UNIVERSITY of SOPRON

FACULTY OF WOOD ENGINEERING AND CREATIVE INDUSTRIES

10th HARDWOOD Conference Proceedings

12–14 October 2022 Sopron

Editors: Róbert Németh, Christian Hansmann, Peter Rademacher, Miklós Bak, Mátyás Báder

WOOD KPLUS

Mendel University in Brno

10TH HARDWOOD CONFERENCE PROCEEDINGS

Editors: Róbert Németh, Christian Hansmann, Peter Rademacher, Miklós Bak, Mátyás Báder

UNIVERSITY OF SOPRON PRESS

SOPRON, 2022

10TH HARDWOOD CONFERENCE PROCEEDINGS

Sopron, Hungary, 12-14 October 2022

ISBN 978-963-334-446-0 (pdf)
DOI https://doi.org/10.35511/978-963-334-446-0
ISSN 2631-004X (Hardwood Conference Proceedings)

Constant Serial Editors: Róbert Németh, Miklós Bak

Cover image based on the beech specimens of Radim Rousek and Mátyás Báder by Miklós Bak, 2021

The manuscripts have been peer-reviewed by the editors and have not been subjected to linguistic revision.

In the articles, corresponding authors are marked with an asterisk (*) sign.

University of Sopron Press, 2022
Responsible for publication: Prof. Dr. Attila Fábián, rector of the University of Sopron

Oak (*Quercus* spp.) ratio preferences of oak lace bug (*Corythucha arcuata*) at the front line of its spread

Máté Tóth[1*], Csaba Béla Eötvös[2], Márton Paulin[2], Ágnes Fürjes-Mikó[2], Csaba Gáspár[2], Marcell Kárpáti[2], Anikó Hirka[2], György Csóka[2]

[1] University of Sopron, H-9400 Sopron, Bajcsy-Zsilinszky utca 4.

[2] University of Sopron, Forest Research Institute, Department of Forest Protection, H-3232 Mátrafüred, Hegyalja utca 18.

E-mail: mate.mage@gmail.com

Keywords: invasive, herbivore, effects, short term, long term, forest health is

ABSTRACT

There is increasing evidence of the effects of tree species composition on herbivores, with numerous examples of smaller damage caused in tree-species-rich forests. We investigated the effect of tree species richness on leaf damage caused by the oak lace bug, *Corythucha arcuata*, a rapidly spreading invasive pest of oak trees. We found no significant effect of the percentage of oak in the investigated forests on the level of *C. arcuata* infection. We have shown that higher infection categories are significantly more frequent next to roads at the initial stage of the invasion. We conclude that a mixture of tree species does not significantly reduce the impact of *C. arcuata* on oak foliage. This highlights the importance of further investigation of biological control options against this invasive pest.

INTRODUCTION

After the first detection of the North American oak lace bug (OLB), *Corythucha arcuata* (Say, 1832) (Heteroptera, Tingidae) in Europe and Asia Minor in the years 2000 in Italy (Bernardinelli & Zandigiacomo, 2000) and 2002 in Turkey (Mutun, 2003), began its extremely fast spread most probably across the Balkan Peninsula to Central Europe, reaching Hungary in 2013 (Csóka et al., 2020). By 2019 the total area infested by *C. arcuata* in Hungary was estimated about 114.000 ha, almost 1/5th of the Hungarian oak forests (Paulin et al., 2020) (Fig. 1). By 2021, even in the Vas County, which was the least affected in 2019, we could hardly find any uninfected oak forest stands (Fig. 2).

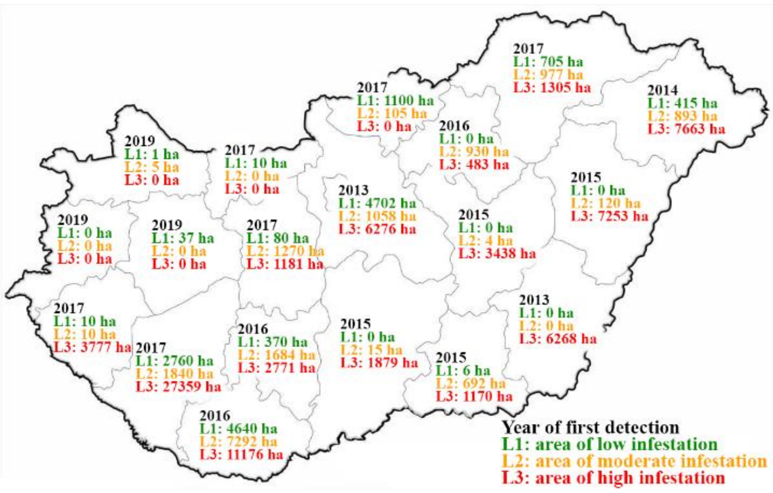

Figure 1: OLB infestation areas in the counties of Hungary in 2019

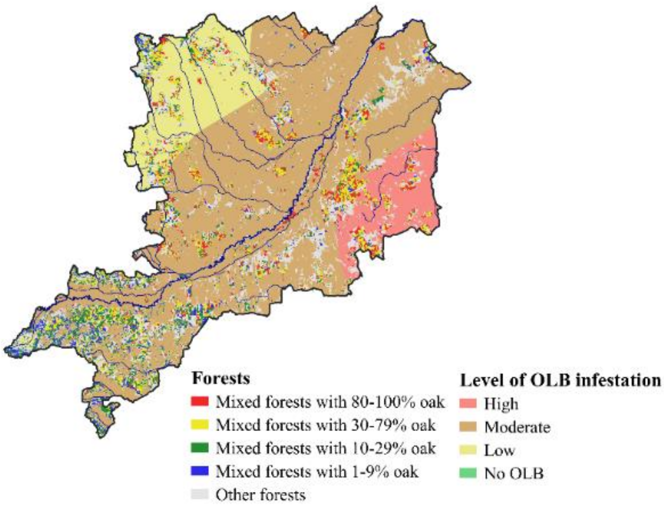

Figure 2: OLB infestation levels in Vas County in 2021

The discoloration and drying of leaves caused OLB at high infestation levels are easily recognizable symptoms even by public (Bălăcenoiu, Japelj, et al., 2021). In the infested areas the damage has remained at high level in consecutive years since the introduction which can cause negative effects on oak health in the future. OLB nymphs and adults damages the leaf tissue by sucking it and this leads to reduction of photosynthetic activity by 58.8% (Nikolic et al., 2019). It has no direct effects on annual wood increment, since most radial growth of oaks occurs in the first half of the growing season, but an accumulated effect of repeated damage seems likely (Paulin et al., 2020). We know numerous long-lasting negative impacts of biotic factors such as spongy moth (*Lymantria dispar*) (McManus & Csóka, 2007), geometrid moths (Manderino et al., 2014), oak powdery mildew (Marçais & Desprez-Loustau, 2014) and climate extremes including prolonged drought periods and heat waves (Czúcz et al., 2011) and now we have to add oak lace bug to this list. Beyond its economic impact it will probably have negative effects on other herbivores feeding on oak foliage, particularly specialist species that develop in the later growing season (Paulin et al., 2020).

Until now there is no feasible options for control of this invasive pest. Native natural enemies have no or little impact on *C. arcuata* populations (Williams et al., 2021). Chemical control achieves significant short term control but does not prevent re-infestation of treated areas in the same season and it hase severe side effects to natural communities (Bălăcenoiu, Nețoiu, et al., 2021). Overvintering of *C. arcuata* is very good, they can survive even -26°C without damage (Paulin et al., unpublished data). Biological control programs seam the only alternative. However, no successful control agent is available yet. In addition, to develop forest management approaches, it is also interesting whether the characteristics of the forest area and especially the density of the host tree species influence *C. arcuata* infection.

A recent meta-analysis showed that damage by specialized herbivores is lower in mixed stands than in monocultures (Jactel et al., 2021). Enemies and resource concentration hypotheses give an explanation for these effects of plant mixture on herbivory (Root, 1973). Since predation on OLB by natural enemies is sporadic and has no significant effect (Paulin et al., 2020), the enemies hypothesis, i.e. a higher effectiveness of natural enemies in more complex environments (Russell, 1989), is not expected to be relevant. On the other hand, resource concentration could be important. The probability of finding a host tree can be lower for a specialist herbivore in mixed stands (Jactel et al., 2021). *C. arcuata* can be considered a specialist developing on species of the genus Quercus from the sections Quercus and Cerris, while sections Lobatae and Ilex are not suitable (Csóka et al., 2020). Although Tilia, Ulmus, Corylus or several Rosaceae can be infested this occurs more as a spillover from nearby oak trees (Csóka et al., 2020). We hypothesized that infestation levels will be lower in forests with lower percentage of oak at an earlier stage of invasion.

EXPERIMENTAL METHODS

We established our sample sites close to the western border of Hungary in Őrség. The infestation level of OLB in previous years was very low in this area, thus, we could observe the spread of the infection in the initial stages. We selected sample sites in different mixed oak forests with low (8%, 17%, 19%), moderate (30%, 41%, 46%, 54%) and high (70%, 85%, 100%) proportion of oaks. We included the native *Quercus petraea*, *Q. robur* and *Q. cerris* in oak ratio, but excluded the North American Q. rubra as it is not host plant of OLB. We collected data monthly basis in 2021 (07.08., 08.18., 09.14.). We considered the paved road with higher traffic as source of infection, so we sampled 6-6 oak trees in five different distances (0, 45, 90, 135 and 180 metres) from it. Four classes of OLB infestation (based on Csóka et al., 2020) were recorded: (0) no symptoms; (1) symptoms and/or different developmental stages of OLB are sporadic; (2) symptoms and/or different developmental stages of OLB are found along whole branches that can easily be spotted on the tree, parts of the crown without symptoms; (3) symptoms and/or different developmental stages of OLB cover the whole tree, the whole crown is affected.
To answer our hypothesis, we performed an ANOVA test, with Tukey posthoc test in R version 4.2.1. (R Development Core Team, 2011) with package 'DescTools' (Andri et mult. al., 2022). The dependent variable was the average frequency of the infestation categories, and the explanatory variables were the distance from the paved road and native oak proportion categories.

RESULTS AND DISCUSSION

Corythucha arcuata occurred on all study sites and infested most of the examined oak trees. In July 31% of the oak trees were infested, however by September all trees except one were infected. We found no significant differences in OLB infestation between low, moderate and high proportion of native oak trees (p=0.942). Thus, the hypothesis that stands with greater tree species diversity suffer less damage from OLB than stands with a high proportion of oaks should be rejected. This does not conform by generous agreement that associational resistance in forests against herbivores is strong (Jactel et al., 2021). Our finding is supported by the observation from Ukraine as they found no difference in infestation levels between mixed and pure stands (Meshkova et al., 2020) and results from Austria, Slovenia and Serbia (Gernot Hoch personal communication, 2021).
Admixture of non-host trees can lead to reduced damage by invasive herbivorous insects, as it has been shown for the bark scale *Matsucoccus feytaudi* in Corsica (Rigot et al., 2014). The dispersal of the bark scale takes place through passive wind transportation of larvae. Apparency of a host tree is therefore crucial for infestation. We believe, that *C. arcuata* is disperse through a combination of short distance active flight and wind aided dispersal of adults (Zubrik et al., 2019). A survey at the front of the invasion in our sampling area showed rapid spread from urban oak trees and from parking lots from hiking spots into forest stands. Hence OLB should be considered as specialist, the fact that it can survive on other tree and shrub genera such as *Rubus*, *Carpinus* etc. (Csóka et al., 2020) it may help the colonization.
The importance of human mediated passive transportation of OLB hitchhiking on vehicles or trains is unquestionable (Jurc & Jurc, 2017; Mutun et al., 2009). The detection of OLB is more likely in areas on lower altitudes, with more oak trees, nearby highways and railways (de Groot et al., 2022). We also found that higher infection categories were significantly more frequent next to the road than 45 meters or further away from the road (p<0.001). A more detailed study including a finer measurement may would be able to detect host plant density dependence of OLB, however it would be without much practical impact for preventing establishment of invasive *C. arcuata* populations.

CONCLUSIONS

The results of our study show that mixed forests cannot slow down the invasion of *C. arcuata* populations. This underlines the importance of developing biological control options. However, even complete deforestation can be prevented by increasing tree species mix in the case of continuing additive effects of severe damage of oaks by *C. arcuata* in combination with other pests, pathogens and climate effects.

ACKNOWLEGMENT

The project was supported by the Őrség National Park, the OTKA-128008 research grant (Quantifying forest-health-related ecosystem services in Hungarian oak forests) and the OTKA-142858 research grant (Assessment of impacts of the invasive oak lace bug (*Corythucha arcuata*) in oak forests, and exploration of the potential for its biological control) provided by the National Research, Development and Innovation Office.

REFERENCES

Andri et mult. al., S. (2022). *DescTools: Tools for Descriptive Statistics. R package version 0.99.45*. https://cran.r-project.org/package=DescTools

Bălăcenoiu, F., Japelj, A., Bernardinelli, I., Castagneyrol, B., Csóka, G., Glavendekić, M., Hoch, G., Hrašovec, B., Krajter Ostoic, S., Paulin, M., Williams, D., Witters, J., & de Groot, M. (2021). Corythucha arcuata (Say, 1832) (Hemiptera, Tingidae) in its invasive range in Europe: perception, knowledge and willingness to act in foresters and citizens. *NeoBiota, 69,* 133–153. https://doi.org/10.3897/neobiota.69.71851

Bălăcenoiu, F., Nețoiu, C., Tomescu, R., Simon, D. C., Buzatu, A., Toma, D., & Petrițan, I. C. (2021). Chemical Control of Corythucha arcuata (Say, 1832), an Invasive Alien Species, in Oak Forests. *Forests, 12*(6), 770. https://doi.org/10.3390/f12060770

Bernardinelli, I., & Zandigiacomo, P. (2000). Prima segnalazione di Corythucha arcuata (Say) (Heteroptera, Tingidae) in Europa. *Informatore Fitopatologico*, *12*, 47–49.

Csóka, G., Hirka, A., Mutun, S., Glavendekić, M., Mikó, Á., Szőcs, L., Paulin, M., Eötvös, C. B., Gáspár, C., Csepelényi, M., Szénási, Á., Franjević, M., Gninenko, Y., Dautbašić, M., Muzejinović, O., Zúbrik, M., Netoiu, C., Buzatu, A., Bălăcenoiu, F., … Hrašovec, B. (2020). Spread and potential host range of the invasive oak lace bug [Corythucha arcuata (Say, 1832) – Heteroptera: Tingidae] in Eurasia. *Agricultural and Forest Entomology*, *22*(1). https://doi.org/10.1111/afe.12362

Czúcz, B., Gálhidy, L., & Mátyás, C. (2011). Present and forecasted xeric climatic limits of beech and sessile oak distribution at low altitudes in Central Europe. *Annals of Forest Science*, *68*(1), 99–108. https://doi.org/10.1007/s13595-011-0011-4

de Groot, M., Ogris, N., van der Meij, M., & Pocock, M. J. O. (2022). Where to search: the use of opportunistic data for the detection of an invasive forest pest. *Biological Invasions, In press*.

Jactel, H., Moreira, X., & Castagneyrol, B. (2021). Tree Diversity and Forest Resistance to Insect Pests: Patterns, Mechanisms, and Prospects. *Annual Review of Entomology*, *66*(1), 277–296. https://doi.org/10.1146/annurev-ento-041720-075234

Jurc, M., & Jurc, D. (2017). The first record and the beginning the spread of oak lace bug, Corythucha arcuata (Say, 1832) (Heteroptera: Tingidae), in Slovenia. *Šumarski List*, *141*(9–10), 488–488. https://doi.org/10.31298/sl.141.9-10.5

Manderino, R., Crist, T. O., & Haynes, K. J. (2014). Lepidoptera-specific insecticide used to suppress gypsy moth outbreaks may benefit non-target forest Lepidoptera. *Agricultural and Forest Entomology, 16*(4), 359–368. https://doi.org/10.1111/afe.12066

Marçais, B., & Desprez-Loustau, M.-L. (2014). European oak powdery mildew: impact on trees, effects of environmental factors, and potential effects of climate change. *Annals of Forest Science*, *71*(6), 633–642. https://doi.org/10.1007/s13595-012-0252-x

McManus, M., & Csóka, G. (2007). History and Impact of Gypsy Moth in North America and Comparison to the Recent Outbreaks in Europe. *Acta Silvatica & Lignaria Hungarica*, *3*, 47–64.

Meshkova, V., Nazarenko, S., & Glod, O. (2020). The first data on the study of Corythucha arcuata (Say, 1832) (Heteroptera: Tingidae) in Kherson region of Ukraine. *Наукові Праці Лісівничої Академії Наук України*, *21*, 30–38. https://doi.org/10.15421/412023

Mutun, S. (2003). First report of the oak lace bug, Corythucha arcuata (Say, 1832) (Heteroptera: Tingidae), from Bolu, Turkey. *Israel Journal of Zoology*, *49*, 323–324.

Mutun, S., Ceyhan, Z., & Sözen, C. (2009). Invasion by the oak lace bug, Corythucha arcuata (Say) (Heteroptera: Tingidae), in Turkey. *Turkish Journal of Zoology*. https://doi.org/10.3906/zoo-0806-13

Nikolic, N., Pilipovic, A., Drekic, M., Kojic, D., Poljakovic-Pajnik, L., Orlovic, S., & Arsenov, D. (2019). Physiological responses of Pedunculate oak (Quercus robur L.) to Corythucha arcuata (Say, 1832) attack. *Archives of Biological Sciences*, *71*(1), 167–176. https://doi.org/10.2298/ABS180927058N

Paulin, M., Hirka, A., Eötvös, C. B., Gáspár, C., Fürjes-Mikó, Á., & Csóka, G. (2020). Known and predicted impacts of the invasive oak lace bug (Corythucha arcuata) in European oak ecosystems – a review. *Folia Oecologica*, *47*(2), 131–139. https://doi.org/10.2478/foecol-2020-0015

R Development Core Team. (2011). *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing.

Rigot, T., van Halder, I., & Jactel, H. (2014). Landscape diversity slows the spread of an invasive forest pest species. *Ecography*, *37*(7), 648–658. https://doi.org/10.1111/j.1600-0587.2013.00447.x

Root, R. B. (1973). Organization of a Plant-Arthropod Association in Simple and Diverse Habitats: The Fauna of Collards (Brassica Oleracea). *Ecological Monographs*, *43*(1), 95–124. https://doi.org/10.2307/1942161

Russell, E. P. (1989). Enemies Hypothesis: A Review of the Effect of Vegetational Diversity on Predatory Insects and Parasitoids. *Environmental Entomology*, *18*(4), 590–599. https://doi.org/10.1093/ee/18.4.590

Williams, D., Hocht, G., Csóka, G., de Groot, M., Hradil, K., Chireceanu, C., Hrašovec, B., & Castagneyrol, B. (2021). *Corythucha arcuata (Heteroptera, Tingidae): Evaluation of the pest status in Europe and development of survey, control and management strategies (OLBIE)*. https://doi.org/10.5281/ZENODO.4898795

Zubrik, M., Gubka, A., Rell, S., Kunca, A., Vakula, J., Galko, J., Nikolov, C., & Leonotvyč, R. (2019). First record of Corythucha arcuata in Slovakia – Short Communication. *Plant Protection Science*, *55*(No. 2), 129–133. https://doi.org/10.17221/124/2018-PPS