ANALYSIS OF THE EVOLUTION OF THE INVASIVE SPECIES *Corythuca arcuata* Say, 1832 (TINGIDAE, HEMIPTERA) WITHIN THE RĂŞINARI FOREST DISTRICT, SIBIU COUNTY

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Abstract. The present study investigates the presence and dynamics of the invasive species *Corythucha arcuata* Say, 1832 in oak stands (especially *Quercus petraea* and *Q. cerris*) within the Răşinari Forest District, Sibiu County. Data collected in the active season 2024 revealed a high degree of infestation, ranging from 45% to 90%, with the maximum values being recorded in plots 9, 2 and 14. The identified colonies were at all stages of development, signaling a mature invasion, with a rapid ecological adaptation to local climatic conditions. At least two complete generations per season and prolonged biological activity until late autumn were confirmed, indicating an increased potential for overwintering of adults and early reactivation in spring. The distribution of colonies followed an edge-interior pattern, with increased densities near forest access roads and previously exploited areas. The analysis of the correlations between the degree of infestation and ecological factors reveals the significant influence of altitude, southern exposure and crown opening, while the age of the trees did not significantly influence the susceptibility to attack. The results highlight an accelerated and stable spread of the *Corythucha arcuata* species in the studied area, with important implications for the phytosanitary management of oak forests in the mountainous region of Romania.

Keywords: *Corythucha arcuata*, invasive species, oak lacewing, oak, infestation, Răşinari Forest District, ecological factors.

Rezumat. Analiza evoluției speciilor invazive *Corythuca arcuata* Say, 1832 (Tingidae, Hemiptera) în districtul forestier Răşinari, județul Sibiu. Prezentul studiu investighează prezența și dinamica speciei invazive *Corythucha arcuata* Say, 1832 în arborete de stejar (în special *Quercus petraea* și *Q. cerris*) din cadrul Ocolului Silvic Răşinari, județul Sibiu. Datele culese în sezonul de toamnă a anului 2024 au relevat un grad ridicat de infestare, variind de la 45% la 90%, valorile maxime fiind înregistrate în parcelele 9, 2 și 14. Coloniile identificate se aflau în toate stadiile de dezvoltare, semnalând o invazie matură, cu o adaptare ecologică rapidă la condițiile climatice locale. Au fost confirmate cel puțin două generații complete pe sezon și activitatea biologică prelungită până la sfârșitul toamnei, indicând un potențial crescut de iernare a adulților și reactivare timpurie primăvara. Distribuția coloniilor a urmat un model margine-interior, cu densități crescute în apropierea drumurilor de acces forestier și a zonelor exploatate anterior. Analiza corelațiilor dintre gradul de infestare și factorii ecologici relevă influența semnificativă a altitudinii, expunerii spre sud și deschiderii coroanei, în timp ce vârsta arborilor nu a influențat semnificativ susceptibilitatea la atac. Rezultatele evidențiază o răspândire accelerată și stabilă a speciei *Corythucha arcuata* în zona studiată, cu implicații importante pentru managementul fitosanitar al pădurilor de stejar din regiunea muntoasă a României.

Cuvinte cheie: *Corythucha arcuata*, specii invazive, stejar, infestare, Ocolul Silvic Răşinari, factori ecologici.

INTRODUCTION

Invasive forest species constitute a major factor of ecological imbalance, generating direct effects on the vitality and resilience of ecosystems. Through ecological plasticity and high multiplication capacity, they compromise the health of the host trees, reduce biodiversity and diminish the stability of forests. In recent decades, European forests have been under increasing pressure from invasive species, notably *Corythucha arc*uata Say, 1832 (laced oak bug).

This species (Tingidae, Hemiptera), originally from North America, was reported for the first time in Europe in 2000, in Italy (BERNATINELLI & ZANDIGIACOMO, 2000), and in Romania since 2015 (DON et al., 2016; CHIRECEANU et al., 2017; CICEOI et al., 2017; FLORIAN et al., 2022; STANCĂ-MOISE et al., 2023, STANCĂ-MOISE, 2024 a,b), its rapid expansion being facilitated by the international transport of wood materials and climate change (WILLIAMS et al., 2021). *C. arcuata* is 3–4 mm long, gray-white body with lacy appearance and transparent wings with dark spots (DOBREVA et al., 2013; SIMOV et al., 2018). The biological cycle includes the egg–nymph–adult stages, with up to several generations per year in temperate regions (DIOLI et al., 2007; FARACI, 2019; FORSTER et al., 2005; STREITO et al., 2018; JURC, 2017; DAUTBASIC et al., 2018; DE GROOT et al., 2022). Feeding with leaf sap causes discoloration, drying and premature defoliation, leading to the reduction of photosynthesis and the weakening of tree vitality, with negative effects on forest biodiversity (CSEPELÉNYI et al., 2020; CSÓKA et al., 2020; KOVAČ et al., 2020; KOVACS et al., 2020).

The purpose of this study, which is part of a research project that will take place during the years 2025-2027, is to evaluate the degree of infestation with *C. arcuata* in the oak groves (*Quercus petraea, Q. cerris*) from Production Unit VI, Răşinari Forest, through a phytosanitary and ecological analysis that correlates the intensity of the attack with environmental factors (altitude, exposure, composition and age of the groves). The specific objectives of the study were: determining the presence and intensity of the attack in various types of quercine trees, identifying the stages of development and estimating the number of generations per season, correlating the degree of infestation with ecological parameters and identifying some population control measures following monitoring based on data obtained from the field in the years 2025-2027.

The working hypotheses that were the basis of the research were the following: *C. arcuata* was reported starting in 2022 and is present in all oak groves in U.P. VI Resins, in all stages of development (eggs, nymphs, adults); the degree of attack varies significantly depending on the exposure of the plots and their altitude, being higher in areas with southern exposure and altitudes below 1500 m; middle-aged trees (55–150 years) are more vulnerable than very young (under 50 years) or very old (over 100 years) trees, due to their higher foliage density and stable microclimate.

This analysis allowed not only a detailed understanding of the impact of the lace bug on the oak groves in Rășinari, but also the formulation of practical directions for management, monitoring and control, with direct implications for the conservation and maintenance of the health of the forests within the bypass.

MATERIALS AND METHODS

The research area is represented by the Rășinari forest, located in Sibiu county, within the Rășinari Forest Circle, Production Unit VI. This unit includes a series of quercinee stands, characterized by the predominance of oak species (*Quercus petraea, Q. cerris*), with high ecological and economic importance. The groves are located on slopes with varied exposures, at average altitudes between 600 and 1400 m, presenting a significant structural and functional diversity. The local ecological conditions temperate-continental climate, fertile brown-acidic and brown-eumesobasic soils support the development of deciduous forests, but at the same time make them susceptible to attacks by invasive species such as *C. arcuata*.

To evaluate the degree of infestation, 13 representative plots were monitored: 3A, 3B, 5A, 5B, 125F, 116F, 9, 10A, 10B, 12, 13, 14A, 14B. The selection criteria concerned: the predominance of oak species in the composition of the stand; altitudinal diversity and slope exposure; the existence of a recent history of infestation reported by forestry personnel; physical accessibility for traveling in the field and applying observation methods (Fig. 1).

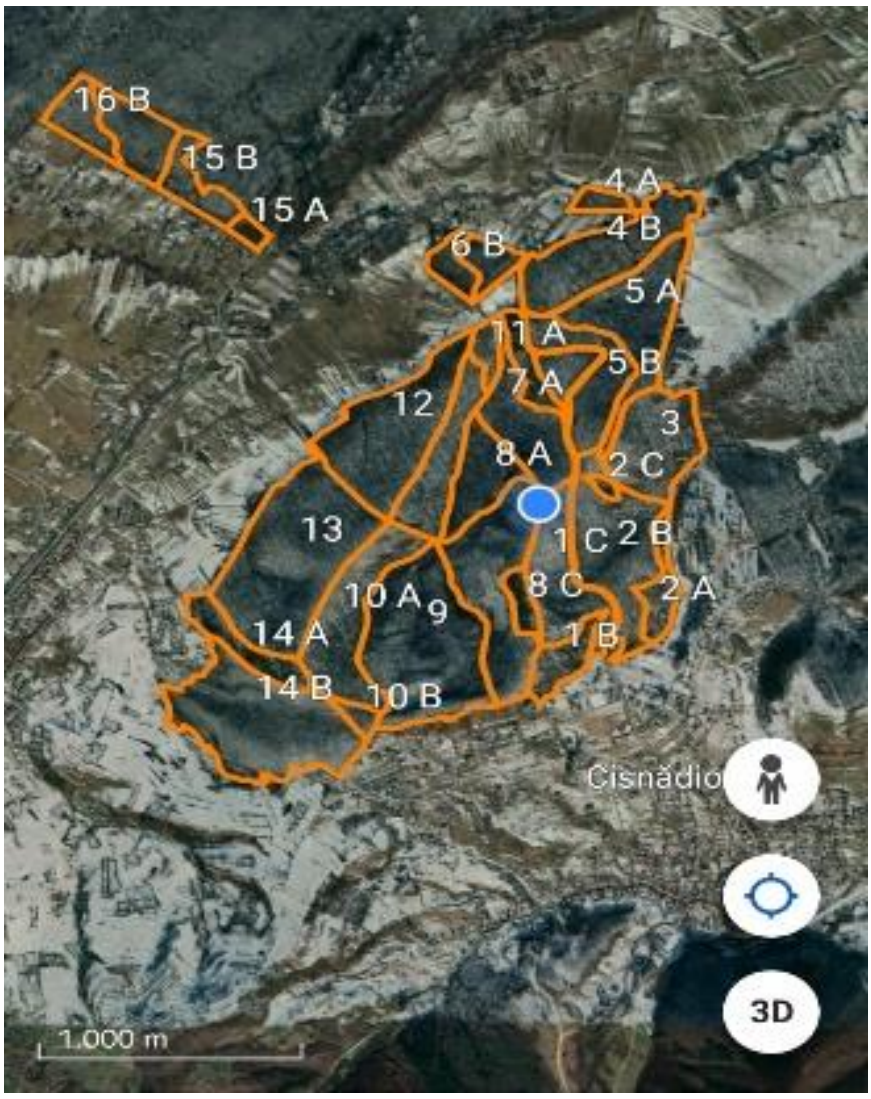

Figure 1. Map with plots where observations were made (google maps).

The applied methodology was of the observation type, carried out directly in the field. The observations were made in collaboration with the forestry staff, during several months: September 2024-June 2025. Systematic visual inspection of leaves in the lower (1.5–2 m) and middle canopy (with a telescopic pole or by controlled climbing). Each tree was evaluated from four cardinal points to obtain representative data. The identification of biological stages was recorded eggs (on the underside of leaves), nymphs in different stages and adults (Fig. 2**)**.

Figure 2. Systematic visual inspection (original photo).

Estimation of the degree of percentage attack, based on the affected leaf surface or the degree of tree colonization, according to the standards of the Phytosanitary Evaluation Guide (ICAS, 2011). The data were recorded in the field notebook.

Recording of ecological factors altitude (GPS), general exposure (compass), stand composition, dominant age, degree of crown closure and substrate moisture. These data were centralized in a database for further analysis. The choice of periods aimed at capturing the various developmental stages of the insect: autumn (presence of adults and eggs), spring (early emergence), respectively the beginning of summer (maximum activity of nymphs and adults).

RESULTS AND DISCUSSIONS

The studies carried out within Production Unit VI of the Răşinari Forestry have confirmed the widespread presence of the invasive species *C. arcuata* in all investigated plots. All biological stages (eggs, nymphs, adults) were identified, indicating a stable and reproductive population adapted to local conditions. The temporal evolution reveals the persistence of the infestation from one season to another, which suggests the existence of at least two active generations per season, with a consistently high intensity of attacks.

The species *C. arcuata* is present in all 13 analyzed plots, which confirms the hypothesis regarding the widespread spread of the pest in the quercinee stands of U.P. VI Repentance.

All biological stages (eggs, nymphs, adults) were identified, indicating an active, well-established population in reproductive phase (Fig. 3).

The recorded values show a high degree of attack in most plots, ranging between 45% and 90%. This range confirms that the species *C. arcuata* is well established in oak ecosystems and has an extensive distribution within the U.P. VI.

The highest attacks were recorded in plots 10A (85–90%), 3A (85%) and 5B (80%), indicating areas of intense biological pressure.

The lowest degree of infestation was observed in plot 9 (45%), a fact that can be correlated with the southeast exposure and the intermediate altitude, but also with specific microclimatic factors.

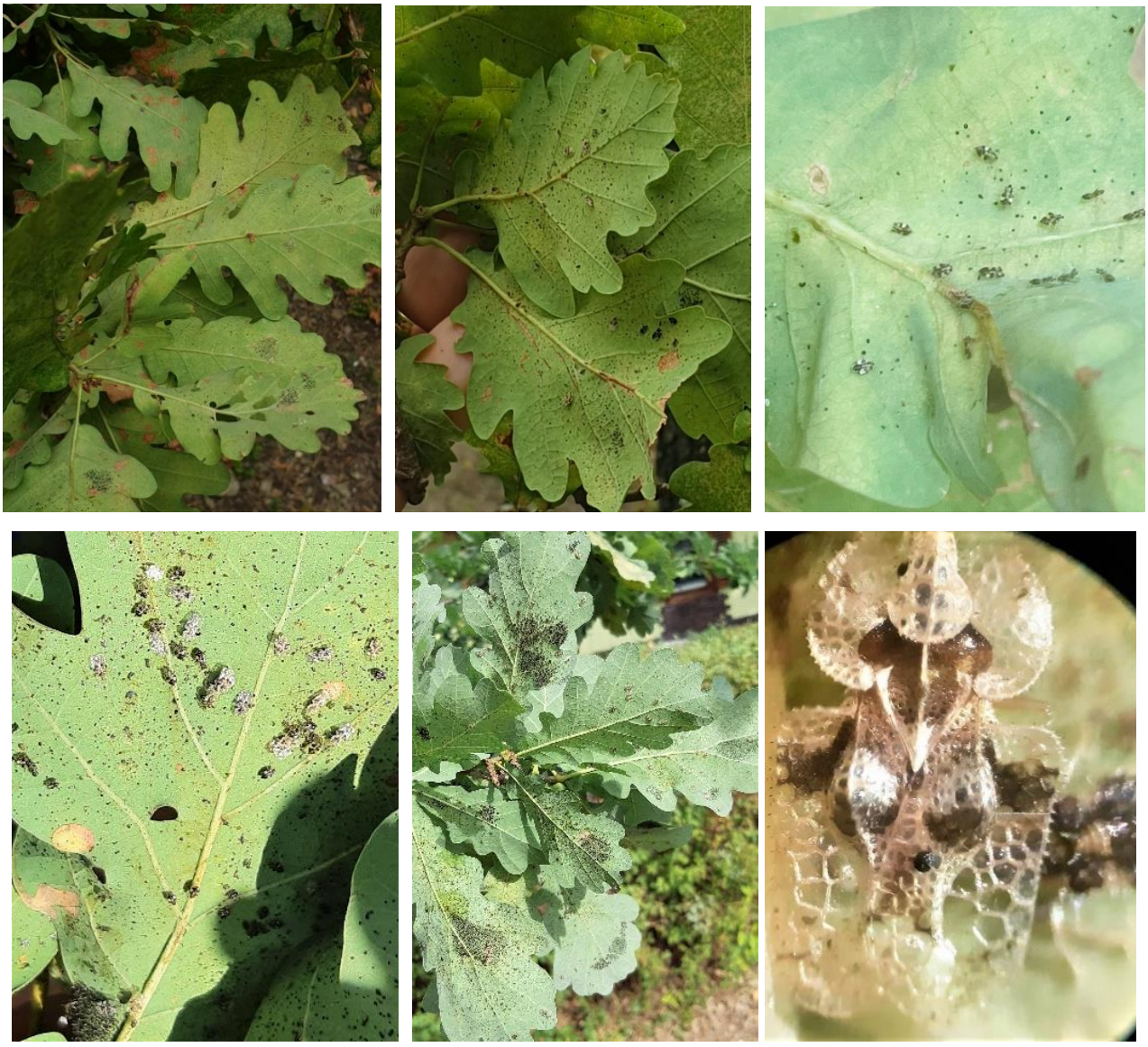

Figure 3. The developmental stages of the insect identified on the attacked leaves (original photo).

The influence of altitude shows a tendency to decrease infestation intensity at high altitudes (above 1450 m), where values are generally moderate (75–80%), compared to lower altitudes (600–1250 m), where attacks are more frequent and severe (75–90%). Thus, plots located at 600 m (3A, 3B, 5A, 5B) show consistent attacks (75–85%). At high altitudes (over 1500 m, ex. 14A, 13), infestations remain high (75–80%), indicating that the species has a capacity to adapt to mountainous areas as well, even if its activity is slightly reduced.

The role of the exposure the exposure of the plots visibly influences the degree of attack, the plots with southern and south-eastern exposure (9, 10A, 12, 14B) show variable values, between 45% and 90%, with a tendency towards more severe attacks at intermediate altitudes (10A, 12, 14B). Northeastern exposures (3A, 3B, 5A, 5B, 13, 14A) generally show constant and high attacks (75–85%), suggesting that the species is not limited by slope orientation.

The influence of the age of the stands indicates a transversal vulnerability, the trees being affected regardless of the age class: Old stands (135–145 years, ex. 3A, 3B, 10B) show attacks of 55–85%. Young trees (55–70 years, ex. 14B, 13) are also intensively attacked (75–80%). Medium trees (100–120 years, ex. 5A, 9, 12, 14A) have greater variability, from 45% (9) to 80% (5A, 14A).

This confirms that the species affects trees of all ages, contradicting the hypothesis that old trees would be significantly more vulnerable (Table 1).

The bar chart illustrates (Fig. 4) the attack rate (%) of the invasive species *Corythucha arcuata* in the 13 plots analyzed in the Răşinari Forest District (U.P. VI). The values vary between 45% (plot 9) and 88–90% (plot 10A), indicating a generalized infestation. The most affected plots are 10A, 3A, 5B and 14B, all with attack rates ≥ 80%. A strict correlation with altitude is not observed, but plots with southern or southeastern exposure tend to present higher values. Plots located at lower altitudes (600–900 m) show constant and severe attacks (75–85%), which suggests a high climatic favorability for the development of the insect.

Table 1. Synthetic data regarding the degree of *Corythucha arcuata* attack in the analyzed plots.

Parcel	Altitude (m)	Exposition	Composition	Age (years)	Attack Degree (%)
3A	600	NE	10Go	135	85
3B	600	NE	10Go	145	75
5A	600	NE	7Go3St	120	75
5B	600	NE	7Go2St1Ca	100	80
125F	1450–1710	NE	5Go3Pi2Fa	60	75–80
116F	800-1000	E	9Go1Fa	120-150	80
9	1360	SE	10Go	105	45
10A	1270–1590	SE	10Go	80	85–90
10B	1250	SV	10Go	135	55
12	1250–1330	SE	10Go	110	75–80
13	1470–1700	NE	10Go	70	75
14A	1500–1710	NE	5Pi3Go2PIN	110	75–80
14B	1330–1560	S	9Go1Ca	55	80

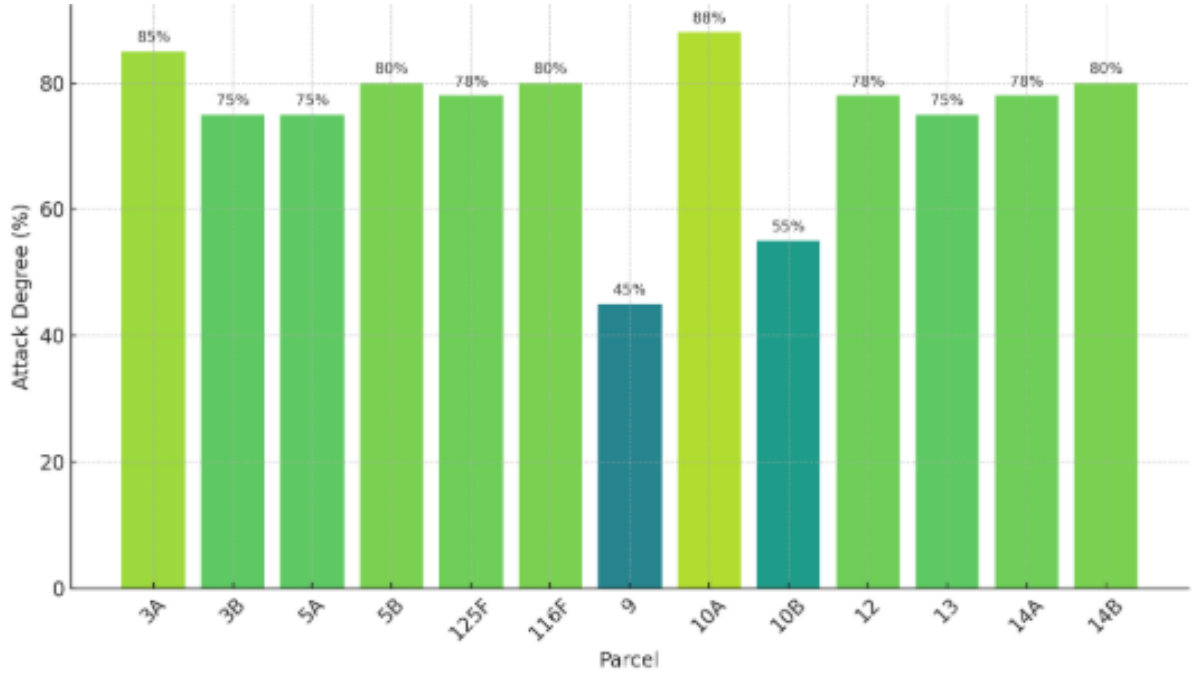

Figure 4. Degree of *Corythuca arcuata* Attack by Parcel (Răşinari Forest).

The graph highlights an irregular but intense distribution of invasion in all areas analyzed, confirming the high adaptive capacity of the C. arcuata species.Influence of the composition, all plots with gorun dominance (Go) showed high attacks, which confirms the trophic preference of the species for *Quercus spp*. In plots with mixtures (Go + St, Go + Ca, Go + Pi), the degree of attack was not significantly reduced, indicating a wide ecological tolerance of the species and a possible secondary colonization on other species.

The heatmap (Fig. 5) shows the variation in attack intensity depending on the plot and the slope exposure (NE, SE, S, SW, E). Darker shades (violet–intense yellow) correspond to a higher degree of infestation. Plots with southern and southeastern exposure (S, SE) generally show higher values (up to 90%), which confirms the positive influence of high temperatures and a drier microclimate on the activity of the species. Northeast exposures (NE), although colder, are not protected, showing attacks of 75–85%, which suggests an extended ecological adaptability. The thermal

distribution indicates a uniformity of the attack degree between different orientations, with slight intensifications in sunny areas.

The heatmap confirms that invasion is not limited by geographical exposure, but is accentuated in plots with southern exposure, which corresponds to the hypothesis regarding the positive influence of solar radiation on the development of *C. arcuata*.

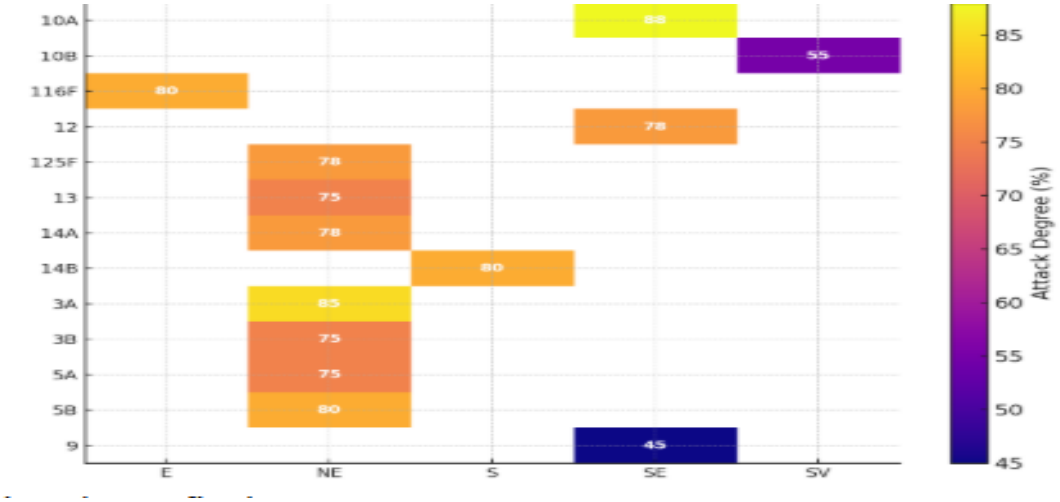

Figure 5. Heatmap -Attack Degree by Parcel and Exposition.

CONCLUSIONS

The study carried out within the Rășinari Forest confirmed the widespread presence and high degree of infestation of the invasive species *C. arcuata* in the oak groves of U.P. VI. The values of the degree of attack recorded after the assessment in the fall of 2024 were between 45% and 90% which demonstrates the stabilized invasive nature of the species, with colonies present in all stages of development and with at least two complete generations per season. This fact emphasizes the fast adaptation capacity of the lace bug to the climatic and ecological conditions in the mountainous area of Sibiu.

The distribution of infestation revealed significant differences between plots, with increasing trends in areas with intermediate altitudes, southern or southeastern exposure and open canopy. The results confirm the influence of ecological factors on population dynamics and suggest that tree vulnerability is not strictly dependent on age. However, middle-aged trees (60–80 years) frequently recorded the highest attacks, indicating an increased risk for this forest structural category.

Comparing the data obtained in Rășinari with those from the city of Sibiu, studies carried out by the authors between the years 2021-2023 in the urban parks and Dumbrava forest, but also in other regions of the country (Arad, Ilfov) reveal a similarity of the trophic and ecological preferences of the species, but also particularities related to the Transylvanian topography and microclimate, which can influence the pace and intensity of the invasion (DON et al., 2016; CICEOI et al., 2017; FLORIAN et al., 2022; STANCĂ-MOISE et al., 2023; STANCĂ-MOISE, 2024).

At the level of Sibiu county, the careful monitoring of invasive insects is a priority for the protection of forest and urban heritage. In oak forests, *C. arcuata* infestation is a direct threat to biodiversity and ecosystem stability, and in urban green spaces it can affect the health of ornamental trees and the comfort of the population.

Effective management of this invasive species requires an integrated strategy based on: systematic monitoring through field observations and digital tools; biological methods (introduction or stimulation of natural predators and specific parasites) what I proposed during the project; cultural practices (clearing fallen leaves, managing affected trees, maintaining the diversity of the forest composition); cautious application of chemical methods, where possible and where there are no risks to the environment or public health.

In conclusion, *C. arcuata* represents a major challenge for the management of oak forests in Sibiu, with a significant ecological and economic impact. Monitoring efforts and obtaining biological control solutions will continue until 2027 and we propose that research and application of integrated control measures must be continued and expanded in order to limit the spread of the invasion and protect forest resources and regional biodiversity.

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Funding
Research services contract, No. 2288 of 17.04.2025

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Received: April 15, 2025
Accepted: September 03, 2025