Integrated Forest Protection In FSC Certified Forests And Precautions In Oak Timber Production – Invasive Oak Lace Bug In Eastern Croatia

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ABSTRACT

In Croatian state forests pedunculate oak (*Quercus robur* L.) represents 14.9% (45.0 mil m³) and sessile oak (*Quercus petraea* (Matt.) Liebl.) 9.5% (29 mil. m³) of the total growing stock. Pedunculate oak is considered as the most valuable tree species as it is of a well-known quality and with very demanding management conditions. In FSC certified oak stands of Eastern Slavonia oak timber production is compromised by series of negative biotic and abiotic factors. The rapid spread and high population level of invasive alien species oak lace bug *Corythucha arcuata* (Heteroptera, Tingidae) in Croatia form 2013 onward is one of the factors that contribute to concerns by forest operatives and forest protection specialists alike. In 2017 the Ministry of Agriculture restricted the transport of oak roundwood (and seeding material) outside of Coratia with the purpose of preventing the spread of harmful organisms. Many questions arrived with new pest: what are the pathways for the spread of this pest and an assessment of how well adults overwinter, do the infested trees suffer from tree mortality, reduced growth and/or reduced acorn production/germination? Are the effects more of an aesthetic issue with trees turning brown earlier than usual with relatively little impact on tree growth, or are impacts only detectable over longer periods? Is there any evidence that oak trees or stands of oak trees infested with *C. arcuata* are more susceptible to other pests and pathogens? For better understanding and developing of strategies for integrated pest management of *C. arcuata* from summer of 2017 until 2019 series of oak lace bug suppression tests were conducted including areal treatment, terrestrial spraying, tree infusion with insecticides, oak seed tests in nurseries and cardboard ring application on overwintering adults. During these trials, only FSC certified insecticides were used, and they were applied in experimental purposes. Nevertheless experimental aerial oak lace bug suppression showed weak results because oak lace bug was resistant to insecticide certified for the application. Injectioning with insecticides is promising in some objects as oak seed orchards although in the first season of testing with mixed results. Oak seed tests did not show an established pattern between *C. arcuata* infested seed locations and control locations. Overall poor seed quality had greater impact on seed germination, and it is unclear if oak lace bug influences seed germination, growth and quality of roundwood. *C. arcuata* suppression of overwintering adults showed good results in oak seed orchards because of bark structure and proximity of branches but not in old stands were protection is marginal.

Key words: Corythucha arcuata, integrated forest protection, forest management, invasive alien species

INTRODUCTION

Corythucha is a genus of the family Tingidae (Heteroptera), which is represented by 49 lace bug species in North America. One of the members of the genus *Corythucha* is *C. arcuata* (Say), commonly known as the oak lace bug (OLB), which is considered a native species to North America. Until 2000, *C. arcuata* was known only in the Nearctic area, with a particular distribution in the United States and southern Canada; however, the *C. arcuata* oak lace bug originates from North America: Canada (south), USA (most states). Reported for the first time in 2000, in Italy (Lombardia, Piemonte). In 2001, it was present on 7000 km² in Lombardia and Piemonte, and an isolated infested oak tree was found on the northern coast of Lake Como. In Turkey it was detected in 2003., Switzerland 2005., Bulgaria 2012, Hungary 2013. In Croatia first findings are recorded in 2013. and detected on five locations Lipovac, Vrbanja, Gunja, Otok, Vinkovci. During period from 2013 evaluation of damage to leaves in oaks stands, area of infestation and phenology in Croatian climatic and ecological conditions by oak lace bug were observed. In Croatian climate conditions overwintering adults of *C. arcuata* start with activity in period of mid March few weeks before leaf buds start to shoot. With beginning of April first signs of feeding are present on new leafs and oviposition of first generation starts at end of April beginning of May. First larvae are hatched and present on leafs by the end of May. This is the period when damage to leafe surface starts to show and by the end of June most leafes have more than 60 % of its surface damaged by feeding of five larval stages. In Croatian forests *C. arcuata* is highly polifagous and polivoltin species that develops two complete generations while third generation is incomplete due to climatic conditions and starvation of larvae. Croatian lowland oak stands show high loss of leaf assimilation surface from June/July period due to intensive feeding of bugs even before summer drought begins, and are accompanied by abortion of acorn before its normal fructification period. This is great concern in regard with sustainable management of even-aged oak stands and their growth and increment. Westernmost region of Croatia Istria and Kvarner coastal region with pubescent oak stands is currently not affected with new pest. According to, the com-pany »Hrvatske Šume« Ltd. state owned company manages 76 % or 302.4 million m³ of the Croatian state owned forests, where pedunculate oak (*Quercus robur* L.) accounts for 14.9 % (45.0 mil m³) and sessile oak (*Quercus petraea* (Matt.) Liebl.) for 9.5 % (29 mil. m³) of the total growing stock. Pedunculate oak accounts for 13.6 % (0.79 mil m³) and sessile oak accounts for 9.0 % (0.52 mil m³) in the an-nual allowable cut. Economically most valuable tree species in the Croatian forests is pedunculate oak which is of high quality and very demanding management conditions. Because of oak species importance for Croatian forestry it is necessary to develop strategies for sustainable developement goals and evaluate influence of oak lace bug on growth and increment but also on vitality and seed production. Test of insecticide suppression against *C. arcuata* in oak seed plantations were conducted with varying results. In the growing number of infested oak stands which are FSC certified, the application of insecticides for the protection from oak lace bug is restricted be-cause of FSC policy (in relation to the use of pesticides in FSC-certified forests and plantations) with the aim of minimizing the negative environmental and social impacts of pesticides whilst promoting economically viable management. This policy is implemented through compliance with the requirements of FSC-STD-01-001 FSC Principles and Criteria of Forest Stew-ardship and the associated national or subnational indicators and means of verification (FSC-POL-30-001 (2005) EN). This altogether makes additional challenge for foresters and narrows forest management strategies and integrated forest protection against invasive alien species that is rapidly spreading in Croatian oak stands and oak seed plantations.

Figure 1. Individual trees of pedunculate oak selected for treatement with caterpilar glue, STORANET ® and cartboard rings during winter 2017./18.

Figure 2 Pedunculate oak trees treated with BITE ® (Blade for Infusion in Trees) conducted on 23rd May 2018, and evaluation of succes in September 2018.

MATERIALS AND METHODS

Oak seed plantation Petkovac (45° 8'52.22"N 18°51'35.53"E) was selected for monitoring of *C. arcuata* phenology for two reasons it has relatively low position of leafs and branches in regard to managed forest stands and is highly infested with OLB. Oak seed plantation Petkovac covers area of 29 ha of which 25 ha are planted with pedunculate oak (*Quercus robur* L.) overall 3162 trees is present in oak seed plantation. Pedunculate oaks are planted in 102 rows each with 31 plant. Oaks are planted in 8 m × 10 m configuration In oak seed plantation. In Petkovac individual trees of pedunculate oak were selected for treatement with caterpilar glue, STORANET and protective cartboard during winter 2017./18. (Fig. 1.). Treatment with BITE ® (Blade for Infusion in Trees) system was also conducted on 23rd May 2018. KRAFT 18 EC was used for purpose of injectioning with BITE ® (Blade for Infusion in Trees) system its active compund being abamektin. Before period of *C. arcuata* oviposition experimental treatment of overwintering adults was conducted on 17 rows in oak seed plantation Petkovac. Rows from 32 to 49 were treated (out of total 102 with insecticide Neemazal TS on 18th April 2017. Evaluation of treatment was conducted on 25th April 2017. Biological insecticide NeemAzal TS was applied. Its active compound Azadirachtin is a natural tetranortriterpenoid compound derived from seed kernels of the neem tree (*Azadirachta indica* Juss) and has been shown to express insecticidal activity and be highly effective against a number of insect pests. This compound displays an array of effects on insects acting as a phago- and ovi-position deterrent, repellent, antifeedant, growth retardant, moulting inhibitor, sterilant, and pre-venting insect larvae from developing into adults. Its principal mechanism of effect is expected to consist in impairing the homeostasis of insect hormones. The plants receive azadirachtin very easily and store it as a natural metabolite in their leaves without changing its biological effect. Inside of insect metabolism, azadirachtin blocks hormones which results in suppression of feeding, flight and oviposition. After treatment NeemAzal TS is absorbed in leaves and has partially systemic effect. Sucking and chewing insects digest active compound which causes inhibition of feeding and growth. Because of its properties especially low toxicity NeemAzal TS is registered for use in FSC certified forests. Insecticide Asset was tested in oak seed plantation on 9th June 2017. after first larvae have been observed feeding on leafs. Asset is insecticide based on fast acting derivative from the pyrethrum (*Chrysanthemum cinerariifolium*) plant, and act as a broad spectrum poison. Pyrethrin is highly toxic, with as little as 0.02 micrograms sufficient to kill a bee (Caldwell et al. 2001, Cox 2002). Pyrethrins may be harmful for up to seven days (Applied Bionomics, Ltd 2006). Pyrethrum is a broad-spectrum insecticide used to control true bugs, caterpillars, beetles, aphids, flies, mites, whiteflies, thrips, and leafhoppers (Casida 1973). However it is considered non-synthetic and it is allowed but preventive, cultural, mechanical, and physical methods must be first choice for pest control.

CONCLUSIONS

From its first record in Croatia in 2013. oak lace bug had spread over large area and moved around 250 km westwards. Damage levels in eastern part of Croatia on oak leafs are significant and on number of locations during period of late spring early summer make for 75-100% of individual leaf surface (IV category). It has been noted that oak lace bug can spread on a distance of 100 km/year. First use of Neemazal TS against oak lace bug is inefficient but this can be attributed to late period of application when egg masses were present but not affected with Neemazal TS. Asset had shown ineffective for suppression of larvae or adults in oak seed orchard Petkovac but also in managed stands of Croatian forests. Based on study of some authors, botanical insecticides based on azadirachtin can be recommended as suitable for systemic trunk injections against sucking and munching tree pests. Treatment with BITE ® (Blade for Infusion in Trees) system and a abamektin showed partial protection (Fig 2.) Methods of biocontrol are not to be ignored. *C. ciliata* has several known natural enemies: certain types of true bugs, spiders, crickets and locusts, viruses, nematodes and spore plants and deuteromycete fungi species (e.g., *Beauveria bassiana,* Clavicipitaceae, *Verticilium lecanii* Cordycipitaceae, *Paecilomyces farinosus*, Trichocomaceae) that ravage the populations of overwintering adults. During these trials, only FSC certified insecticides were used, and they were applied in experimental purposes. Nevertheless experimental aerial oak lace bug suppression showed weak results because oak lace bug was resistant to insecticide certified for the application. Injectioning with insecticides is promising in some objects as oak seed orchards although in the first season of testing with mixed results. Oak seed tests did not show an established pattern between *C. arcuata* infested seed locations and control locations. Overall poor seed quality had greater impact on seed germination, and it is unclear if oak lace bug influences seed germination, growth and quality of roundwood. *C. arcuata* suppression of overwintering adults showed good results in oak seed orchards because of bark structure and proximity of branches but not in old stands were protection is marginal. So far it is impossible to fully understand and evaluate negative effects of this new pest in Croatian lowland oak stands and urban oak trees. For this reason it is necessary to develop monitoring and continue field experiments in regard with oak seed production, growth and increment in correlation with oak lace bug infestation and reduction of assimilation area of oak leafs.

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