

0511 ბიოლოგია BIOLOGY**Ecological analysis of pest and disease dynamics in urban plant ecosystems**

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Abstract

Urban ecosystems are characterized by altered environmental conditions that significantly affect plant health, pest abundance, and pathogen dynamics. Monitoring conducted in Tbilisi, Georgia, from 2023 to 2025 revealed high diversity and pronounced spatial and temporal variation of plant pests and diseases across different urban green spaces, including parks, street trees, botanical gardens, and private yards. Several dominant insect pest groups, including representatives of *Ceroplastes*, *Pulvinaria*, *Tetranychus*, *Eulachnus*, and *Corytucha*, were consistently recorded, with peak population densities occurring in late spring and summer. Some pest species completed multiple generations per year in warmer and sheltered microhabitats. Fungal diseases were the most prevalent plant health issues, with frequent detection of *Cytospora*, *Phomopsis*, *Diplodia*, *Sphaeropsis*, *Alternaria*, and *Fusarium*, whereas bacterial and viral diseases were less common. Seasonal trends were evident: insect abundance increased with elevated air and soil temperatures, reflecting the urban heat island effect, while fungal disease severity was associated with higher relative humidity, reduced air circulation, and soil conditions, including moisture, compaction, and pH, which influenced both pest abundance and disease incidence, particularly in enclosed urban sites. Statistical analyses demonstrated strong positive correlations between pest abundance and abiotic factors such as temperature and soil moisture, and between disease severity, soil compaction, and microclimatic stress. Vegetation structure, biodiversity, and connectivity influenced pest and disease dynamics, with fragmented and low-diversity green spaces exhibiting higher pest abundance and disease incidence. The abundance of natural enemies was reduced in isolated urban patches, contributing to frequent pest outbreaks. Urban stressors, including pollution, traffic, and human-mediated plant movement, facilitated the introduction and spread of invasive pests and pathogens. These findings highlight the complex interactions of biotic and abiotic factors shaping urban plant health and provide insights for developing ecologically informed management strategies to enhance the resilience of urban green spaces.

Keywords: Urban ecosystems, Plant pests, Fungal pathogens, Ecological monitoring.

Introduction

Urban ecosystems generate profoundly altered environmental conditions that significantly influence the occurrence, development, and spread of plant pests and diseases. Compared to natural or agricultural landscapes, cities present a unique combination of abiotic and biotic stressors that interact in complex ways to shape plant health and pest population dynamics [1, 2].

One of the primary drivers is the urban heat island (UHI) effect, which elevates air and soil temperatures, prolongs the growing season, accelerates insect metabolic and reproductive rates, and enhances the development cycles of many pathogens.

These elevated temperatures, combined with drought stress and irregular irrigation, weaken plant physiological processes such as photosynthesis, water regulation, and the production of defensive compounds, thereby increasing plant susceptibility to infestation and infection [2, 6].

Urban areas also consist of fragmented and highly isolated green spaces - parks, street trees, botanical gardens, and private yards which limit ecological connectivity and reduce the abundance of natural enemies such as predators, parasitoids, and entomopathogenic organisms [3, 4]. This decline in ecological regulation often leads to uncontrolled pest outbreaks [4].

Additional urban stressors, including reduced biodiversity, soil degradation and compaction, air pollution from particulate matter and gaseous pollutants, and frequent anthropogenic disturbances such as construction and traffic, further compromise plant vigor and facilitate pest colonization [3, 6].

Moreover, urban landscapes function as gateways for biological invasions, as the movement of ornamental plants, globalized trade networks, and high levels of human mobility contribute to the introduction and rapid establishment of invasive pests and pathogens [4, 6].

These species often thrive in urban microhabitats that provide warm temperatures, abundant host plants, limited competition, and fewer natural enemies.

Consequently, plants in urban environments are continuously exposed to interacting biotic and abiotic pressures that create microclimatic hotspots favorable for pest population growth and recurrent disease outbreaks [1, 5].

In addition to temperature, humidity, and other urban stressors, soil conditions - including moisture, compaction, and pH play a critical role in influencing both pest abundance and disease severity, particularly in enclosed or fragmented urban sites. For example, enclosed urban spaces with reduced airflow and elevated humidity may promote foliar fungal diseases, while warmer microclimates can support multiple insect generations per year [4, 5].

Understanding how these ecological factors operate in urban landscapes is essential for evaluating their impacts on plant health and for identifying ecologically informed principles to guide sustainable pest and disease management [6].

Main Part

Materials and methods - The study was conducted in urban green spaces of Tbilisi, Georgia, encompassing a range of habitat types including public parks, street trees, the botanical garden, and private residential yards. Sampling sites were selected to represent different degrees of vegetation fragmentation, anthropogenic disturbance, and microclimatic conditions, following approaches commonly applied in urban ecological studies [3,6]. Geographic coordinates and environmental characteristics of each site were recorded using GPS and field surveys.

Plant pest and pathogen populations were monitored from 2023 to 2025. Sampling was conducted biweekly across all selected sites. Insect pests were collected using standardized sweep nets, sticky traps, and visual inspection of leaves, stems, and flowers, as recommended for urban arthropod monitoring [4]. Collected insects were identified to the lowest possible taxonomic level using regional identification keys [7].

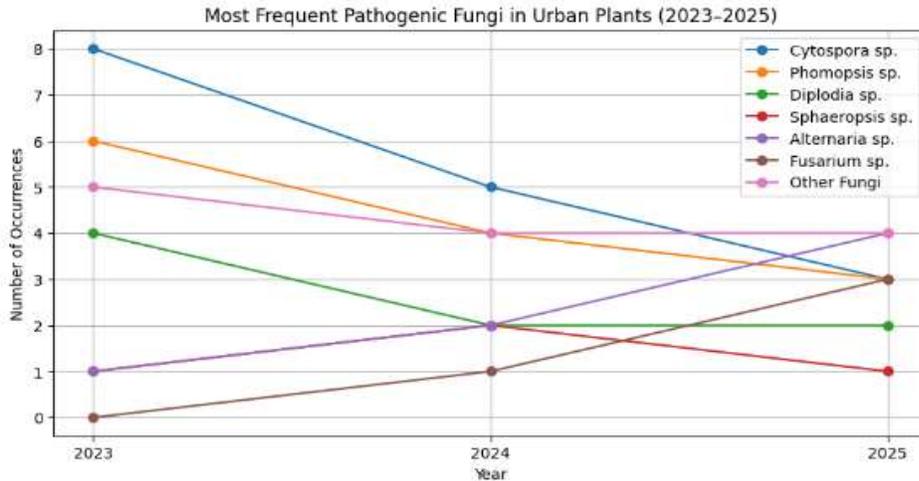
Pathogen incidence was assessed through visual examination of symptomatic plant tissues, including leaves, stems, and fruits. Fungal pathogens were identified based on morphological characteristics and microscopic analysis following standard diagnostic procedures [5, 6, 7]. Disease severity was quantified using standardized rating scales (percentage of leaf area affected or lesion count per plant).

Microclimatic parameters, including air temperature, relative humidity, and soil temperature, were recorded at each site using digital sensors. Soil moisture content and pH were measured to evaluate stress factors influencing plant susceptibility [1, 6]. Vegetation structure, host plant diversity, and canopy cover were documented to assess habitat complexity and ecological connectivity [3].

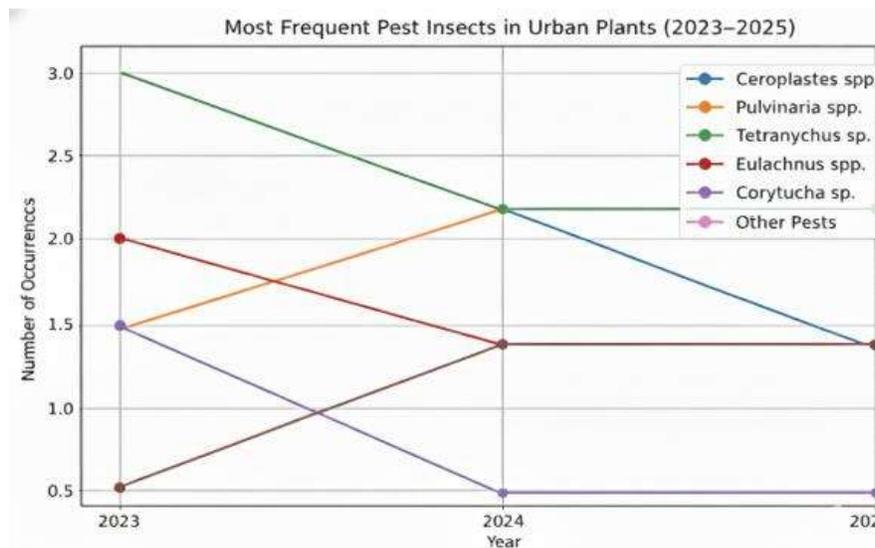
Temporal and spatial trends in pest and pathogen populations were analyzed using descriptive statistics and multivariate methods. Correlations between pest and disease occurrence and abiotic factors (temperature, humidity, soil conditions) were assessed using regression models. The effects of vegetation fragmentation, host plant density, and urban stressors on pest abundance and disease severity were evaluated using generalized linear models [4, 6].

Results

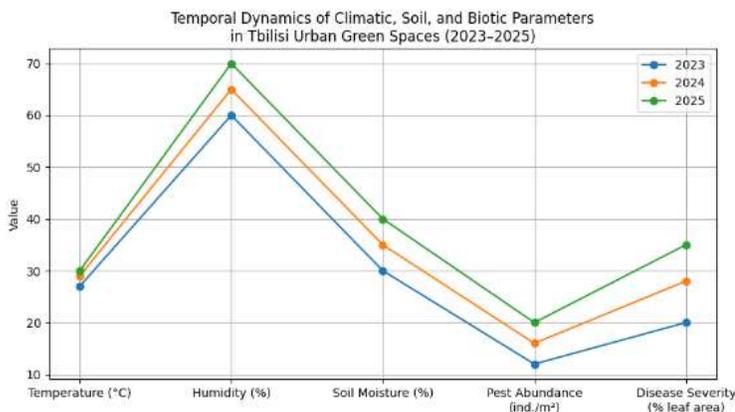
The monitoring of plant pests and pathogens conducted across the urban green spaces of Tbilisi between 2023 and 2025 revealed a high diversity of species characterized by pronounced spatial and temporal variation. Fungal pathogens were identified as the most prevalent plant health threat, with the genera *Cytospora*, *Phomopsis*, *Diplodia*, *Sphaeropsis*, *Alternaria*, and *Fusarium* being the most frequently detected, particularly on ornamental trees and shrubs. Temporal trends showed a dynamic shift: while the occurrence of *Cytospora* sp. declined from 8 cases in 2023 to 3 in 2025, other pathogens such as *Alternaria* sp. and *Fusarium* sp. exhibited a gradual increase in frequency over the same period.



Parallel to the fungal dynamics, the entomological survey identified *Ceroplastes*, *Pulvinaria*, *Tetranychus*, *Eulachnus*, and *Corytucha* as the dominant insect pest groups. These pests were present throughout the growing season, reaching peak population densities during late spring and summer. The study established a clear correlation between abiotic factors and the severity of biotic stress. Insect pest abundance significantly increased in tandem with elevated air and soil temperatures a phenomenon exacerbated by the urban heat island effect reaching approximately 20 individuals per m² as temperatures approached 30°C.



Conversely, fungal disease incidence was primarily driven by relative humidity and limited air circulation. Specifically, disease severity reached a maximum of 35% leaf area involvement when relative humidity climbed to 70%. Spatial analysis indicated that enclosed urban sites, such as inner-city parks and residential courtyards, experienced an earlier onset and longer persistence of foliar diseases compared to more open locations.



Soil conditions also played a critical role in influencing both pest abundance and disease severity. Sites with compacted or poorly drained soils showed a higher incidence of fungal pathogens, particularly *Cytospora* and *Phomopsis*, while soil moisture positively correlated with pest density in warmer microhabitats. Furthermore, deviations from neutral pH were associated with increased plant susceptibility to both insect infestation and fungal infection.

Finally, the data suggest that vegetation structure and biodiversity are critical determinants of ecosystem resilience. Urban sites characterized by low plant species diversity and high fragmentation exhibited significantly higher pest abundance and disease severity. This increased vulnerability is associated with a lower presence of natural enemies in fragmented habitats, leading to more frequent pest outbreaks and reduced biological control.

Discussion

The monitoring of urban green spaces in Tbilisi from 2023 to 2025 highlights the profound impact of the urban environment on plant-pest-pathogen interactions. The findings confirm that the Urban Heat Island (UHI) effect is a primary driver of insect population dynamics. The correlation analysis specifically demonstrates that as temperatures approach 30°C, insect pest abundance rises to approximately 20 individuals per m². These elevated temperatures not only accelerate the metabolic rates of dominant pests such as *Ceroplastes* and *Tetranychus* - the latter of which showed a peak occurrence of 3.0 in 2023 but also extend the growing season, allowing species to complete additional generations. This "thermal advantage" for pests, coupled with stressors in urban microhabitats, significantly compromises host plant resistance [2, 6, 7, 8]. The prevalence of fungal pathogens, particularly *Cytospora*, *Phomopsis*, and *Diplodia*, reflects the dual nature of urban microclimates. While open areas suffer from heat stress, enclosed spaces like residential courtyards create "humidity pockets" with reduced air circulation. Data indicates a strong positive correlation between humidity and disease severity; when relative humidity reaches 70%, fungal disease severity peaks at 35% leaf area involvement. Interestingly, while *Cytospora* sp. showed a declining trend from 8.0 to 3.0 occurrences over the study period, emerging threats like *Alternaria* sp. rose from 1.0 to 4.0, suggesting a shift in the fungal community composition. A key ecological insight is the impact of habitat fragmentation. The observed reduction in natural enemies in isolated green patches explains the frequency of pest outbreaks. In the absence of sufficient biodiversity and ecological connectivity, the natural "checks and balances" of the ecosystem fail. This confirms that the high incidence of pests in Tbilisi is a structural issue, driven by low-diversity landscapes where fragmented spaces exhibit higher pest abundance and greater disease severity compared to structurally complex sites. In the specific context of Tbilisi's landscape, the implementation of Green Corridors serves as a strategic necessity to counteract this fragmentation. These corridors would act as ecological bridges, connecting isolated green pockets like the National Botanical Garden, Vake Park, and the suburban forested areas. By restoring this connectivity, we facilitate the movement of natural enemies (predators and parasitoids) from stable reservoirs into infested urban zones. Furthermore, green corridors help mitigate the UHI effect by creating continuous pathways for cool air circulation along the city's natural topography, directly enhancing plant physiological resistance against opportunistic pathogens. Synergistic Stressors: Urban plant health is governed by a complex synergy where abiotic stressors weaken plant defenses. 1 Soil properties, including moisture, compaction, and pH, significantly influenced dynamics. Sites with compacted or poorly drained soils showed higher incidence

of fungal pathogens, while variations in soil pH were associated with increased susceptibility to both insect infestation and fungal infection. These findings underscore the need to consider soil management in ecological mitigation strategies.

Conclusions

Climate Sensitivity: Insect pest abundance is highly sensitive to temperature increases (reaching peak density at 30°C), whereas fungal disease severity is more closely linked to relative humidity and poor air circulation in enclosed sites.

Resilience through Diversity: High vegetation complexity and plant diversity act as natural buffers. Conversely, fragmented green spaces are more susceptible to severe infestations due to the loss of natural enemy populations.

Pathogen Shifts: Monitoring reveals dynamic shifts in pathogen frequency, notably the rise of *Alternaria* and *Fusarium* species, necessitating continuous surveillance.

Management Shift: To enhance resilience in Tbilisi, management must shift toward proactive practices, such as creating "green corridors" to restore ecological connectivity, enhance urban ventilation, and support biological control agents.

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ურბანულ გარემოში მცენარეთა მავნებელი დაავადებების გავრცელების ეკოლოგიური ანალიზი

ქეთევან თავართქილაძე

მირანდა წეროძე

რეზიუმე

ურბანულ გარემოში ჩამოყალიბებული სპეციფიკური ეკოლოგიური პირობები მნიშვნელოვან გავლენას ახდენს მცენარეთა ჯანმრთელობის მდგომარეობაზე, მავნებლების გავრცელებასა და პათოგენების განვითარების დინამიკაზე. ქ. თბილისში ურბანულ მწვანე სივრცეებში 2023 -2025 წლებში განხორციელებულმა მონიტორინგმა ნათლად წარმოაჩინა მანე ორგანიზმების მრავალფეროვნება, მათი სივრცით-სეზონური დინამიკის ინტენსიური ცვლილება, ურბანული სითბური კუნძულის ეფექტის და ჰაბიტატების ფრაგმენტაციის როლი მცენარეთა ფიტოსანიტარიული მდგომარეობის დეგრადაციაში. მავნებელთა შორის დომინირებდნენ *Ceroplastes*, *Pulvinaria*, *Tetranychus*, *Eulachnus* და *Corytuca* გვარების წარმომადგენლები, რომელთა პოპულაციების პიკი ძირითადად გვიან გაზაფხულსა და ზაფხულში აღინიშნა. სოკოვანი დაავადებები მცენარეთა ჯანმრთელობის ძირითად პრობლემას წარმოადგენდა, განსაკუთრებით *Cytospora*, *Phomopsis*, *Diplodia*, *Alternaria* და *Fusarium* გვარის წარმომადგენლების ფართო გავრცელებით, რაც პირდაპირ კავშირშია კლიმატურ და ნიადაგურ პირობებთან. ურბანულმა სტრუქტურებმა, მათ შორის დაბინძურებამ, ავტოტრანსპორტმა, მცენარეების ანთროპოგენულმა გადაადგილებამ, მწვანე სივრცეების იზოლაციამ და სხვ. ხელი შეუწყო ბუნებრივი აგენტების შემიგრებას და მავნებელ-დაავადებათა ინვაზიური სახეობების ინტროდუქციასა და გავრცელებას. მიღებული შედეგები მიუთითებს რომ ურბანული ნარგავების მდგრადობის ასამაღლებლად აუცილებელია ეკოლოგიურად დასაბუთებული მართვა, მათ შორის ეკოლოგიური კავშირებისა და ბუნებრივი ვენტელაციის აღსადგენად მწვანე დერეფნების შექმნა.

საკვანძო სიტყვები: ურბანული ეკოსისტემები, მავნებლები, დაავადებები, ეკოლოგიური მონიტორინგი, მწვანე დერეფნები.