Network for phytosanitary research coordination and funding

Final Report

Project title (Acronym)
Corythucha arcuata (Heteroptera, Tingidae): Evaluation of the pest status in Europe and development of survey, control and management strategies Short title – Oak Lace Bug In Europe (OLBIE)

Project duration:

Start date:	01-04-19
End date:	31-03-21

Contents

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2. Short project report

2.1. Short executive summary

The OLBIE project focused on *Corythucha arcuata* (oak lace bug, OLB) (Heteroptera: Tingidae) an invasive Hemiptera introduced from its native range in North America into Europe, and which was first detected in Europe in Italy in 2000. Since its accidental introduction it has spread rapidly over a wide geographical area and is now found in over a dozen other European countries. In some countries, such as Hungary and Croatia its population has reached substantial levels where there is now serious concern that the pest may have significant impacts on oak health, as well as potentially increasing the susceptibility of oaks to other pests and diseases.
There is very limited published information on this particular insect species. Within its natural range in North America it is generally regarded as a nuisance pest, causing only incidental damage, although dense populations can cause premature leaf fall. Within Europe there is considerable variation in its reported impacts, hence there is a real need to understand what factors are influential in the development of this insect species and how it can damage oak. OLBIE aimed to address key questions and gaps in the knowledge of *Corythucha arcuata*, particularly in relation to the biology, dispersal, control and management options and the wider environmental impacts.

2.2. Project aims

The project tried to answer the following priority questions:

• What are the impacts of *C. arcuata* on oak growth and fecundity, and why is there such variability in the insect’s apparent impacts across Europe (i.e. high impacts in Croatia and Hungary, and seemingly low impacts in Italy and Switzerland?)
• What are the key pathways for movement of the pest and how can we better protect against the risk of further introductions and wider spread in Europe ?
• What are the rates of natural spread, and what are the key human mediated means of dispersal of the pest?
• What are the best survey strategies to detect the pest as early as possible?
• What cost-effective control and management approaches are available? Is there scope for biological control? And ultimately is there scope for preventing or limiting spread in the case of successful establishment?

Several European countries had ongoing research activities underway to investigate some of these key issues, and hence the OLBIE consortium was able to draw upon the expertise of research scientists that were already dealing with *C. arcuata*. The project was focused on literature reviews and effective knowledge-gathering and sharing of information with those individuals from countries that were already dealing with *C. arcuata*. An important aspect of the project was to evaluate potential impacts, assess any management approaches, and identify pathways and dispersal mechanisms of *C. arcuata*. Hence, by assessing the information currently available the project contributed to the development of best practice guidelines in pathway management, early detection methodologies, contingency planning, pest risk analyses and sustainable management practices.

2.3. Description of the main activities

To accomplish the project objectives the collaborative network of the project consisted of research scientists from, 1) countries where *C. arcuata* had already been established for many years, 2) countries where the insect pest had only just arrived or was imminently going to arrive, and 3) countries where the insect pest had not arrived but there were concerns regarding the potential impacts of its introduction. This provided an opportunity for many research scientists with different knowledge on the pest and perceptions of the risks to contribute to the project, which ensured an effective exchange of information on ongoing research projects, ideas and expertise.

2.4. Main results

2.4.1. Review evidence of impacts

A preliminary review and consideration of potential impacts of the oak lace bug has revealed that there is very little published information detailing the impacts of this invasive insect (Paulin *et al*., 2020), or the closely related plane lace bug *Corythucha ciliata*. There is a real need to establish long term monitoring and research projects to assess the accumulated damage incurred by the feeding of *C. arcuata* on oak trees, and what the wider biodiversity impacts might be in oak forests. A summary of key points to consider regarding impacts following the review by Paulin *et al*., (2020) is presented below:

1. Evident visual impacts - This includes early discoloration of infested leaves, early drying of infested leaves and subsequently premature leaf abscission. Depending on the abundance of the overwintering populations and the environmental conditions (i.e. temperature and precipitation) these symptoms may appear uniformly in large forest blocks even up to several hundred hectares of forest by mid-summer. This effect can be seen from the ground but also on aerial satellite images.

2. Physiological impacts – Extensive feeding by *C. arcuata* leads to the removal of chlorophyll from the upper surface of severly infested leaves, which will significantly impact the photosynthetic capacity of the leaf, leading to disruption of nutrient and water movement. Nikolić *et al*. (2019) cite the following 'The rate of photosynthesis, transpiration and stomatal conductance were lowered by 58.84, 21.66 and 35.71%, respectively on severely infested leaves, in comparison to non-infested plants. The concentrations of photosynthetic pigments and activities of antioxidant enzymes, catalase and ascorbate peroxidase, were affected by the presence of *C. arcuata*. To our knowledge this is the first paper providing a report on the physiological responses of *Quercus robur* plants exposed to *C. arcuata* infestation. Understanding the impact of pests, such as the invasive species *C. arcuata* on physiological processes and vitality of young plants and plant responses, could provide a foundation for efficient preservation of oak forests endangered by the oak lace bug.' Similar results have been found in comparable studies conducted in Hungary (G. Csóka, unpublished data). In addition, measuring of the concentration of different elements in infested and non-infested leaves has revealed that Nitrogen concentration is significantly lower in infested leaves, which may have indirect effects on insect herbivores (G. Csóka, pers. comm.).

3. Oak tree growth impacts - The decreased photosynthetic and transpiration activity may negatively affect tree growth particularly if mass feeding of *C. arcuata* is repeated in many consecutive years. Preliminary dendrochronological analysis has not revealed a decrease in tree ring width of *Quercus robur* (Gyula, SE Hungary, pers. comm.), but growth parameters must be studied over a longer period of time to assess the accumulated effects of repeated feeding damage and defoliation. Late wood is more likely to be affected than early wood due to the phenology of *C. arcuata*, but in the case of long term chronic mass feeding even early wood may show some responses over time.

4. General oak tree health condition - The mass feeding of *C. arcuata* in itself is likely enough to cause the weakening of trees particularly over a number of years of consecutive damage. Oaks are affected by many abiotic and biotic factors (droughts, frosts, xylophagous insects, defoliators, pathogens) often resulting in serious declines. Hence, the mass feeding of *C. arcuata* will likely have a significant additional or even synergistic effect on oak health and could potentially accelerate and exacerabte the decline process. In addition, the physiological effects described above may decrease the self-defence abilities of oaks possibly leading to higher herbivore pressure and/or pathogen attacks.

5. Impacts on oak fecundity - The physiological impacts highlighted above will likely have effects on the fecundity of oak trees, with potential effects being:

- Less frequent masting (good acorn crop) in long term – makes the regeneration (both natural and artificial) even more unpredictable.
- Decreasing volume of acorn crop (even in masting years).
- Early abscission of premature acorns.
- Production of smaller acorns – providing less “starting food” for the seedling, leading to a competitive disadvantage.
- Severely infested trees may produce less nutrient rich acorns. This is again disadvantageous from the point of view of the seedlings emerging from these acorns, and poses a wider issue of less nutritious acorns for those other organisms that utilise them as part of their diet (e.g. mammals, birds).
- A decrease in the acorn crop (and the quality of the acorns) may have a detrimental influence on the animals feeding on acorns (boar, deer, squirrels, jays, dormice, etc.).

6. Impacts on herbivorous arthropod diversity and abundance associated with oaks – The genus *Quercus* is the richest among the woody plant genera from the point of view of herbivore arthropods feeding on them. In Hungary at least 650 species of herbivorous insects have been recorded from oaks, with more than 40% of them (close to 300 species) being oak-specialists, and with many protected species among them (Csóka & Ambrus, 2016). The drastic change of leaf quality due to the high population density of *C. arcuata* will more than likely have severe effects on oak herbivores. It can be assumed that those species feeding and developing on leaves in the late season (from July onward) are likely to be influenced the most strongly. By midsummer the impact of *C. arcuata* can be strong enough to perish the food sources of other leaf feeders almost entirely.

- Preliminary experimental results show that leaf feeding young larvae of two oak specialists, *Drymonia querna* and *Harpya milhauseri* (Lepidoptera, Notodontidae) do not feed on *C. arcuata* infested leaves, with the larvae starving and then dying if there are no *C. arcuata* uninfested leaves available (Paulin *et al*., 2020). These experiments can be repeated with other specialists and some generalist species too. It is worth mentioning that the larvae of at least 300 Lepidopteran species feed on oaks in Hungary (Csóka & Ambrus, 2016; Csóka & Szabóky, 2005). On top of the decreasing leaf quality (less nutrient in dry leaves) the mere presence of *C. arcuata* and its faeces may have repellent effects to leaf feeding herbivores.
- The autumn generations of some gall wasps on leaves (i.e. *Cynips* and *Neuroterus* species) will likely be affected too, since the oak leaves are dry and lose a significant amount of the nutrient content before the galls would fully finish their development (late August - September) (Paulin *et al*., 2019).
- The mass feeding of *C. arcuata* in any given year may change the nutrient content and quality of the leaves flushing in the following spring, hence if this occurs then spring herbivore larvae (mainly lepidoptera) might also be influenced by these changes.
- Impacts on wider invertebrate biodiversity (predators, parasitoids) and food webs associated with oak trees and forests are inevitable.

7. Impacts on soil fauna and litter decomposition – The altered leaf quality may have an influence on the decomposing soil and leaf litter fauna.

8. Indirect impacts on vertebrates - The different life stages of herbivorous insects associated with oak trees provide food for many forest dwelling vertebrates. Decreasing the biomass of spring herbivore larvae/pupae/adults (because of the presence of *C. arcuata*) may have negative effects on the breeding success of insectivorous birds and also on the food supply of bats, and other small mammals.

9. Human health impacts – The closely related plane (sycamore) lace bug, *Corythucha ciliata* has been associated with incidents of ‘biting’ humans (Dutto & Bertero, 2013; Izri *et al*., 2015). Following examination of several patients attending a clinic in Paris, France, examining clinicians who discovered adult *C. ciliata* during their examination of the patients concluded that ‘Lace bug infestations may have health consequences, including nuisance biting and cutaneous and systemic reactions. Clinicians should be aware of the existence of this insect with its newly recognized bloodsucking ability as potentially responsible for skin lesions and pruritus that can cause real discomfort and anxiety’ (Izri *et al*., 2015). It is therefore likely that oak lace bug will also pose a similar risk to human health, with reports from Romania, Hungary and Croatia already occurring of OLB biting humans (see Paulin *et al*., 2020 for references).

10. Wider ecological impacts – The closely related plane (sycamore) lace bug, *Corythucha ciliata* has been implicated with a peculiar phenomenon in northwest Greece resulting in considerable losses of rainbow trout in Louros river following heavy summer rainfall (Savvidis *et al*., 2009). The key points from the publications abstract are:

- The study aimed to investigate cases of sudden fish death in rainbow trout farms located along the Louros River (region of Ioannina Prefecture, N.W. Greece) during the summer months.
- All of the cases were preceded by a downpour and appeared with common and identical characteristics concerning the swimming behaviour, dark coloured large spots on the body surface of the fish, and sudden death (regardless of size, age and weight).
- After conducting in situ experiments, it was demonstrated that the phenomenon was strongly correlated with the presence of *Corythucha ciliata*, which heavily infests the plane trees along the river during the spring and summer period.
- The rainwater washes the leaves of the trees, and thus, an enormous number of insects (nymphs and adults) and their secretions fall down into the running river water, which is the supplier of the rainbow trout farms located in this area.

This is a a particularly strange phenomenon and certainly needs further investigation to establish exactly what is causing fish mortality and how it relates to populations of *Corythucha ciliata,* and whether *Corythucha arcuata* is capable of similarly affecting life in aquatic ecosystems.

References

- Csóka G and A. Ambrus (2016) Erdei fa- és cserjefajok szerepe a herbivor rovarok fajgazdagságának fenntartásában [Role of forest woody plants in maintaining species richness of herbivorous insects]. In Korda, M. (ed.). *Az erdőgazdálkodás hatása az erdők biológiai sokféleségére. Tanulmánygyűjtemény.* Budapest: Duna-Ipoly Nemzeti Park Igazgatóság, p. 155–192.
- Csóka, G. and C. Szabóky (2005) Cheklist of Herbivorous Insects of Native and Exotic Oaks in Hungary I (Lepidoptera). Acta Silvatica et Lignaria Hungarica, 1: 59-72.
- Izri, A., Andriantsoanirina, V. and R. Durand (2015) Dermatosis caused by blood-sucking *Corythucha ciliata*. JAMA Dermatology, May 13, 2015 E1-E2.
- Dutto, M. and M. Bertero (2013). Dermatosis caused by *Corythucha ciliata* (Say, 1932) (Heteroptera, Tingidae). Diagnostic and clinical aspects of an unrecognized pseudoparasitosis. *Journal of Preventive Medicine and Hygiene*, 54 (1): 57–59.
- Nikolić, N., Pilipović, A., Drekić, M., Kojić, D., Poljaković-Pajnik, L., Orlović, S. and D. Arsenov (2019) Physiological responses of pedunculate oak (*Quercus robur* L.) to *Corythucha arcuata* (Say, 1832) attack. Archives of Biological Sciences, 71, 167–176.
- Paulin, M., Hirka, A., Mikó, Á., Tenorio-Baigorria, I., Eötvös, Cs., Gáspár, Cs. and Gy. Csóka (2019) Tölgycsipkéspoloska – Helyzetjelentés 2019 őszén [The oak-lace bug – status report in autumn 2019]. In *Alföldi Erdőkért Egyesület Kutatói Nap. Tudományos eredmények a gyakorlatban. Lakitelek 2019.* Kecskemé t, Alfö ldi Erdő ké rt Egyesület, p. 110–119.
- Paulin M., Hirka A., Eötvös Cs. B., Gáspár Cs., Fürjes-Mikó Á., and Gy. Csóka (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.
- Savvidis, G., Zartaloudis, Z. and G. Vafeas (2009) Massive fish losses in rainbow trout cultures of Louros River (N.W. Greece) after strong summer rainfall. Implication of the sycamore lace bug *Corythucha ciliata* (Hemiptera: Tingidae). Bulletin European Association of Fish Pathologists 29: 66-72.

2.4.2. Prevention and detection

Early detection of *C. arcuata* is essential if eradication is to be considered, and critical to long-term management under a containment regime and for delimiting affected areas. The key tasks in this work package were to develop surveying techniques/protocols to detect *C. arcuata* as early as possible in new areas, to review, evaluate and test early detection methods/trapping techniques, to retrieve information on potential pathways from surveys, and to suggest feasible methods for early detection and control options.

2.4.2.1. Developing early detection and surveying techniques/protocols for *Corythucha arcuata*

C. arcuata was detected in Austria and the Czech Republic in 2019. This situation provided the opportunity to develop, perform and evaluate visual surveys in recently infested areas along the front of expanding populations.

<u>Visual surveys in Austria and Czech Republic</u>

A survey was carried out in the Czech Republic in late summer and autumn in 2019 and 2020. Oaks along major roads were visually inspected; additionally, sweep netting and beating of branches were used to collect invertebrates. A total of 32 localities (in 2019) and 112 localities (in 2020) were visited; *C. arcuata* was found on one site near Břeclav in Southern Moravia in 2020.

A similar survey was carried out in Austria covering the southern parts of the Federal Provinces Styria and Burgenland. After the first finding of *C. arcuata* in Austria in August 2019, a rapid delimitation survey was carried out in an approximately 40 km radius in September 2019. The survey team inspected oaks on forest edges and solitary oak trees near roads approximately every 10 km for symptoms of *C. arcuata.* This quick survey detected infestations on 21 sites in the study area. A team of two inspectors worked for three days, and focused their efforts on traffic hotspots, such as gas stations or rest areas along major roads or points of touristic interest that appeared the most promising locations for the quick survey.

In September 2020, a more systematic survey was carried out in Austria. The aim was to delimit the infested area but also to get information on the effect of human activities on the spread. Therefore, survey plots were selected along major roads, near commercial or tourist sites but also in more remote areas. In order to cover a large area in a short time, all plots were accessible by roads. Inspectors followed a defined route and looked out for oaks on forest edges or near the road. Oak trees in the survey plots were inspected with binoculars to determine whether leaves showed the characteristic damage symptoms associated with *C. arcuata*. When leaves with suspicious discoloration were detected, *C. arcuata* was either confirmed when insect stages or the characteristic faeces were spotted on leaves or after cutting branch samples with a pole saw. The percent of crown infested as well as the average discoloration of infested leaves were estimated for each infested oak. A team of three inspectors worked for three days, and a total of 226 oak trees on 89 survey plots were examined.

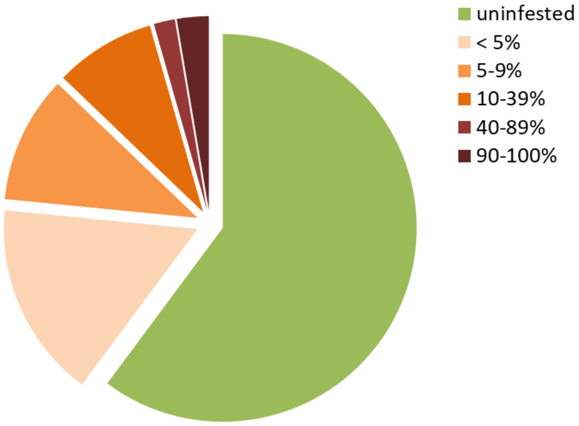


Figure 1. Infestation by *C. arcuata* (% of crown) of 226 oak trees visually inspected in the survey in Austria in September 2020.

Of the inspected 226 oak trees, 40 % were infested. Only 13 % of the inspected trees showed infestation of more than 10 % of the crown (Figure 1). The majority of trees showed little symptoms; often only a few leaves on individual branches were found to be infested. Moreover, discoloration of infested leaves remains innocuous on lightly infested trees (Figure 2).

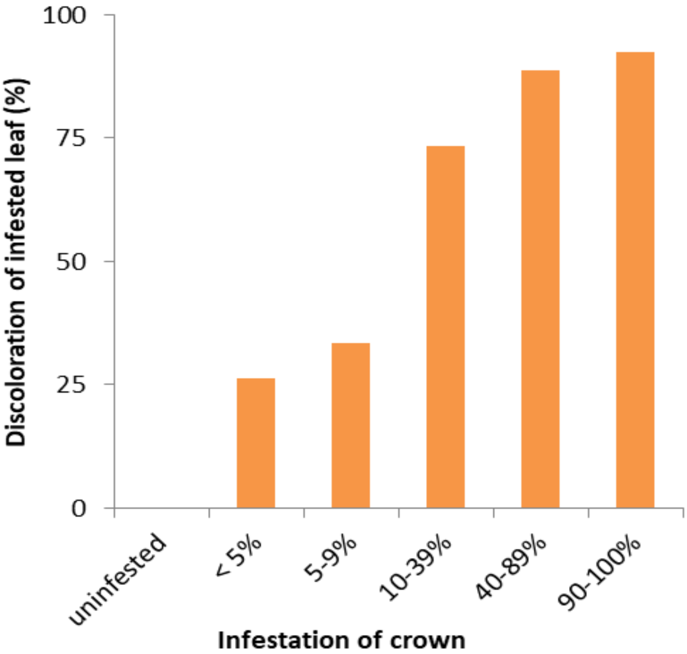


Figure 2. Average discoloration of infested leaves on oak trees with different levels of attack by *C. arcuata*.

Overall, the survey showed the status of *C. arcuata* in Austria in 2020 (Figure 3). Negative findings indicate the borders of the infested zone to the north. The border to the south-west will be given by unavailability of host trees with increasing elevation 10-20 km west of the survey plots. Heavy infestations were found along motorways A9/A2, a major north-south transit route and along a main road connecting Hungary to this motorway. Plots near human infrastructure (main roads, gas stations, rest stops, commercial sites) were more likely to be infested than more remote plots in the newly invaded area (e.g. in the north-east of the survey area). In the generally infested area (e.g. the south-west and the south-east of the surveyed area, respectively) this differentiation disappeared.

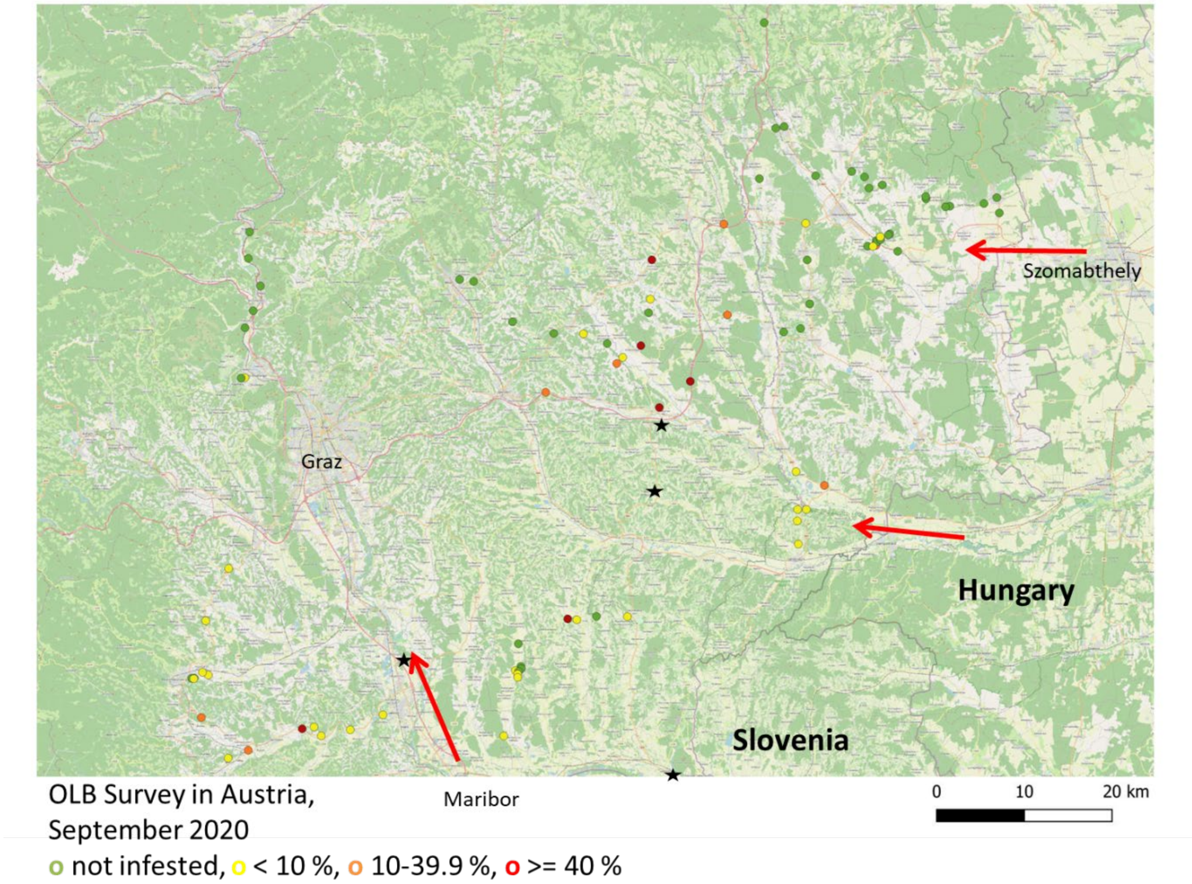


Figure 3. Plots surveyed for the presence of *C. arcuata* (colored dots) in south eastern Austria in September 2020. Black stars indicate heavily infested areas detected in 2019; red arrows indicate major traffic routes from Hungary and Slovenia.

<u>Proposed methodology for visual surveys of *Corythucha arcuata*</u>

- Based on the finding that many trees show very low infestation levels with innocuous crown symptoms in the newly invaded area a systematic survey is necessary, in order to meticulously inspect oak trees along defined survey routes. For early detection, the focus should be on oaks near major roads with special attention to gas stations, rest stops and/or tourist and commercial sites.
- A survey in late summer or autumn is recommended for maximum visibility of damage symptoms that have accumulated throughout the season.
- Because of other agents, such as leaf fungi (e.g. *Erysiphe* sp.), defoliators (e.g. *Caliroa annulipes*) or sucking insects and mites that cause similar symptoms, confirmation of the presence of *C. arcuata* is necessary. Insect stages or the characteristic faeces can be

spotted on the lower leaf surface with binoculars. Additionally, taking samples of twigs with conspicuous leaves with a pole saw will likely be necessary.
- Teams of two or three inspectors are advantageous for spotting oak trees from the car as well as for examining tree crowns from different angles.

Surveying for overwintering adults in Romania

In order to know the status of overwintering adults of *C. arcuata*, field studies were performed in Romania in 2018 and 2019 by peeling the bark of old apple and sweet cherry trees in abandoned orchards situated in the vicinity of oak trees under observation. In addition, in searches for other potential overwintering sites, dead leaves from the litterfall under the canopy of oak trees from different species were collected inside a frame of 30 x 30 cm. The leaves collected from different sites were weighed and the mortality of adults was also calculated. Key observations were:

- The trunks of a number of trees were inspected in autumn, winter, and spring months. It was confirmed that *C. arcuata* overwinters under the bark of different trees (hosts and non-hosts) and in the litterfall under the oak tree canopy.
- The gregarious behavior of *C. arcuata* was observed, not only during their feeding activity, but also as large overwintering adult groups under the bark of different tree species.
- It was also observed that the preferred trees for overwintering were the old trees with deeper cracked bark that provided shelters.
- The status of overwintering adults of *C. arcuata* collected in the field was evaluated in the laboratory. The proportion of dead adults was different depending on the overwintering location of the adults and time of evaluation. Mortality of overwintering adult under trees bark was lower than of overwintering adults under litterfall, between 10 and 25.2% and between 16 and 63.4% respectively. Mortality of overwintering adults in the litterfall under the canopy of *Q. cerris* was 47.6% and under the canopy of *Q. robur* was 68.3%. Mortality of females was between 5 and 11.4% while mortality of males was between 2.3 and 5%.
- Comparable studies have been undertaken in Hungary (Paulin *et al*., 2021), where results indicate that even after relatively harsh winters severe mortality of overwintering populations are not observed, and average mortality rates were estimated to be 30.6% (range 9.1 – 58.5%).

2.4.2.2. Reviewing, evaluating, and testing early detection methods/trapping tools

No particular trapping method has been developed for *C. arcuata*. However, several existing methods that are used for surveillance of other pests seem suitable for detection of *C. arcuata*. Within this project, yellow sticky traps and suction traps were evaluated.

Yellow sticky traps

In the United Kingdom a preliminary trial involving the Observatree volunteer network was undertaken in 2019. Volunteers were asked to deploy yellow sticky traps in both oak and plane trees to see if it was possible to detect whether both oak lace bug and/or plane (sycamore) lace bug might be present in the UK. Neither species are currently believed to be present in the UK. At least 43 volunteers from the Observatree network took part in the survey, deploying 146 yellow sticky traps across the UK, of which 130 (103 in oak trees, and 27 in plane trees) were subsequently recovered (having been left out for at least two weeks) and returned for inspection (Table 1). Examination of the yellow sticky traps revealed no indications of either oak or plane lace bug. However, the sample size was low, and the distribution of trap deployment was patchy and not targeted to high risk locations, hence caution is advised over the negative findings of both lace bug species.

Table 1. Observatree monitoring of *Corythucha* species in the UK.

Year	No of volunteers participating	% of active Observatree network participating	No. of traps deployed[1]	No. of traps recovered	% trap recovery rate	Average traps returned/vol	No. of *Corythucha* detected
2019	43	32%	146	130	89.0%	3	0
2020	50	36%	214	205	95.8%	4	0

[1] Traps deployed in both oak and plane trees

A more targeted approach was considered for 2020, where Observatree volunteers were again asked to deploy yellow sticky traps, but in locations where oak and plane (sycamore) lace bugs were more likely to initially occur (amenity trees in cities/towns, trees in rest stops and industrial estates etc.). A few more individuals from the Observatree network participated in the 2020 survey programme, and they deployed a total of 214 yellow sticky traps, of which 205 (149 in oak trees, and 56 in plane trees) were subsequently recovered and returned for inspection (Table 1). Examination of the yellow sticky traps again revealed no indications of either oak or plane lace bug.

The deployment of traps in 2020 covered a wider geographical area than in 2019 (Figure 4). However, what was noticeable from the distribution map, was that relatively few traps were actually being deployed within major cities (London, Birmingham, Liverpool, Sheffield), or near to the main entry points into the UK (Dover, Folkestone, Portsmouth, Southampton), where the invasive pests are most likely to be initially introduced (Figure 4). Any future efforts of using the Observatree network of volunteers (or other volunteer groups) should try to emphasize the need to concentrate efforts within larger towns and city center's rather than rural locations.

Figure 4. The location of traps deployed by the Observatree volunteers in the UK in the lace bug survey of 2020 (traps deployed in both oak and plane trees).

In Romania, yellow sticky traps were set up during the vegetative season from 2016-2020 in grapevine, fruit tree and vegetable growing plots in different regions within the framework of other research projects on detection and monitoring of invasive pest species. The traps were renewed at one- or two-week intervals from May/June until October, transferred to the laboratory, and examined under a stereomicroscope. Adults of *C. arcuata* were identified according to the keys in the relevant literature and counted.

The first *C. arcuata* adults on yellow sticky traps were observed in the south of the country in 2016, at the time when the pest was first recorded in this zone. High catches on yellow traps in the Northern area of Bucharest throughout the summer indicated a consistent presence of adults (Table 2).

The results from this initial trial indicated that yellow sticky traps were attractive to adults of *C. arcuata* and that they could be a potentially useful tool to detect the insect's presence before the damage symptoms or adults are detected by visual observations. The location of yellow sticky traps used for the monitoring of *C. arcuata* in Romania is presented in Figure 5.

Table 2. Number of adult *C. arcuata* caught on yellow sticky traps in the South zone of Romania in 2016.

Date	Northern area of Bucharest (140 traps)	Botanical Garden of Bucharest (west of the city) (18 traps)	Moara Domnească village, Ilfov County (15 km east of Bucharest) (18 traps)
01-15.07.	294	0	0
16-31.07	58	0	0
01-15.08	256	0	7
16-31.08	477	4	0
01-15.09	148	31	86
16-30.09	80	0	33
17-18.10	8	7	0
28.10	2	0	0
22.11	0	0	1
Total	**1876**	**42**	**127**

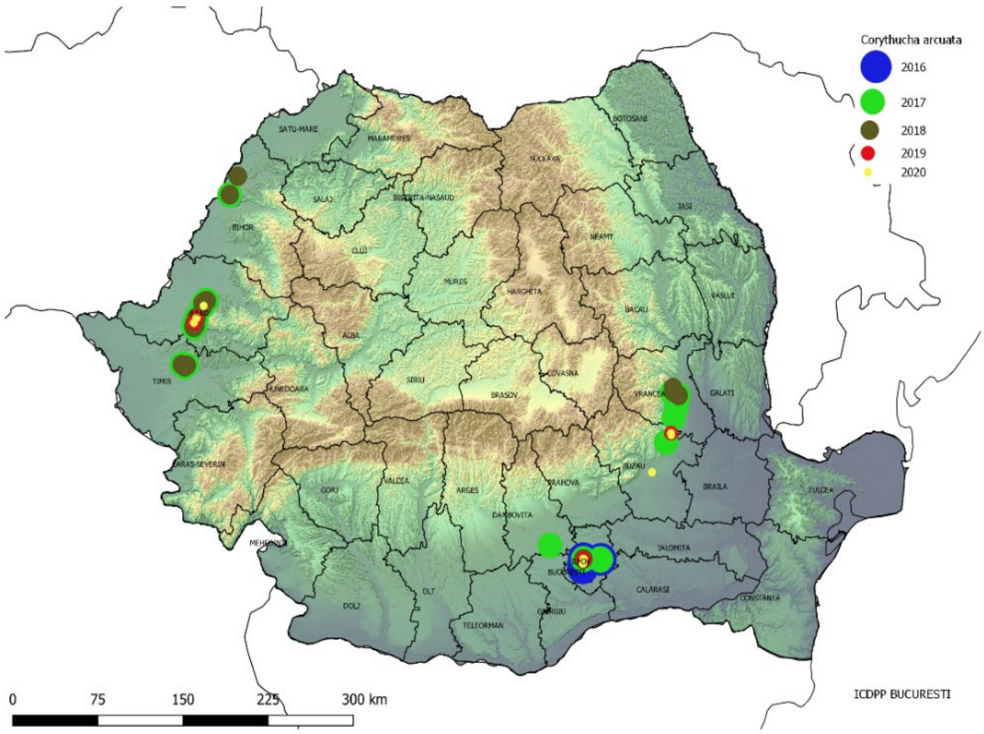


Figure 5. Location of yellow sticky traps used for the monitoring of *C. arcuata* in Romania (coloured circles indicate the year *C. arcuata* was captured).

Trap data showed that the yellow sticky traps detected the presence of *C. arcuata* in all zones and all survey years (Table 3). A significantly higher number of adults were trapped in the two zones where the first outbreaks of the pest were recorded (2015 in the northern, and 2016 in southern part of the country). Captures are also directly related to the number of traps used. Only 3.8 to 52.8 % of the traps showed the presence of adults of *C. arcuata* in the area where they were deployed. With a large number of traps deployed the chances of adults being caught increased. Most adults were captured on yellow traps in the spring and at the end of the summer season (Figure 6), corresponding to spring flight of the overwintering adults to the host plants and to the flight of the last generation of adults that were leaving host plants in search of overwintering locations.

Table 3. Number of adult *C. arcuata* (C.a.) caught on yellow sticky traps used for monitoring other pest insects on grapevine, fruit trees, potatoes and vegetables in Romania from 2016 to 2020.

Year	West and North-West Romania (Maramures, Crisana and Banat Hills) Grapevine		East Romania (Moldova Hills) Grapevine		South Romania (Bucharest area) Fruit trees		South Romania (Lunguletu, Dambovita County) Potatoes		South-East Romania (Buzau, Buzau County) Vegetables	
	No. of traps	*C.a.*	No of traps	*C.a.*	No of traps	*C.a.*	No of traps	*C.a.*	No of traps	*C.a.*
2016	320	unchecked for C.a.	512	unchecked for C.a.	140	1876	-	-	-	-
2017	360	41	576	14	89	1452	8	1	-	-
2018	400	351	640	3	78	320	-	-	-	-
2019	10	34	37	6	26	261	-	-	-	-
2020	625	1906	432	771	150	2140	-	-	53	2

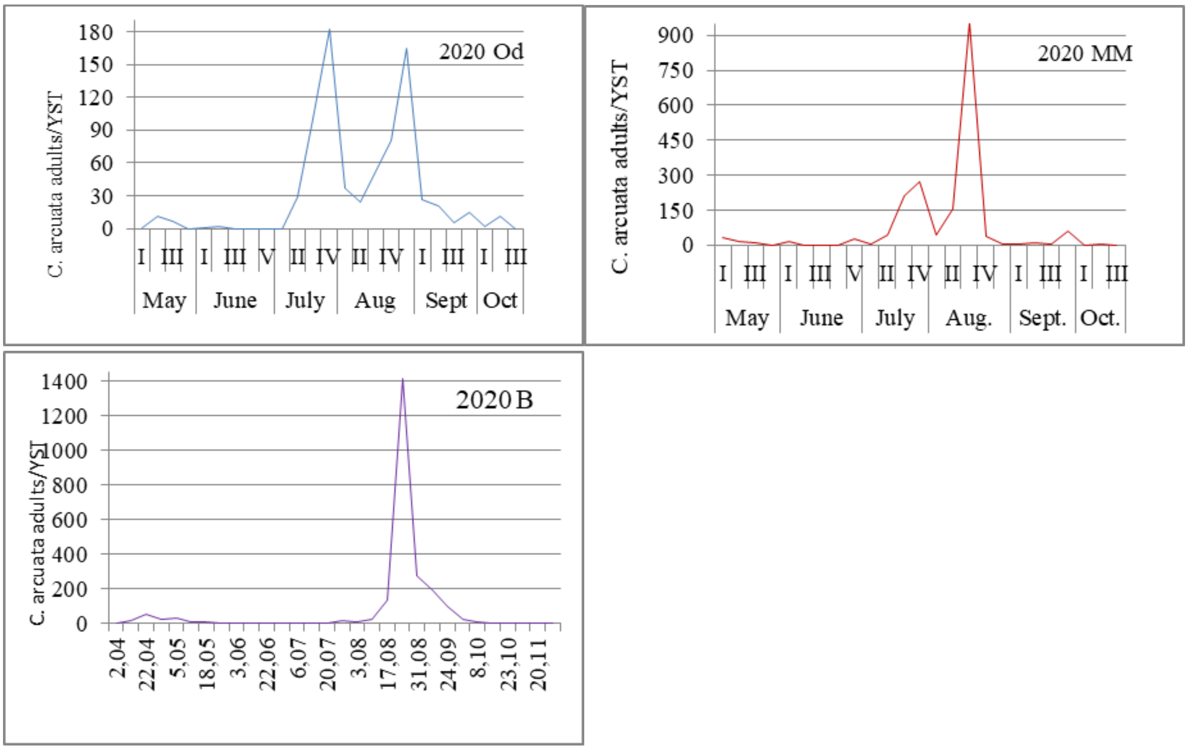


Figure 6. Dynamics of *C. arcuata* adult captures on yellow sticky traps in East (top left), West (top right) and South (left bottom) of Romania in 2020.

It was concluded from this study that yellow sticky traps can be used for the early detection of adults of *C. arcuata* in previously uninfested areas. However, the deployment of traps must be combined with field trips and visual surveys of host plants. The chances for detection are higher during the aerial migration periods of *C. arcuata*, one in the early spring when overwintering adults fly to oak trees, and the second at the end of summer when adults leave the host plants in search of overwintering locations. In the Bucharest area, these two migration periods start in early April and early August, respectively (personal observations). A more consistent capture occurred in the second period when spring adults were in large numbers.

<u>Suction traps</u>

A network of suction traps, which form part of an aphid monitoring system in the Czech Republic (Figure 7) provided a potential resource for surveying and monitoring for *C. arcuata*, particularly since these traps are already known to capture sycamore lace bug (*C. ciliata*). In 2019 the captures from one of these suction traps located in the south east of the country in Chrlice, Moravia, close to the border with Austria was assessed for the presence of *C. arcuata* - but no positive findings were detected. In 2020 the trap captures from five of the suction traps located across the country in Čáslav, Dobřichovice, Lípa, Chrlice and Věrovany were assessed for the presence of *C. arcuata* (Figure 7). The suction traps caught species from the Tingidae family, including *Corythucha ciliata*, *Stephanitis rhododendri*, *Kalama tricornis*, *Acalypta* sp., *Dictyla* sp., however, no *C. arcuata* were found in the trap catches. The assessment of trap catches is likely to continue into the future as this clearly could be part of an early detection programme.

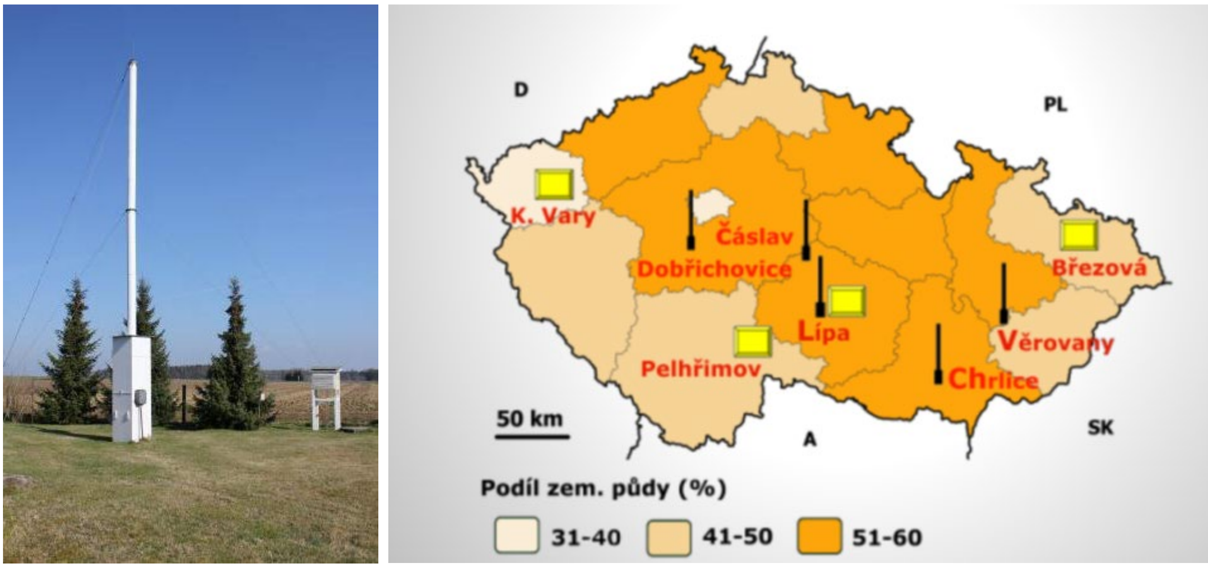


Figure 7. Johnson-Taylor suction trap used in the Czech Republic for monitoring aphid populations and location of the suction traps.

<u>Cardboard rings</u>

A trapping technique using cardboard rings wrapped around tree trunks was developed and tested in Croatia. The rationale was to provide artificial hibernation places for over-wintering adult *C. arcuata* from which they could then be subsequently easily collected and killed. The cardboard rings were set up in two oak seed orchards (Petkovac – a heavily infested location, and Pleščice - a recently infested location), in October (2018-2020), and were then removed in the subsequent January and all overwintering adult *C. arcuata* underneath the cardboard were collected (Figure 8). The artificial habitat created by the cardboard rings was highly effective at creating an over-wintering location for adults, and the trend over the three-year period at each location clearly shows a buildup in the population. This methodology has potential for being developed as an early detection protocol and has also been trialed in Romania (C. Chireceanu pers. comm.).

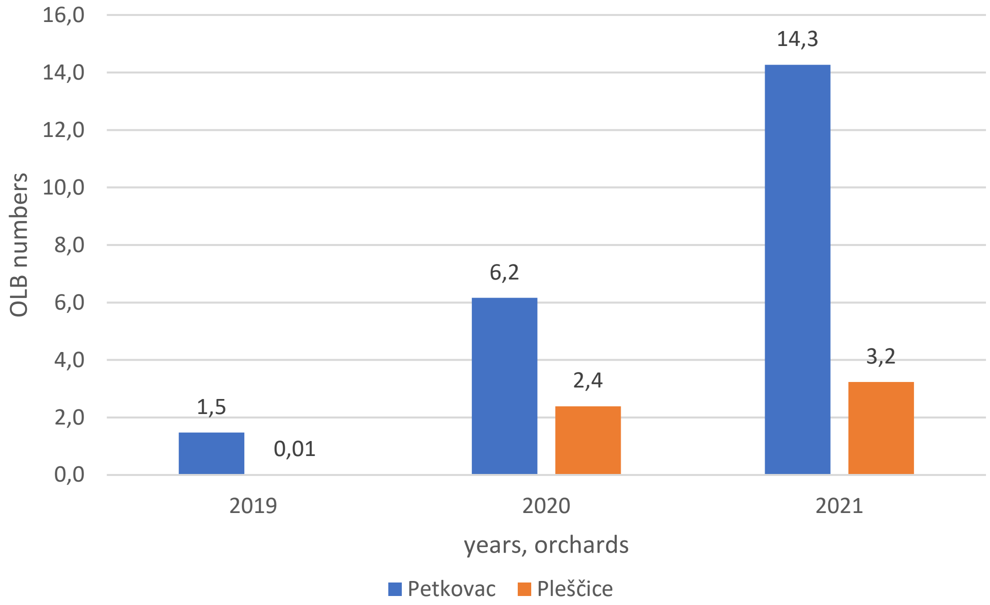


Figure 8. The average number of adult *C. arcuata* collected per cm^2 of cardboard, from sampling in Petkovac and Pleščice oak seed orchards.

2.4.2.3. Evaluation of potential pathways

The survey at the edge of the expanding range of *C. arcuata* in Austria in 2020 gave an indication on the roles of human mediated transportation and natural dispersal. In newly invaded areas, local infestations were found along major traffic routes and commercial centers (Figure 9). For example, infested trees were detected near a busy transit road connecting motorways in Hungary and Austria. Moreover, industry (hardwood sawmill, brick producer) and a train station are located there. Another infested plot in this area was at a busy intersection with a commercial center, a tree nursery, and a gas station. Oaks along other, minor roads in the area were not infested. In the generally infested area, plots with *C. arcuata* positive trees were also located along minor roads in rather remote places (Figure 10).

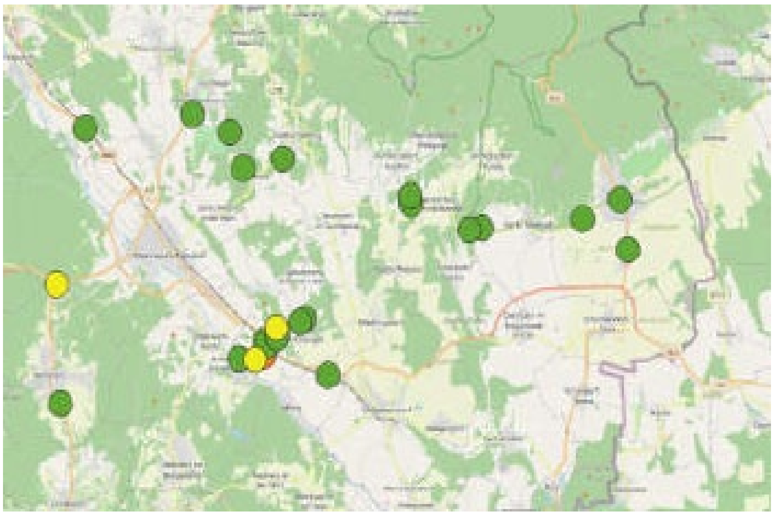


Figure 9. Along the front of the expanding population in Austria, survey plots with *C. arcuata* infested oaks (yellow and orange) were located near traffic infrastructure and industry. Plots along minor roads were not infested (green). Detail from map in Figure 3 (Survey results).

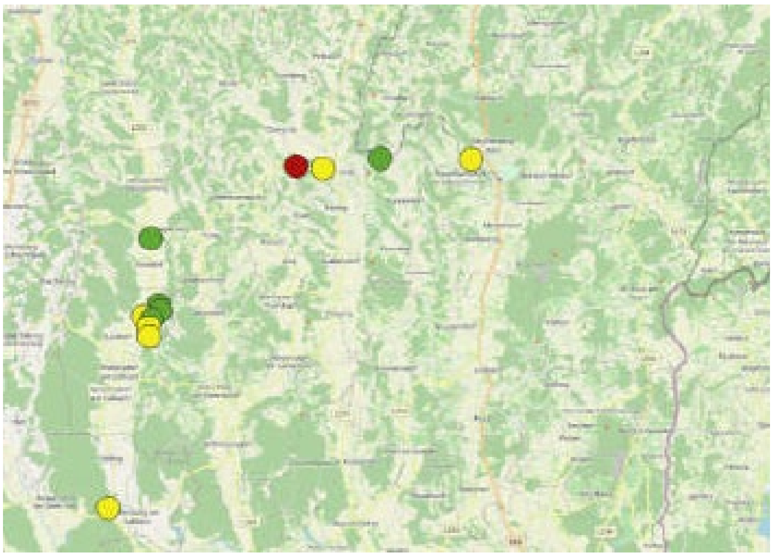


Figure 10. In the generally infested area, infested oaks (yellow and red) were also found along minor roads in rather remote areas. Detail from map in Figure 3 (Survey results).

The results of the 2020 survey in Austria suggest an expansion of the *C. arcuata* range by formation of satellite populations in previously uninfested areas that have originated from anthropogenic transportation (e.g. hitchhiking on vehicles), followed by natural dispersal (likely aided by wind) together with passive transportation. Frequent findings of infested trees next to gas stations, rest stops or commercial centers highlight the importance of movement by traffic. Plots near five hardwood processing industries were examined. Three of the localities had oak trees in the direct vicinity, and two of them were in the generally infested area, one along the border of the expanding population. *C. arcuata* was detected in all localities. Two other sites had oak trees more than 500 m distance away (separated by houses and gardens), and both were located along the border of the expanding population. *C. arcuata* was present in one case and absent in the other. A relation to transportation of timber from infested areas appears possible, however, given the widespread infestation it has to be assumed that *C. arcuata* has spread via several pathways.

2.4.2.4. Summary of potential early detection methods

- The standard methods for early detection are based on visual surveys by trained inspectors. Since levels of infestation will be very low in the early stage, symptoms that affect only a few twigs of a crown will not be spotted easily. Therefore, oaks at survey locations have to be examined using binoculars (for more details on proposed methodology see page 12). The focus of the survey should be along major traffic routes, oak trees near gas stations, rest stops, commercial centers, timber industry, etc. should be checked.
- Yellow sticky traps can be a valuable addition to visual surveys, and a combination of approaches is likely to be a cost-effective option. Experiences from Romania show that *C. arcuata* can be detected on yellow traps that are in place for surveillance of other insect pests. If traps are set up especially for *C. arcuata*, placement in the above-mentioned high-risk areas are advisable. When other trap networks are available, such as the suction traps in the Czech Republic, trap catches can also be checked for *C. arcuata*. In addition, a further evaluation of the use of cardboard sleeves on the trunks of oak trees during late autumn and winter may also lead to the development of an effective early detection protocol.
- The presence of *C. arcuata* can be detected even on fallen leaves in the autumn (over-wintering adults, eggshells, larval skins and frass). Hence, collecting fallen leaves from potentially infested locations (near busy roads etc.) in a bag and undertaking inspections of the material in the laboratory (or even in the field) could be informative.
- Beating of branches, cutting upper canopy branches with long pole pruners, and using sticky bands around the trunk of oak trees may also be useful techniques for early detection.
- Theoretically the early detection of *C. arcuata* could be achieved, however, in many cases there will be no feasible control options to respond to such early detections. Unfortunately, there is no real viable control options for *C. arcuata* that are currently available that can be recommended for eradication of newly introduced, isolated populations. Moreover, as for example indicated by the surveys undertaken in Austria, *C. arcuata* invasion from a widely infested area takes place along several entry paths (at least three major traffic routes appear to be associated with the introduction into southern Austria). Therefore, the chances of stopping the spread would be extremely low even with highly effective control measures. Any attempts to slow the spread would need to focus on areas where new satellite populations occur behind a natural barrier, such as oak free zones beyond mountain ranges, and even in this case, the limited control options remain a major problem.

2.4.3. Natural and human-mediated spread

A recent review of alien Heteroptera species in Europe highlighted the major pathways by which these species are introduced into new countries, with both translocation on ornamental plants and as stowaways on transport vehicles being identified as the main pathways (Rabitsch, 2008, 2010). *Corythucha arcuata* is a relatively recent introduction into Europe, only first being discovered in Italy in 2000 (Bernardinelli & Zandigiacomo, 2000). However, since this initial detection it has now spread (and likely been further introduced) to many other countries in Europe (Csóka *et al*., 2020). Oak lace bug, however is not the only lace bug (Tingidae) to be introduced into Europe (Rabitsch, 2008; Table 4), and comparisons with other related species in the Tingidae family can be made particularly in relation to spread and dispersal mechanisms.

2.4.3.1. Natural dispersal rates

Adult lace bugs (Tingidae) are not generally considered to be particularly strong fliers (Guidoti *et al*., 2015), primarily due to their small size and delicate wings. There are relatively few studies examining flight potential of lace bugs and none so far have been conducted specifically on oak lace bug. However, several authors have noted that the adults of *Corythucha* (both *C. arcuata* and *C. ciliata*) are not good flyers, and hence their natural rates of spread are slow (Chireceanu *et al*., 2017; Küçükbasmaci, 2014; Mutun *et al*., 2009). Similarly Neil and Schaefer (2000) state that adult *Stephanitis pyroides* are weak fliers, and suggest that dispersal flights occur mainly due to exhaustion of local food source because of overcrowding, and occassionally as a result of disturbance of the host plant.

Table 4. Introduced species of lace bug (Tingidae) into Europe.

Genus Corythucha – at least 70 species described worldwide
Corythucha arcuata – Oak lace bug; discovered in Italy in 2000 (Bernardinelli & Zandigiacomo, 2000)
Corythucha ciliata – Plane (Sycamore) lace bug; discovered in Italy in 1964 (Servadei, 1966)

Genus Stephanitis – at least 90 species described worldwide
Stephanitis takeyai – Andromeda lace bug; native to Japan, first recorded in UK in 1998; introduced into Europe via plant trade (Barta & Bibeň, 2016); feeds on rhododendron & azaleas
Stephanitis rhododendri – Rhododendron lace bug; native to N. America; found in UK; feeds on rhododendron & azaleas; introduced into Europe via plant trade (Barta & Bibeň, 2016)
Stephanitis pyrioides – Azalea lace bug; native to eastern Asia. Introduced into Europe via plant trade (Kment, 2007)

Genus Corythauma – unknown number of species
Corythauma ayyari – Jasmine lace bug (Roca-Cusachs & Goula, 2014); An Oriental species found in Pakistan, India, Laos, Malaysia, Thailand & Singapore; polyphagous feeding on ornamental plants including jasmine, marshmallow, blue sage, cardamom, verbane; recently discovered in France, Italy, Spain

Recent studies on plane lace bug (*Corythucha ciliata*) have started to reveal the potential natural dispersal abilities of lace bugs. Initial studies on *C. ciliata* by Wu and Liu (2016) found that an average daily flight distance of approximately 22m, with maximum daily flight distances of 27m were easily possible. Since Ju *et al*. (2011) in their studies on *C. ciliata* determined that adults could live between 20-60 days (depending on temperature), then over the course of an adults lifetime the insect could theoretically fly (unassisted by the wind) distances of greater than 1km. However, a more recent study by Lu *et al*. (2019) using a flight mill system, revealed that *C. ciliata* was more than capable of flight distances in excess of 1km (up to 6km on one occassion) over a 24 hour period in some instances, and they concluded that 'the insect appears to be capable of long distance flights'. This is in accordance with Maceljski (1986) who surmised that natural movement of *C. ciliata* can occur over many kilometeres, stating that 'they are very mobile and good fliers'. However, Maceljski (1986) does qualify this statement by suggesting that their flight does need to be supported by the wind. The observation that wind assists in the dispersal of *C. arcuata* has been noted by many authors and is believed to be a key factor responsible for the rapid spread in localised areas and medium range dispersal (e.g. Zubrik *et al*., 2019; Küçükbasmaci, 2014; Mutun *et al*., 2009). Hence, it seems reasonable to assume that the natural dispersal capability of *Corythucha* species can be through a combination of active flight (short-range) and passive transference by wind currents (mid and long-range).

2.4.3.2. Movement with commodities (plant trade and wood products)

The most important pathway by which alien invasive Heteropteran insects are introduced into Europe is through the importation of ornamental plants (Rabitsch, 2008, 2010). At least four of the known six species of Tingidae introduced into Europe (Table 4) were likely introduced through the importation of ornamental plants (Rabitsch, 2008; Roca-Cusachs & Goula, 2014; Barta & Bibeň, 2016), however there is some uncertainty over how both *Corythucha* species arrived in Europe, even though the most likely route is through the association with imported host plants. Once introduced into Europe though there is evidence of the movement of infested nursery stock being responsible for introductions into new geographical areas (Malumphy *et al*., 2007).

The rapid spread and long distance dispersal of *C. ciliata* has also been attributed to the 'human transportation of plants and logs with bark attached' (Wu *et al*., 2016; Ju *et al*., 2009). Similarly the introduction of *C. arcuata* into the south of European Russia has been proposed as being through the movement of infested plant material from Turkey (Abasov & Blummer, 2012). Accordingly the EPPO (2007) mini data sheet on *C. arcuata* highlights the principal pathway of introduction as 'oak plants for planting, and cut branches from countries where *C. arcuata* occurs.'

2.4.3.3. Evidence of hitch-hiking

A key pathway by which alien invasive Heteropteran insects have been introduced into Europe and subseqently been able to spread, quite rapidly in some cases, has been through the accidental translocation on various modes of transport (ships, trains, cars, lorries). For both species of *Corythucha* (*C. ciliata* and *C. arcuata*) that have been introduced into Europe they have spread rapidly from their initial points of introduction to many other European countries, and many authors cite the accidental movement (hitch-hiking) via vehicles along road and rail networks as the primary reason for this. The CABI Invasive Species Compendium (2019) datasheet for *C. ciliata* states the following in relation to the accidental introduction of *C. ciliata* into new areas: ‘Authors generally agree that the majority of long distance dispersal of *C. ciliata* is facilitated by human activity (e.g. Maceljski, 1986; Halbert and Meeker, 1998; Gillespie, 2007; Mutun et al., 2009). The following is an example of the generally accepted scenario and supported by personal observation (C Bloomfield, Agricultural Scientific Collections, NSW, Australia, personal communication, 2009):

‘The host species (plane trees) of *C. ciliata* are commonly planted as ornamental street trees, as such they line roadways, parking areas and areas of high traffic. *C. ciliata* can be transferred from the tree canopy onto vehicles parked underneath the trees or blown from the canopy by passing vehicles. They can then be transported long distances (or shorter distances within the same town/city) on the vehicles and be blown, brushed (or fly) onto plane trees in the new locality. It is also possible for *C. ciliata* to fly, be blown or brushed onto human pedestrians and moved about in similar ways.*C. ciliata*, being difficult to see when in small numbers, can remain unnoticed until founder populations have increased to the extent that damage to foliage becomes apparent by which time the insects may already have been spread to new areas.’

Clearly this is just as applicable to *C. arcuata*, since its primary host plant (*Quercus* spp.) are widely planted in urban and peri-urban areas across Europe, and this tends to be confirmed by most authors who have commented on the discovery of *C. arcuata* within their respective countries and how it may have arrived there. In a recent overview paper on the spread and potential host range of *C. arcuata* in Eurasia (Csóka *et al*., 2020), the authors cited long-range dispersal as generally being attributable to international road and rail traffic, with the first infested locations in a given region often being found at resting places near motorways or along rail lines (G. Csóka, B. Hrašovec, D. Jurc & M. Jurc, unpublished observations).

In Austria, Sallmannshofer *et al*. (2019) state that ‘We assume that the spread of *C. arcuata* initially took place along main traffic and tourist routes. Thus, the quick spread is likely caused by passive transportation on vehicles.’ In Italy, Bernardinelli (2006) comments that ‘The observation of some *C. arcuata* specimens on an isolated tree along a busy road, in an area where the insect was not otherwise found, suggests that vehicular transportation could be involved in the dispersal of the pest’. In Slovenia, Jurc and Jurc (2017) propose hitchhiking on rail traffic as a means by how *C. arcuata* was introduced into Slovenia from Croatia; and that the ‘extremely rapid’ spread in Croatia is ‘most probably due to the main traffic corridors’. In Bulgaria, Simov *et al*. (2018) and Dobreva *et al*. (2013) note that the majority of observations are made close to main European roads or within towns, and hence supported their hypothesis that human mediated dispersal mechanisms were responsible for both oak and sycamore lace bug introductions into Bulgaria. In Turkey, Küçükbasmaci (2014) suggest that heavy traffic on main arterial roads as a likely explanation for *C. arcuata* transportation, and Mutun *et al*. (2009) similarly state that ‘anthropogenic factors, such as passive transport via vehicles, may promote its distribution to other regions where oak species are the main forest trees’ and ‘we also think that this species has been accidentally introduced via human transport to the areas observed in the present study, as the study areas are located near major highways.' In Russia, Abasov and Blummer (2012) also hypothesise that the introduction of *C. arcuata* into Russia was probably through accidental introductions from Turkey either through translocation on heavy duty vehicles or conveyed on sea vesels with commodities, since there is a ferry line across the black sea (between Samsun, Turkey and Novorossiysk, Russia ports).

Comparable observations are made for *C. ciliata* with Küçükbasmaci (2014) suggesting that adult *C. ciliata* were capable of long-range dispersal, possibly occuring through human activity (in vehicles and on clothes). Arzone (1975) similarly notes that vehicles (trucks and buses) may also carry *C. ciliata* adults or nymphs to other trees when they come into contact with infested branches and leaves causing the spread of the bug. Interestingly Özsi *et al*. 2005 state that '*Corythucha ciliata* is supposed to have been brought into Europe by ships', although it is unclear whether they simply hitch-hiked on the ships or whether they were associated with infested host plants.

References

- Abasov, M.M. and A.G. Blummer (2012) Oak lace bug *Corythucha arcuata* (Say, 1832). Plant Health Research and Practice. December (2) p. 44-45.
- Arzone, A. (1975) The plane lace bug in Piedmont: biological cycle and dispersal. Montie Boschi 26(3): 19-27.
- Barta, M. and Ta Bibeň (2016) *Stephanitis takeyai* and *S. rhododendri* (Heteroptera: Tingidae) in Slovakia: first record and economic importance. Journal of Plant Protection Research, 56: 193-198.
- Bernardinelli, I. (2006) Potential host plants of *Corythucha arcuata* (Het., Tingidae) in europe: a laboratory study. Journal of Applied Entomology, 130: 480-484.
- CABI Invasive Species Compendium (2019) *Corythucha ciliata* (sycamore lace bug) Datasheet. Corythucha ciliata (sycamore lace bug) (cabi.org) (last modified 25/11/19).
- Chireceanu, C., Teodoru, A. and A. Chiriloaie (2017) New records of the oak lace bug *Corythucha arcuata* (Say, 1832)(Hemiptera: Tingidae) in southern Romania. Acta Zoologica Bulgarica, Suppl. 9: 297-299.
- Csoka, G., Hirka, A., Nutun, S., Glavendekic, M., Mikó, Á., Szõcs, 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., Jurc, M., Jurc, D., Bernardinelli, I., Streito, J.-C., Avtzis, D. and B. Hrašovec (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): 61-74.
- Dobreva, M., Simov, N., Georgiev, G., Mirchev, P. and M. Georgieva (2013) First record of *Corythucha arcuata* (Say) (Heteroptera: Tingidae) on the Balkan Peninsula. Acta Zoologica Bulgarica, 65: 409-412.
- EPPO Mini data sheet on oak lace bug, *Corythucha arcuata* (2007) 1 page. See link at https://gd.eppo.int/taxon/CRTHAR/documents
- Gillespie P.S. (2007) Sycamore Lace Bug PrimeFact 361. Sycamore Lace Bug PrimeFact 361. NSW DPI, 3 pp.

- Guidoti, M., Montemayor, S.I and É. Guilbert (2015) Lace Bugs (Tingidae). Chapter 14, In: True Bugs (Heteroptera) of the Neotropics (eds A.R. Panizzi and J. Grazia). P.395-419. Springer.
- Halbert S.E. and J.R. Meeker (1998) The sycamore lace bug, *Corythucha ciliata* (Say) (Hemiptera: Tingidae). Entomology Circular (Gainesville), No. 387:2 pp.
- Ju, R., Li, Y., Wang, F. and Y. Du (2009) Spread of and damage by an exotic lacebug, *Corythucha ciliata* (Say, 1832)(Hemiptera: Tingidae), in China. Entomological News, 120:409-414.
- Jurc, M. and D. Jurc (2017) The first record and the beginning of the spread of oak lace bug, *Corythuca arcuata* (say, 1832) (Heteroptera: Tingidae), in Slovenia. Šumarski list, 141: 485-488.
- Küçükbasmaci, I. (2014) Two new invasive species recorded in Kastamonu (Turkey): Oak lace bug (*Corythucha arcuata* (Say, 1832)) and sycamore lace bug (Corythucha ciliata (Say, 1832))(Heteroptera: Tingidae). Journal of Entomology and Nematology, 6:104-111.
- Lu, S., Wei, M., Yuan, G., Cui, J. and D. Gong (2019) Flight behavior of the sycamore lace bug, *Corythucha ciliata*, in relation to temperature, age, and sex. Journal of Integrative Agriculture, 18: 2330-2337.
- Maceljski, M. (1986) Current status of *Corythucha ciliata* in Europe. EPPO Bulletin, 16: 621-624.
- Malumphy, C.P., Reid, S. and D. Eyre (2007) The Platanus lace bug, *Corythucha ciliata* (Say) (Hemiptera: Tingidae), a nearctic pest of plane trees, new to Britain. Br. J. Ent. Nat. Hist., 20: 233-239.
- Mutun, S., Ceyhan, Z. and C. Sözen (2009) Invasion by the oak lace bug, Corythucha arcuata (Say) (Heteroptera: Tingidae), in Turkey. Turkish Journal of Zoology, 33: 263-268.
- Neil Jr., J.W. and C.W. Schaefer (2000) Lace Bugs (Tingidae), In: Heteroptera of Economic Importance (eds C.W. Schaefer and A.R. Panizzi), pages 85-134. CRC Press, Boca Raton, FL.
- Özsi, B., Ladányi, M. and L. Hufnagel (2005) Population dynamics of the sycamore lace bug, *Corythucha ciliata* (say) (Heteroptera: Tingidae) in Hungary. Appl. Ecol. Environ. Res. 4(1): 135-150.
- Rabitsch, W. (2008) Alien true bugs of Europe (Insecta: Hemiptera: Heteroptera). Zootaxa 1827: 1-44.
- Rabitsch, W. (2010) True Bugs (Hemiptera, Heteroptera). Chapter 9.1. In: Roques et al. (Eds) Alien terrestrial arthropods of Europe. BioRisk 4(1): 407-433.
- Roca-Cusachs, M. and M. Goula (2014) First record of the invasive tingid species *Corythauma ayyari* (Drake, 1933) in the Iberian Peninsula (Insecta: Hemiptera: Heteroptera: Tingidae). Butlleti de la Institució Catalana d'Història Natural, 78: 119-124.
- Sallmannshofer, M., Ette, S., Hinterstoisser, W., Cech, T.L. and G. Hoch (2019) Erstnachweis der Eichennetzwanze *Corythucha arcuata*, in Österreich. Forschutz Aktuell, Nr., 66, 1-6.
- Simov, N., Grozeva, S., Langourov, M., Georgieva, M., Mirchev, P. and G. Georgiev (2018) rapid expansion of the oak lace bug *Corythucha arcuata* (Say, 1832) (Hemiptera: Tingidae) in Bulgaria. Historia naturalis bulgarica 27: 51-55.

- Wu, H. And H. Liu (2016) Movement behavior and host location ability of *Corythucha ciliata*. PloS ONE 11(3): e0152205. Doi:10.1371/journal.pone.0152205
- Wu, H.-W., Li, X.-C. and H.-X., Liu (2016) Starvation resistance of invasive lace bug *Corythucha ciliata* (Hemiptera: Tingidae) in China. Entomologica Fennica, 27: 8-14.
- Zubrik, M., Gubka, A., Rell, S., Kunca, A., Vakula, J., Galko, J., Nikolov, C. and R. Leontovyč (2019) First record of Corythucha arcuata in Slovakia – Short communication. Plant Protection Science 55(2): 129-133.

2.4.4. Engagement

The main aim of this work package was to raise awareness and engagement of *Corythucha arcuata*. This was achieved by preparing popular articles, datasheets, including the species in citizen science projects and presentations at conferences and workshops.

2.4.4.1. Popular articles

Numerous popular articles were prepared for different media. In Slovenia, 6 articles were written that were published in 4 national magazines and on 2 national websites. An overview of the oak lace bug was also presented on one popular national TV show. The articles presented the oak lace bug and its problems in a popular way in order to reach and engage with the public. In the UK an article in the trade journal 'Forest and Timber News' was published, primarily to raise awareness and inform those working in the forestry and wood sector in the UK on the risks and potential consequences of accidentally bringing oak lace bug into the UK. In Austria, three articles were published in professional journals, and in Hungary several articles have also been published.

2.4.4.2. Field guides

The project partners contributed to several field guides that were prepared both prior to and during the OLBIE project. During the project LIFE ARTEMIS (Awareness, training and measures on invasive alien species in forests (LIFE15 GIE/SI/000770)) a field guide for alien species in Slovenian forests was prepared in Slovenian which also included the oak lace bug (https://www.tujerodne-vrste.info/wp-content/uploads/2019/11/LIFE-ARTEMIS_terenski_prirocnik_druga_dopolnjena_izdaja.pdf). With help of the COST action Alien CSI (Increasing understanding of alien species through citizen science (COST Action CA17122)), the field guide was translated into English and extended to cover species from the whole of Europe (https://www.tujerodne-vrste.info/wp-content/uploads/2019/12/Field-Guide-Alien-species-in-European-Forests.pdf) (Figure 11). In this guide a short description is made including the identification characteristics, habitat, status, and connection to other species. Additionally, a current distribution map was prepared of the species.

For the project Observatree (Monitoring tree health), a field identification guide has been prepared for *C. arcuata* (Figure 12):
(https://www.observatree.org.uk/wp-content/uploads/2018/01/16_0048_One-off-literature-Observatree-Guide-Oak-lace-bug_wip07.pdf)
It includes an extensive description of the species and how to recognize it, and photos are included to help differentiate the damage symptoms from other similar damage caused by other insect pests. A comparable guide for *C. ciliata* is also available.

2.4.4.3. Citizen science projects

The oak lace bug has been included in at least four citizen science portals prepared by the partners. Observatree, LIFE ARTEMIS, the INTERREG project REFOCUS (Resilient riparian forests as ecological corridors in the Mura-Drava-Danube Biosphere Reserve), and the Phytosanitary Portal in the Czech Republic.

The Observatree project started in 2013 and covers the area of Great Britain. This project has 452 trained volunteers located all over the country and has from the start of the project logged tens of thousands of records from other tree pests and diseases (none on *C. arcuata* yet!). People can send their information to the Tree Alert portal (https://www.forestresearch.gov.uk/tools-and-resources/tree-alert/).

The LIFE ARTEMIS project started in 2016 and covers the territory of Slovenia. This project focuses on all invasive species in forests including plants, insects, fungi, and mammals. In total 13,931 records were made from which 1183 were on forest insect pests and diseases. During the project special attention has been given to the oak lace bug in the action “Record an alien species”. During the activity popular articles were written on the oak lace bug and a leaflet was prepared (Figure 13). Up until relatively recently there have been 106 observations over the whole of Slovenia of oak lace bug (Figure 14), which includes observations by foresters and citizen scientists.

On the basis of the data collected in the LIFE ARTEMIS, a detection model is in preparation for better understanding of early detection. In this model the presence data and pseudo absence data will be correlated to several variables which could influence the detection the oak lace bug, and furthermore the bias of the citizen science data for the different variables will be investigated. A map will be produced of areas in Slovenia where the species will be expected to be found first.

During the REFOCUS project the information system Danube Forest Health was prepared (https://danubeforesthealth.eu/). This information system is a portal where tree pests and diseases can be reported and covers Austria, Hungary, Slovenia, Croatia and Serbia, and the oak lace bug is included in this information system.

The Central Institute for Supervising and Testing in Agriculture, in the Czech Republic, has recently developed an online ‘Phytosanitary Portal’ web portal (Figure 15) (http://eagri.cz/public/app/srs_pub/fytoportal/public/#rlp|so|skudci) which gives detailed information (biology, host plants, distribution, photos) on pests and pathogens, and includes pages and information on oak lace bug, and which from 2020 will include information on recent survey results and an up to date map showing distribution of oak lace bug in the country.

2.4.4.4. Public awareness survey

A public awareness survey on the oak health status and the management of the oak lace bug was conducted in 2020. Public opinion was surveyed regarding the recognition, impact, and the willingness to take measures against this species. In total seven countries contributed with more than 2000 people filling in the questionnaire. The analysis is still being undertaken, but preliminary results were presented at the OLBIE final project meeting in February 2021, and the authors are currently working on a journal paper.

2.4.4.5. Undergraduate, Masters and PhD Theses undertaken by students working on *Corythucha arcuata*

Undergraduate theses

1. Martina Bičanić (2020) Application of cardboard rings in monitoring of oak lace bug *Corythucha arcuata* (Say, 1832) population (in Croatian).
2. Tena Hatvalić (2019) Presence of parasitoids (Hymenoptera: Mymaridae) on oak lace bug *Corythucha arcuata* (Say, 1832) (Heteroptera: Tingidae) in Croatia (in Croatian).
3. Adam Pandurić (2020) Host species of oak lace bug *Corythucha arcuata* (Say, 1832) in Valpovo city area (in Croatian).
4. Igor Kambić (2020) Host species of oak lace bug *Corythucha arcuata* (Say, 1832) in Bjelovar city area (in Croatian).

Master's theses

1. Niko Labor (2019) Efficacy of the insecticidal injection of pedunculate oak (*Quercus robur* L.) against the attack of oak lace bug (*Corythucha arcuata* Say.) (in Croatian).
2. Petra Plavac (2019) Assessment of the impact of oak lace bug (*Corythucha arcuata* Say.) on the ripening of pedunculate oak (*Quercus robur* L.) acorn (in Croatian).

PhD theses

1. Márton Paulin (Sept. 2020 – Aug. 2024) Spread and Impact of the invasive oak lace bug in Hungary. Institute: University of Sopron, Hungary.
2. Alex Stemmelen (Nov. 2019 - Oct. 2022) Associational resistance to non-native forest pests. Institute: INRAE, France.
3. Flavius Bălăcenoiu (2019-2022) Bioecology of the invasive alien species *Corythucha arcuata* in Romania. Institute: Transilvania University of Brasov.
4. Antonija Kolar: Chemical composition of oak (*Quercus robur* L.) leaves considering damage caused by oak lace bug *Corythucha arcuata* (Say, 1832) (in Croatian) – this PhD also being an integral part of the 4-year project financed by the public enterprise "Hrvatske šume" (Croatian forests Ltd).
5. Marta Kovač (2021) Entomopathogenic fungi of the genus Beauveria in Croatia and possibilities of their application in biological control of forest pests (in Croatian with English summary), 112 pp. (public defense held on January 29, 2021).

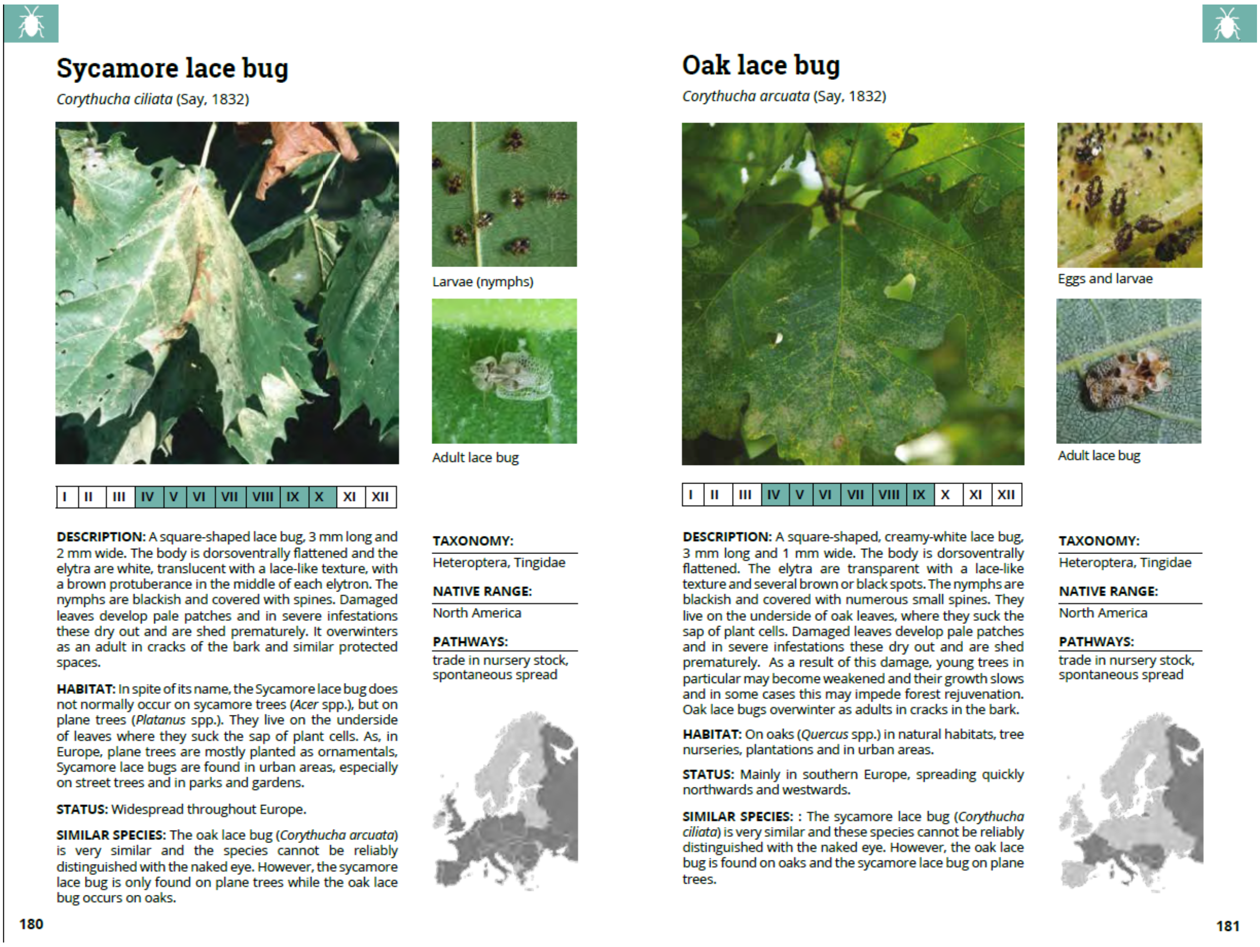
2.4.4.6. Presentations

- Constantina Chireceanu, Andrei Teodoru, Alina Geicu, Ioana Florescu, Andrei Chiriloaie-Palade (2020). Status of the oak lace bug *Corythucha arcuata* during overwinter period. Annual Scientific Session of Research and Development Institute for Plant Protection Bucharest, November 6, 2020, Bucharest, Romania.
- Csóka, G., Paulin, M., Eötvös, C., Gáspár, C., A. Hirka, A., Williams, D., Mikó, Á., Glavendekic, M. and B. Hrašovec (2020). Oak lace bug, a 'rising star' in Europe. 30th USDA Interagency Research Forum on Invasive Species, 14-17th January 2020, Annapolis, Maryland, USA.
- OLBIE workshop 23-25th July in Hungary/Croatia.
- Csóka, G., Paulin, M., Mikó, Á., Eötvös, C., Gáspár, C. and A. Hirka (2019).The oak lace bug (*Corythucha arcuata*) – a multiple threat on oak ecosystems. Detection and control of forest invasive alien species in a dynamic world. International conference of the LIFE ARTEMIS project, 25-28th September 2019, Ljubljana, Slovenia.

- Matek, M. and M. Pernek (2019). Effectiveness of entomopathogenic *Beauveria pseudobassiana* on *Corythucha arcuata* in laboratory conditions. SIP/IOBC (International Congress on Invertebrate Pathology and Microbial Control); Valencia, Spain.
- Matek, M and M. Pernek (2019) Prvi nalaz entomopatogenih gljiva kao prirodnih neprijatelja hrastove mrežaste stjenice (*Corythucha arcuata*). V. Međunarodni seminar- Integralna zaštita šuma; Bihać, Bosnia Hercegovina.
- Milivoj Franjević, Antonija Kolar, Andreja Đuka, Boris Hrašovec (2019). Oak lace bug in eastern Slavonia (Croatia), integrated forest protection in FSC certified forests and precautions in oak timber production. FORMEC - Exceeding the Vision: Forest Mechanisation of the Future, Sopron, Hungary.
- Antonija Kolar (2019). Dosadašnja istraživanja vezana uz hrastovu mrežastu stjenicu (*Corythucha arcuata*). Dan doktorata 2019. – Simpozij doktorskog studija Šumarstva i drvne tehnologije Šumarski fakultet Sveučilišta u Zagrebu, Zagreb.
- Milivoj Franjević, Antonija Kolar, Vesna Ančić-Tunuković, Nataša Čopčić, and Boris Hrašovec (2019). Primjena kartonskih traka u zaštiti od hrastove mrežaste stjenice na području UŠP Vinkovci. 63. Seminar biljne zaštite, Opatija, Hrvatska.
- Bălăcenoiu, F., Tomescu, R., Nețoiu, C., Buzatu, A. and G. Isai (2019). Distribution of the oak lace bug, *Corythucha arcuata* (Say.) (Hemiptera: Tingidae), in Romania. IUFRO WP 7.03.10 Methodology of forest insect and disease survey in Central Europe, Recent Changes in Forest Insects and Pathogens Significance - Working Party Meeting, 16-20 September 2019, Suceava, Romania.
- Williams, D., Csóka, G. and B. Hrašovec (2019). Evaluation of the pest status in Europe of the oak lace bug (*Corythucha arcuata*). Poster presented at IUFRO joint meeting of WP 7.03.06 - Integrated management of forest defoliating insects, and WP 7.03.07 – Population dynamics of forest insects. 8-11th July 2019, Quebec City, Canada.
- Williams, D., Csóka, G., Hrašovec, B., Hoch, G., de Groot, M., Hradil, K., Chireceanu, C. and B. Castagneyrol (2019). Evaluating the pest status in Europe of the oak lace bug, *Corythucha arcuata* (Heteroptera: Tingidae), and developing survey, control and management strategies. Detection and control of forest invasive alien species in a dynamic world. International conference of the LIFE ARTEMIS project, 25-28th September 2019, Ljubljana, Slovenia.

2.4.4.7. Information via online portals

- www.invazivke.si
- www.zdravgozd.si
- http://eagri.cz/public/app/srs_pub/fytoportal/public/#rlp%7Cso%7Cskudci
- https://www.forestresearch.gov.uk/tools-and-resources/pest-and-disease-resources/oak-lace-bug-corythucha-arcuata/



Sycamore lace bug

Corythucha ciliata (Say, 1832)

Larvae (nymphs)

Adult lace bug

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII

DESCRIPTION: A square-shaped lace bug, 3 mm long and 2 mm wide. The body is dorsoventrally flattened and the elytra are white, translucent with a lace-like texture, with a brown protuberance in the middle of each elytron. The nymphs are blackish and covered with spines. Damaged leaves develop pale patches and in severe infestations these dry out and are shed prematurely. It overwinters as an adult in cracks of the bark and similar protected spaces.

HABITAT: In spite of its name, the Sycamore lace bug does not normally occur on sycamore trees (*Acer* spp.), but on plane trees (*Platanus* spp.). They live on the underside of leaves where they suck the sap of plant cells. As, in Europe, plane trees are mostly planted as ornamentals, Sycamore lace bugs are found in urban areas, especially on street trees and in parks and gardens.

STATUS: Widespread throughout Europe.

SIMILAR SPECIES: The oak lace bug (*Corythucha arcuata*) is very similar and the species cannot be reliably distinguished with the naked eye. However, the sycamore lace bug is only found on plane trees while the oak lace bug occurs on oaks.

TAXONOMY:
Heteroptera, Tingidae

NATIVE RANGE:
North America

PATHWAYS:
trade in nursery stock, spontaneous spread

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Oak lace bug

Corythucha arcuata (Say, 1832)

Eggs and larvae

Adult lace bug

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII

DESCRIPTION: A square-shaped, creamy-white lace bug, 3 mm long and 1 mm wide. The body is dorsoventrally flattened. The elytra are transparent with a lace-like texture and several brown or black spots. The nymphs are blackish and covered with numerous small spines. They live on the underside of oak leaves, where they suck the sap of plant cells. Damaged leaves develop pale patches and in severe infestations these dry out and are shed prematurely. As a result of this damage, young trees in particular may become weakened and their growth slows and in some cases this may impede forest rejuvenation. Oak lace bugs overwinter as adults in cracks in the bark.

HABITAT: On oaks (*Quercus* spp.) in natural habitats, tree nurseries, plantations and in urban areas.

STATUS: Mainly in southern Europe, spreading quickly northwards and westwards.

SIMILAR SPECIES: : The sycamore lace bug (*Corythucha ciliata*) is very similar and these species cannot be reliably distinguished with the naked eye. However, the oak lace bug is found on oaks and the sycamore lace bug on plane trees.

TAXONOMY:
Heteroptera, Tingidae

NATIVE RANGE:
North America

PATHWAYS:
trade in nursery stock, spontaneous spread

181

Figure 11. The field guide for alien species in European forests, which includes the descriptions of the sycamore lace bug and the oak lace bug.

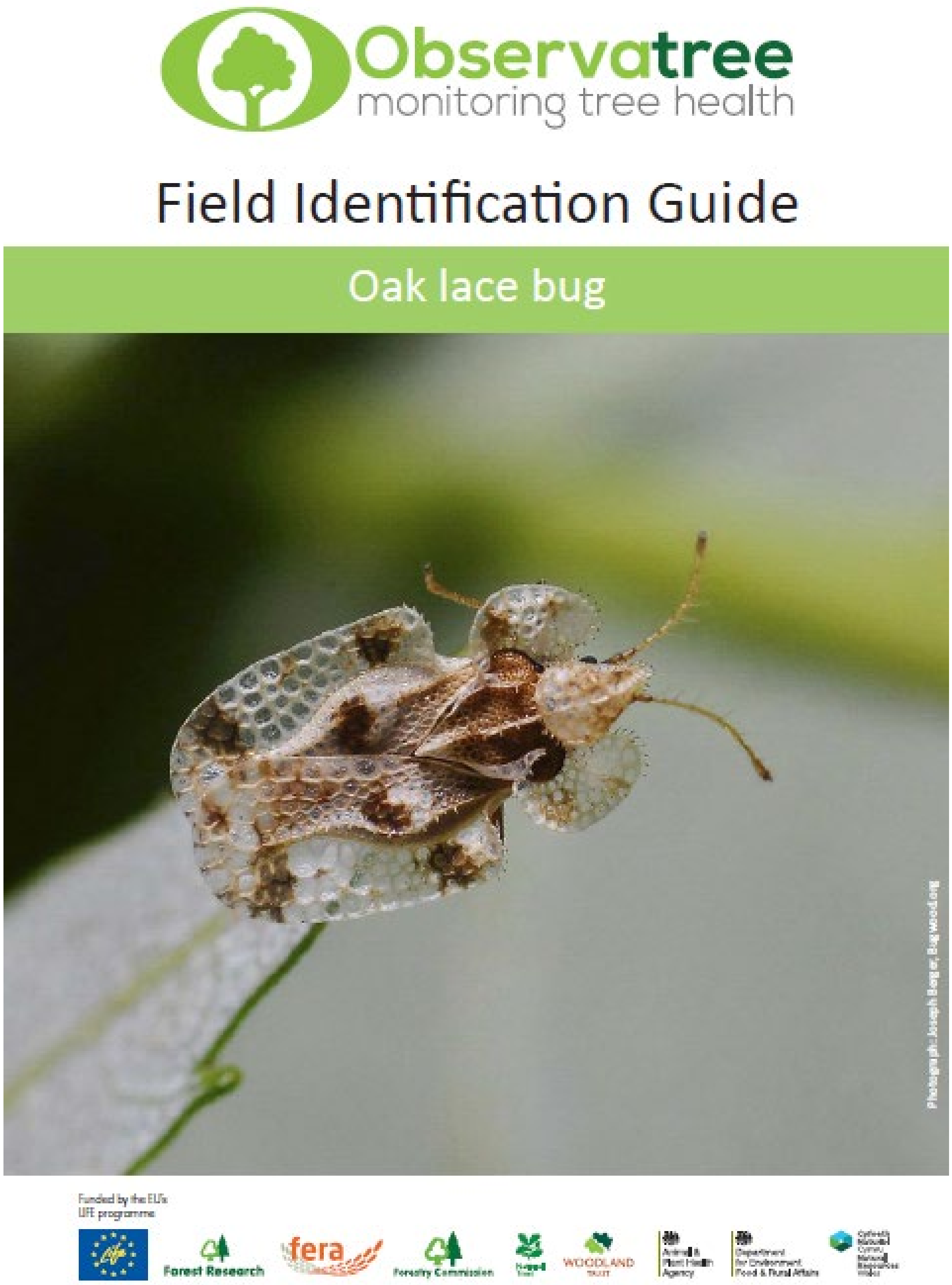

Figure 12. The field identification guide prepared during the Observatree project.

Figure 13. Leaflet prepared for the citizen science action “Record an alien species” for the detection of the oak lace bug in Slovenia.

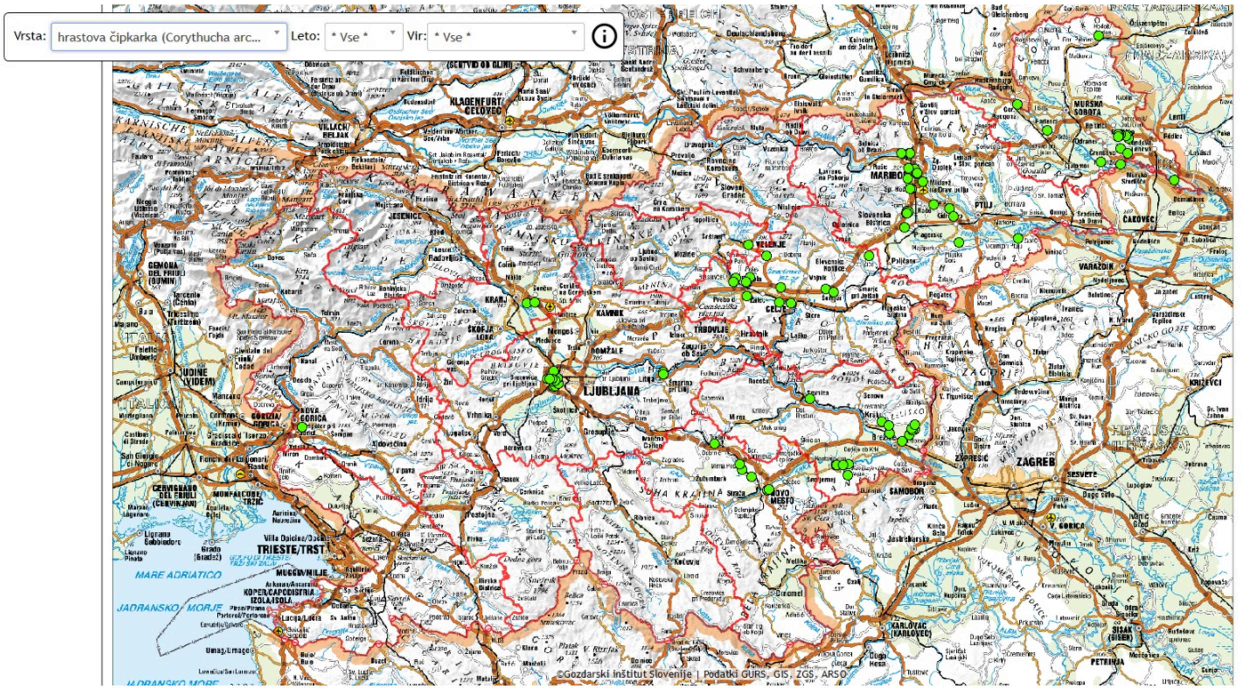

Figure 14. Records of the oak lace bug in Slovenia collected from 2017 till 2019 during the LIFE ARTEMIS project (source: www.invazivke.si).

Figure 15. An example page from the 'Phytosanitary Portal' developed by the Central Institute for Supervising and Testing in Agriculture, the Czech Republic.

2.5. Conclusions and recommendations to policy makers

The over-riding conclusion from the OLBIE project was that the continual spread of *C. arcuata* across Europe is inevitable. This is primarily based on 1) the observation that a comparable Tingidae species, *Corythucha ciliata*, which feeds on plane trees, has now spread across almost the entirety of Europe and can now be found on six continents, 2) the primary host plant of *C. arcuata* (oak) is abundant throughout Europe, 3) the climate is unlikely to limit its spread, 4) there are no real options for control and management of the pest within forest and woodland settings, 5) native European natural enemies are having little to no impact on OLB populations, and 6) dispersal of the pest is through stratified dispersal – with short range dispersal aided by the wind, and long range dispersal primarily achieved through the insects hitch-hiking on various modes of transport, and it being transported over significant distances on infected nursery plant material.

A proposed methodology for undertaking visual surveys for *C. arcuata* is outlined within section 2.4.2.1., and other early detection methods that might be considered and developed further, using a variety of trapping and sampling approaches, are outlined within section 2.4.2.4.

The lack of published information on this particular insect pest, particularly in relation to the potential impacts on oaks and oak ecosystems in Europe is clearly a high priority area of research that needs to be addressed urgently.

There are currently no suitable chemical control options available for use within forest/woodland settings. Furthermore, the use of any chemical control approaches within forests and woodlands is considered to be unpractical, uneconomical, generally unacceptable to the public, and would have highly significant detrimental impacts to non-target organisms associated with oaks and oak ecosystems, making it an unrealistic option – hence *C. arcuata* will continue to proliferate. Whilst there is some scope to potentially undertake chemical control of this insect pest within oak seed orchards and nurseries (and possibly solitary trees within amenity areas), evaluation of suitable products and application approaches needs to be undertaken.

A classical biological control approach is likely to be needed for oak lace bug in Europe and further research should be focusing on the potential natural enemies that need to be considered and evaluated for potential release.

Considering the inevitable spread across Europe, it is important to raise awareness of *C. arcuata* and its potential impacts by using wider outreach, citizen science, local authority and public awareness tools.

2.6. Benefits from trans-national cooperation

The collaborators who contributed to the OLBIE project made a concerted effort to evaluate the limited available information on Corythucha arcuata and certainly benefited from the workshops and meetings that were held despite the coronavirus pandemic. The effective sharing of knowledge, useful discussions and exchanging of information and expertise was invaluable and contributed to the many outputs (posters, seminars, papers etc) that were generated throughout the course of the project. The project forged new associations and collaborations that will be invaluable in developing new project areas in the future.

3. Publications

3.1. Article(s) for publication in the EPPO Bulletin

None.

3.2. Article for publication in the EPPO Reporting Service

None.

3.3. Article(s) for publication in other journals

- Kovač, M., Gorczak, M., Wrzosek, M., Tkaczuk, C. and M. Pernek (2020) Identification of entomopathogenic fungi as naturally occurring enemies of the invasive oak lace bug, *Corythucha arcuata* (Say) (Hemiptera: Tingidae). Insects 11(10): 1-12.
- Csóka, Gy.; Hirka, A.; Mutun, S.; Glavendekic, M.; Mikó, Á.; Szőcs, L.; Paulin, M.; Eötvös, Cs.B.; Gáspár, Cs.; Csepelényi, M.; Szénás,i Á.; Franjevic, M.; Gninenko, Y.; Dautbašic, M.; Mujezinovic, O.; Zúbrik, M.; Netoiu, C.; Buzatu, A.; Balacenoiu, F.; Jurc, M.; Jurc, D.; Bernardinelli, I.; Streito, J.C.; Avtzis, D. And B. Hrašovec (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): 61–74.
- Liška, J. (2020) Faunistic records from the Czech republic – 495. Klapalekiana, 56: 295–296.
- Paulin M., Hirka A. and Csóka Gy. (2020) Veszélyben a tölgyek. A mi erdőnk, 10(4): 20–21. Oaks are in danger – popular article in journal “Our forests”.
- Paulin M., Hirka A., Eötvös Cs. B., Gáspár Cs., Fürjes-Mikó Á., Csóka Gy. (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.
- Paulin M., Hirka A., Mikó Á., Tenorio-Baigorria I., Eötvös Cs., Gáspár Cs. and Gy. Csóka (2019) Tölgycsipkéspoloska – helyzetjelentés 2019 őszén. Alföldi Erdők Egyesület, Kutatói nap, Tudományos eredmények a gyakorlatban, Konferencia kötet: 110-119. OLB situation in Hungary in autumn 2019 – proceedings of the conference of the Lowland Forestry Association.
- Paulin M., Hirka A., Mikó Á., Tenorio-Baigorria I., Eötvös Cs., Gáspár Cs. and Gy. Csóka (2020) A tölgy-csipkéspoloska Magyarországon - helyzetkép 2019 őszén. Növényvédelem, 56(6): 245-249. OLB situation in Hungary in autumn 2019 in journal “Plant protection”.
- Paulin, M.; Hirka, A.; Csepelényi, M.; Fürjes-Mikó, Á.;Tenorio-Baigorria, I.; Eötvös1, Cs.; Gáspár, Cs. and Gy. Csóka (2021) Overwintering mortality of the oak lace bug (*Corythucha arcuata*) in Hungary – a field survey. Central European Forestry Journal, 67: 108-112.
- Radulović A., Škornik M. and M. de Groot (2021) Influence of tree diameter and leaf area on the invasive sycamore lace bug in urban areas. Submitted to Urban Ecosystems.
- Sallmannshofer, M., Ette, S., Hinterstoisser, W., Cech, T.L. and G. Hoch (2019) Erstnachweis der Eichennetzwanze, Corythucha arcuata, in Österreich (First report of oak lace bug, Corythucha arcuata, in Austria). Forstschutz Aktuell 66: 1-6 online, https://bfw.ac.at/rz/bfwcms.web?dok=10710
- Williams, D. and J. Morgan (2020) Early warning on oak lace bug. Forestry and Timber News. April 2020, Issue 98.

4. Open Euphresco data

None.