and pronotum, and red elytra marked with seven distinct black spots (Uygun, 1981).

This review aims to synthesize existing data to provide a concise overview of the identification, distribution, and host-pest dynamics of *C. septempunctata* (L.) within forest ecosystems.

RESULTS

Hosts Within The Family Aphididae

***Aphis craccivora* Koch, 1854**

Identification: The body is shiny black in coloration, while immature individuals exhibit a slightly waxy secretion (Ünal & Özcan, 2005). Body length ranges from 1.3 to 2.4 mm. The cauda is approximately half the length of the cornicles (Çanakçıoğlu & Mol, 1998).

Distribution and Hosts: It is distributed almost globally. In Türkiye, it has been widely detected on *Robinia pseudoacacia* in the Black Sea, Marmara, Aegean, and Mediterranean regions (Ünal & Özcan, 2005; Çanakçıoğlu & Mol, 1998).

Type of Damage: It causes damage to the leaves, shoots, and fruits of its host. Infested shoots become deformed, fail to develop, and wilt (Çanakçıoğlu & Mol, 1998).

Furthermore, *Aphis craccivora* serves as a vector for the poplar mosaic virus (Ünal & Özcan, 2005).

Note: Oğurlu (2000) and Kök & Kasap (2019) have identified *Coccinella septempunctata* (L.) as a predator of *Aphis craccivora*. Additionally, in their respective studies, Ünal & Özcan (2005) reported the presence of both larvae and adults of *C. septempunctata* (L.) in association with *A. craccivora* colonies.

***Chaitophorus leucomelas* Koch, 1854**

Identification: The body is yellow or green in coloration, oval-shaped, and measures up to 2.5 mm in length. The cornicles are dark-colored (Say, 2019).

Distribution and Hosts: *C. leucomelas* has been recorded in Konya, Ankara, Istanbul, Adapazarı, Şanlıurfa, Bolu, Diyarbakır, Isparta, Nevşehir, Aydın, Bitlis, Amasya, Trabzon, Bartın, Antalya, Kırşehir, Muğla, Erzurum, Van, Adana, İçel, Niğde, İzmit, and Kahramanmaraş (Uysal et al., 2006; Say, 2019).
Its hosts include *Populus nigra, P. canadensis, P. alba, P. pyramidalis*, and *P. serotina* (Uysal et al., 2006; Gümüş & Avcı, 2015).
Type of Damage: It inhabits the abaxial surfaces of black poplar leaves, as well as petioles and shoots, inducing gall formation. High population densities result in chlorosis (yellowing) of the leaves (Gümüş & Avcı, 2015).
Note: In their study on the predators and parasitoids of aphids (Homoptera: Aphididae) feeding on poplars in the Konya province, Şahbaz and Uysal (2006) identified *Coccinella septempunctata* (L.) among the predators of *C. leucomelas.*

***Chaitophorus populialbae* Boyer de Fonscolombe, 1841**
Identification: The body is small and oval-shaped. Individuals are typically light greenish or yellowish-white, often with small green spots on the body. The head is brownish or blackish. In winged forms, there are transverse dark brown bands on the abdomen (Çota, 2007).
Distribution and Hosts: It has been reported in Istanbul, Ankara, Niğde, and İçel provinces in Türkiye. Furthermore, it has been identified on the leaves of one-year-old shoots of *Populus alba* and *P. tremula* in the Selçuklu and Meram districts of Konya province (Uysal et al., 2006). In the Isparta region, it has been observed to be abundant on the abaxial surfaces of leaves, near the midrib, on hybrid poplars during August and September (Gümüş & Avcı, 2015).
Type of Damage: Due to the colonies formed on the abaxial surfaces of poplar leaves, the leaves become curled and desiccated (Çota, 2007).
Note: Şahbaz and Uysal (2006) reported that *Coccinella septempunctata* (L.) is also a predator of *C. populialbae*.

***Cinara cedri* Mimeur, 1936**
Identification: In apterous viviparous females, the head is brownish-yellow, the eyes are dark brown, the legs are yellow-black, and the antennae are light yellow-black; the thorax and abdomen are dark brown, with body length ranging from 3.0 to 3.8 mm. In alate (winged) viviparous females, the head is dark brown, the eyes are black, the antennae are brownish-red to black, the rostrum is light yellow, the wings are yellowish, and the thorax and abdomen are black. Their body length ranges from 3.5 to 4.4 mm (Çanakçıoğlu & Mol, 1998).
Distribution and Hosts: In Türkiye, this species has been recorded in Ankara, Antalya, Burdur, Eskişehir, Gaziantep, Istanbul, Konya, Kastamonu, and Samsun (Akyıldırım Beğen & Görür, 2020).
It has been identified on *Cedrus libani* in Kastamonu and on *Thuja* sp. along the Taşköprü road (Ünal & Özcan, 2005).
Type of Damage: Due to their clustered feeding habits, particularly on the shoot tips of lower cedar branches, the needles turn brown and eventually desiccate (Çanakçıoğlu & Mol, 1998).
Cinara spp. represents one of the most species-rich genera within the family Aphididae. These aphids exhibit a high degree of adaptation to coniferous species within the families Pinaceae and Coniferaceae. They feed on the roots, stems, branches, shoots, and needles of their hosts without host alternation (Akyıldırım Beğen & Görür, 2020).
Note: In their study conducted in the cedar forests of the Isparta Regional Directorate of Forestry, Oğuzoğlu & Avcı (2019) identified *Coccinella septempunctata* (L.) as one of the natural enemies of *Cinara cedri*.

Furthermore, Oğuzoğlu & Avcı (2025) reported *Cinara laportei* on *Cedrus libani*, and *Cinara obscura* and *Cinara orientalis* on *Pinus nigra*, noting the presence of *C. septempunctata* (L.) among the natural enemies of these pests.
Additionally, Oğurlu (2000) included *Cinara palaestinensis* among the host species of *C. septempunctata* (L.).

***Eulachnus nigricola* Pasek, 1953**
Identification: The body length ranges between 2.0 and 2.3 mm. Apterous individuals are light green in color, with brown legs, while the head, thorax, and dorsal abdomen are covered with a waxy substance. Their bodies are needle-shaped (Görür et al., 2014).
Distribution and Hosts: *Eulachnus nigricola*, which generally prefers *Pinus nigra* as its host, has been identified in the Turkish provinces of Adıyaman, Afyonkarahisar, Bursa, Kütahya, Malatya, Şanlıurfa, Uşak, Burdur, and Isparta (Görür et al., 2014; Görür, 2018; Patlar, 2020; Oğuzoğlu, 2022).
Type of Damage: These aphids generally inhabit pine needles. In pine seedlings with high infestation density, growth stunting occurs, followed by chlorosis (yellowing) of the needles and the onset of localized desiccation (Tuatay, 1999).
Note: *Eulachnus nigricola* is listed among the host species of *C. septempunctata* (L.) (Oğuzoğlu & Avcı, 2024).

***Myzocallis boerneri* Stroyan, 1957**
Identification: In alate (winged) forms, which are yellow in color, the head and thorax are darker. There are two rows of small spots on the dorsal side of the abdomen. The antennae feature brown-to-black rings. Nymphal stages are light yellow in color, and the spots observed in adults are less distinct in these individuals (Oğuzoğlu, 2022).
Distribution and Hosts: The genus *Myzocallis* is specialized on trees belonging to the family Fagaceae (Çalışkan et al., 2012).
In our country, it has been recorded in the provinces of Uşak, Afyonkarahisar, Kütahya, and Isparta on *Quercus ithaburensis*, *Q. cerris*, *Q. trojana*, *Q. infectoria*, and *Q. vulcanica* (Görür et al., 2014; Oğuzoğlu & Avcı, 2024).
Note: It has been determined by Oğuzoğlu and Avcı (2024) that *C. septempunctata* (L.) is a predator of *Myzocallis boerneri*.

***Myzocallis castanicola* Börner, 1950**
Identification: Adult individuals have an average body length of 1.6–1.7 mm and exhibit yellowish body coloration. Regularly arranged dark-colored spots are observed on the abdomen. One of the distinguishing morphological features aiding in the identification of this species is the dark-colored median line located on the head and thoracic regions. The cornicles are short, cylindrical, and dark-colored (Uzel, 2025).
Distribution and Hosts: In Türkiye, this species has been observed in the provinces of Kahramanmaraş, Uşak, and Adana on *Quercus robur*, *Q. ilex*, *Q. cerris*, and *Q. petraea* (Akyürek et al., 2013; Çalışkan et al., 2012; Uzel, 2025).
Type of Damage: *Myzocallis* spp. form colonies on leaves and feed by sucking plant sap, which leads to chlorosis, leaf curling, and physiological weakening. In cases of high pest density, a significant reduction in photosynthetic capacity is observed (Uzel, 2025).
Note: Uzel (2025) determined that *C. septempunctata* (L.) is a predator of *M. castanicola* on *Quercus robur* specimens.

***Pemphigus immunis* Buckton, 1896**
Identification: The body of apterous individuals is oval-shaped and ranges from 1.6 to 2.5 mm in length. The dorsal surface of the abdomen is covered with a waxy substance (Say, 2019).
Distribution and Hosts: The first record of this species in Türkiye was reported in Istanbul on *Populus nigra* and *Populus nigra* var. *pyramidalis* (Uygun et al., 2000). Furthermore, it is widely distributed in the provinces of Ankara, Denizli, Afyon, Kütahya, İçel, Niğde, Hatay, Adana, Sinop, Sivas, Ordu, Çorum, Eskişehir, Bolu, İzmir, Kuşadası, Muğla, Antalya, Burdur, Trabzon, Artvin, Bartın, Kahramanmaraş, Diyarbakır, and Konya, where it has been observed on *Populus nigra*, *P. canadensis*, and *Populus* sp. (Çanakçıoğlu & Toper, 1999; Uysal et al., 2006).
Type of Damage: It induces the formation of highly spherical, gall-like structures on the branches and shoots of poplar trees; these galls, which resemble shelled walnuts, contain numerous eggs (Çanakçıoğlu & Toper, 1999; Uysal et al., 2006).
Note: Uygun et al. (2000) report that *C. septempunctata* (L.) is among the natural enemies (predators) of *Pemphigus immunis*.

***Lachnus roboris* Linnaeus, 1758**
Identification: In their laboratory examination under a microscope, Akça et al. (2016) observed that in apterous females, the coxa and the tibia (from the middle to the distal end) are black, the tarsus is black, the trochanter and femur are brown, and the femorotibial joint is black. The thorax, cornicles, and the 6th antennal segment are black, while the remaining antennal segments are brown. The cauda and anal plates are black, and the body exhibits a pilose (hairy) and brown appearance. There are paired lateral black plates on each abdominal segment, as well as paired black plates on each abdominal segment on the ventral side, situated close to the lateral margins. The rostrum is particularly noted to be black, especially towards the distal end. The authors recorded the egg length as 1.70 mm, body length as 4.66 mm, and body width as 2.23 mm.
Distribution and Hosts: In Türkiye, this species has been recorded in the provinces of Afyonkarahisar, Kütahya, Uşak, Ankara, Kahramanmaraş, Samsun, Kayseri, Istanbul, Artvin, Mardin, Erzincan, Bitlis, Edirne, Konya, and Isparta (Oğuzoğlu, 2022).
It has been identified on *Castanea sativa*, *Picea* sp., *Pinus sylvestris*, *Pinus* sp., *Quercus coccifera*, *Q. cerris*, *Q. ilex*, *Q. petraea*, *Q. pubescens*, *Q. robur*, and *Q. suber* (Akça et al., 2016).
Type of Damage: Colonies are typically found in the axils of 1–3-year-old branches. They secrete abundant honeydew (Tuatay, 1999). This honeydew provides a highly favorable substrate for the development of saprophytic and pathogenic fungi. This condition is referred to as sooty mold (*fumagine*). Sooty mold causes a reduction in photosynthesis and leads to premature leaf abscission (Duravic & Ülgentürk, 2014).
Note: Aslan and Uygun (2005) reported that *Lachnus roboris* is among the primary food sources of *C. septempunctata* (L.).

***Phloeomyzus passerinii* Signoret, 1875**
Identification: *Phloeomyzus passerinii* typically begins its development in the bark crevices of mature poplar stands, generally at a height of 5–6 meters above the ground. Aphid colonies are characterized by the abundant, cottony, and whitish waxy secretions produced primarily by apterous females. The body length of apterous female individuals is 1.5–1.6 mm, whereas alate (winged) oviparous females measure approximately 1.4 mm (Yüksel & Öztürk, 2023).
Distribution and Hosts: In Türkiye, this species has been identified on *Populus nigra* in the provinces of Istanbul, Ankara, Konya, Kastamonu, and Düzce (Tuatay, 1999; Yüksel & Öztürk, 2023).

Type of Damage: *P. passerinii* forms colonies within the bark crevices of young shoots, branches, trunks, and roots (Uysal et al., 2006).
Cracks and necrosis on the bark surface of infected trees, delayed budburst, stunted growth, and dieback of lower branches are common symptoms. While feeding on parenchymal tissue, *P. passerinii* simultaneously injects toxic saliva into the woody tissue, causing the death of the colonized bark section. The accumulation of these secretions in subcortical galls increases the severity of the damage caused by the woolly aphid. It has been reported that the disruption of water and nutrient circulation due to bark necrosis stresses the poplar roots, often leading to trees being uprooted or broken by wind during the summer months (Yüksel & Öztürk, 2023).
Note: Kaynaş (2022) reported that adults and larvae of *Coccinella septempunctata* (L.) are predators of *P. passerinii* adults.
Harmful species within the family Aphididae preyed upon by *C. septempunctata* (L.), their host trees, and the corresponding studies reporting their infestation on these hosts (Table 1).

Table 1. Hosts of *C. septempunctata* (L.) within the family Aphididae identified on forest trees

Family	Harmful Species	Host Tree	Reference
Aphididae	*Aphis craccivora*	*Robinia pseudoacacia*	Ünal and Özcan, 2005
	Chaitophorus leucomelas	*Populus nigra* *P. canadensis* *P. alba* *Populus sp.*	Uysal at al., 2006
	Chaitophorus populialbae	*Populus alba* *P. tremula*	Uysal at al., 2006
	Cinera cedri	*Cedrus libani* *Thuja sp.*	Ünal and Özcan, 2005
	Cinara laportei	*Cedrus libani*	Oğuzoğlu and Avcı, 2024
	Cinara obscura	*Pinus nigra*	
	Cinara orientalis	*Pinus nigra*	
	Eulachnus nigricola	*Pinus brutia*	
		Pinus nigra subsp. pallasiana	Patlar at al., 2022
	Myzocallis boerneri	*Quercus ithaburensis* *Q. cerris*	Oğuzoğlu ve Avcı, 2024
	Myzocallis castanicola	*Quercus robur*	Uzel, 2025
		Q. cerris *Q. Petraea*	Akyürek at al., 2012
		Q. ilex	Çalışkan at al., 2012
	Pemphigus immunis	*Populus nigra* *P. canadensis*	Uysal at al., 2006
	Lachnus roboris	*Castanea sativa* *Picea sp* *Pinus silvestris* *Pinus sp.* *Quercus coccifera* *Q. cerris* *Q. ilex* *Q. etraea* *Q. pubescens* *Q. robur* *Q. suberi*	Akça at al., 2016
	Phloeomyzus passerinii	*Populus nigra* *P. alba*	Yüksel and Öztürk, 2023

Hosts Within The Family Diaspididae
***Carulaspis juniperi* Bouché, 1851**
Identification: The scale cover of adult females is circular or slightly oval, strongly convex, and grayish-white in color, with a cover length ranging from 0.8 to 1.6 mm; the exuviae are central or sub-central and yellow. The male pupal scale cover is narrow, oval, and longitudinally tricarinate, with a cover length of 0.7 to 1 mm; its exuviae are terminal and yellow. The body of the adult female is yellow and circular or broadly pyriform (Yaşar, 2020).
Distribution and Hosts: *Carulaspis juniperi* has been recorded in the Turkish provinces of Adana, Amasya, Ankara, Antalya, Burdur, and İzmir on *Cedrus libani*, *Cupressus sempervirens*, *Juniperus excelsa*, *J. sabina*, *J. virginiana*, *Platycladus orientalis*, *Thuja occidentalis*, and *T. orientalis* (Yaşar, 2020).
Type of Damage: These armored scales inflict damage by piercing plant tissues and sucking sap. During feeding, they inject toxic substances into their hosts, causing chlorosis (yellowing), premature needle drop (abscission), and shoot dieback (Yaşar, 2020).
Note: Ülgentürk and Toros (2000) reported that *Carulaspis juniperi* is included among the host species preyed upon by *Coccinella septempunctata* (L.).

***Leucaspis pusilla* Löw, 1883**
Identification: The scale cover of female individuals is 1.5 to 1.9 mm in length and red in coloration. The antennae are short, slightly curved, and bear stiff setae (Çanakçıoğlu & Mol, 1998).
Distribution and Hosts: This species has been identified on *Cedrus* sp., *Pinus brutia*, *Pinus brutia* "Eldarica", *P. halepensis*, *P. nigra*, *P. nigra* ssp. *laricio*, *P. nigra* ssp. *pallasiana*, *P. pinaster*, *P. pinea*, *P. ponderosa*, *P. radiata*, *P. roxburghii*, *P. sylvestris*, *P. strobus*, and *Salix* sp. within the provinces of Adana, Ankara, Antalya, Aydın, Balıkesir, Bartın, Burdur, Bursa, Çanakkale, Denizli, Edirne, Hatay, Isparta, İstanbul, İzmir, Kahramanmaraş, Karabük, Kastamonu, Kocaeli, Konya, Manisa, Muğla, Osmaniye, Sakarya, Samsun, Tekirdağ, and Zonguldak (Yaşar, 2020).
Type of Damage: It causes damage by extracting sap from the basal portions and inner surfaces of the needles. Needles damaged in the preceding year exhibit chlorosis and develop concentric, grayish-brown rings. Under severe population outbreaks, it can cause host mortality (Çanakçıoğlu & Mol, 1998).
Note: Ülgentürk and Toros (2000) listed *Leucaspis pusilla* among the host pests of *Coccinella septempunctata* (L.).
Harmful species within the family Diaspididae preyed upon by *C. septempunctata* (L.), their host trees, and the corresponding studies reporting their infestation on these hosts (Table 2).

Table 2. Hosts of *C. septempunctata* (L.) within the family Diaspididae recorded on forest trees

Family	Harmful Species	Host Tree	Reference
Diaspididae	*Carulaspis juniperi*	*Cedrus libani* *Cupressus sempervirens* *Juniperus excelsa* *J. sabina* *J. virginiana* *Platycladus orientalis* *Thuja occidentalis* *T. orientalis*	Yaşar, 2020
	Leucaspis pusilla	*Pinus nigra* Arnold. subsp. *pallasiana*	Patlar at al., 2022

Hosts Within The Family Marchalinidae
***Marchalina hellenica* (Gennadius, 1883)**
Identification: Adult female individuals are lemon-yellow in color and are covered with a white waxy substance. Their body length is approximately 8–10 mm and their width is 3–3.5 mm, with brownish antennae and legs (Çanakçıoğlu & Mol, 1998).
Distribution and Hosts: Although its primary distribution is within the Turkish pine (*Pinus brutia*) forests of Muğla, it has also been recorded on *Pinus brutia* in the provinces of Istanbul, Çanakkale, Antalya, Balıkesir, Denizli, and İzmir. Additionally, artificially infested populations exist in Burdur, Adana, and Edirne (Çanakçıoğlu & Mol, 1998; Aslan et al., 2021).
Type of Damage: Located within a self-secreted sticky, cottony sac on the bark of the host tree, *Marchalina hellenica* inflicts damage by inserting its mouthparts into the vascular bundles (phloem) of the tree to suck plant sap (Aslan et al., 2021). This physiological weakening of the Turkish pines predisposes them to colonization by secondary pests (Çanakçıoğlu & Mol, 1998).
Note: Oğurlu (2000) listed *Marchalina hellenica* among the host species of *Coccinella septempunctata* (L.).
Harmful species within the family Marchalinidae preyed upon by *C. septempunctata* (L.), their host trees, and the corresponding studies reporting their infestation on these hosts (Table 3).

Table 3. Host of *C. septempunctata* (L.) within the family Marchalinidae recorded on forest trees

Family	Harmful Species	Host Tree	Reference
Marchalinidae	*Marchalina hellenica*	*Pinus brutia*	Arslan at al., 2022

CONCLUSION AND RECOMMENDATIONS

In light of literature data, the prey species belonging to the order Hemiptera, which are fed upon by *Coccinella septempunctata* (L.) —an important predator in biological control—on forest trees, have been documented. It is understood that *C. septempunctata* (L.) acts as a predator on a total of 16 different forest pests, comprising 13 species from the family Aphididae, 2 species from the family Diaspididae, and 1 species from the family Marchalinidae. This demonstrates that *C. septempunctata* (L.) is a polyphagous species with a broad dietary range and can be utilized as a significant biological control agent in terms of natural balance within forest ecosystems.

It is evident that *C. septempunctata* (L.) plays an active role in naturally maintaining aphid and scale insect species below the economic injury level, particularly those that damage forest trees such as poplar (*Populus* spp.), pine (*Pinus* spp.), oak (*Quercus* spp.), and cedar (*Cedrus* spp.). The fact that *C. septempunctata* (L.) feeds on pests during both its larval and adult stages provides a major advantage in biological control.

The Twelfth Development Plan (2024–2028) states: "Inspections and training regarding the indiscriminate use of agricultural pesticides in crop production will be increased, and alternative biological and biotechnical control methods to chemical applications will be supported and popularized." Within the scope of this plan, training activities aimed at promoting *C. septempunctata* (L.) should be provided, and relevant projects should be supported.

In addition to conserving the presence of *C. septempunctata* (L.) in our forests, its mass rearing should be carried out in the Biological Control Laboratories operating under the Regional Directorates of Forestry, and it should be deployed more effectively in biological control strategies.

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