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# The efficacy of European fruit lecanium, *Parthenolecanium corni* (Bouché, 1844) control using natural products

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**Abstract**: European fruit lecanium, *Parthenolecanium corni* (Bouché, 1844) is among the leading worldwide pests of fruits such as plums, currants, jostaberry, grapevine and many others. This study is focused on testing the effectiveness of natural insecticide treatments compared with conventional insecticides on overwintering nymphs of the European fruit lecanium. In February of 2017, two experiments were conducted under laboratory conditions. The tested products were Boundary SW® (plant extract), Konflic® (plant extract), Ekol® (canola oil) and a tank-mix of Ekol® + Reldan 22® (canola oil and chlorpyrifos-methyl) as a chemical standard. The most effective product tested was the chemical standard tank-mix of Ekol® and Reldan 22®, which was 100% effective in all experiments. High efficiency was also achieved with Ekol® (canola oil) in high concentrations. We can summarize, that using canola oil in high concentration has almost the same effect as the chemical standard. Using canola oil against European fruit lecanium meets the principles of Integrated Pest Management (IPM) and also the need to design cropping systems that are less dependent on synthetic pesticides.

**Keywords**: pest; orchards; overwintering nymphs; natural insecticides

European fruit lecanium, *Parthenolecanium corni* (Bouché, 1844) (Hemiptera: Coccoidea), is a Paleartic polyphagous species with a worldwide distribution (Ben-Dov 1993; Hommay et al. 2007). This pest infests a wide range of host plants, including plums (*Prunus* sp.), currants (*Ribes* sp), walnut (*Juglans regia*), hazelnut (*Corylus avellana*), grape (*Vitis vinifera*) and many others (Ülgentürk, Toros 1999; Kocourek et al. 2015; Silva et al. 2016; CABI 2017). European fruit lecanium produces one generation per year. The main hibernation stage is the second-stage nymph, which occurs on the undersides of host plant branches. In the spring months (mainly in March and April), nymphs migrate to young twigs and remain there for the rest of their life cycle. During May, nymphs moult to become adult females, which are sessile. Their body is oviform and convex, with the size of 4–6 mm. Each female produces hundreds of eggs, which remain under the female's waxy shield. Old, empty waxy shields remain on the tree trunks and branches for many years. Nymphs of the first instar hatch in June and are light green, flat and oval, with a length of 0.5 mm. The nymphs then moult and become second instar, which overwinter on two year-old branches. Nymphs are red-brown to brown

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coloured, flat and elliptical-shaped, with a body size of approximately 2 mm (Kosztarab, Kozár 1988; Lánský et al. 2005; Kocourek et al. 2015). Young summer nymphs suck plant sap mostly from the leaves and, when the population reaches high levels, may cause serious damage. Nymphs produce honeydew, which also damages leaves and fruits (Sforza 2000). Honeydew serves as a substrate for saprophytic fungi, for example black sooty mould that reduces transpiration and photosynthesis in plants (Basheer et al. 2011). The worst damage is considered to be the defoliation of plants, and, in a severe infestation the plant may even die (Japoshvili et al. 2008). Our objectives was to find an effective treatment that is compatible with an integrated pest management (IPM) in orchard system, which uses all options to reduce pest populations giving priority to non-chemical measures. One of the principles of IPM is that a combination of non-chemical methods that may be individually less efficient than pesticides can synergize to provide effective control (Barzman et al. 2015).

The aim of this study was to compare the effectiveness of natural insecticides and conventional tank mixes of insecticides with oil additives against the overwintering nymphs of European fruit lecanium. Our intention was to find environmentally friendly, sustainable and effective treatments for early spring application against this serious pest to prevent high population levels when natural enemies and other non-target species are overwintering. The common summer applications of insecticides are directed at the first-instar nymphs, which disperse in the foliage to feed, but also threaten non-target species. The reasons for selecting naturally based plant protection products for this experiment were to extend the range of control options against European fruit lecanium and reduce the risks posed by conventional pesticides.

## MATERIAL AND METHODS

At the end of February 2017, infested plum branches were sampled at the Research and Breeding Institute of Pomology Holovousy (RBIP) in the Czech Republic for use in two experiments. Infested plum branches were treated with the following plant protection products: seaweed/succulent extract (Boundary SW®, ICAS); *Quassia amara* extract (Konflic®, Atlántica Agricola); canola oil (Ekol®, PROXIM s.r.o.) separately at 3 rates and tank-mixed with Chlorpyrifos-methyl (Reldan 22®, Dow AgroSciences s.r.o); plus a control (distilled water). Ekol® and Reldan 22® have been used as a chemical standard for several years. Ekol® consists of 90% canola oil and is commonly used in orchards especially during early spring. The organophosphate chlorpyrifos-methyl (Reldan 22®) is a broad-spectrum insecticide. Reldan 22® with Ekol® as an additive is commonly used in apple and sour-cherry orchards and is recommended for use as a tank-mix (Gall 2015), so, this combination served as a chemical standard. Boundary SW® and Konflic® are relatively new products that are almost unknown to fruit growers. Konflic® is a biopesticide containing 50% *Quassia amara* (L.) extract and is used for protection against aphids, whiteflies, caterpillars and other pests. Boundary SW® is a biopesticide containing seaweed and succulent extracts and used for protection against various fruit and vegetable pests. Details of all treatments used in our experiments are summarized in Table 1.

The efficacy of both biopesticides against European fruit lecanium is unknown. All plant protection products were used at rates recommended by their manufacturers: Boundary SW® (3.5 l/ha), Konflic® (3 l/ha), Ekol® (10, 20, and 30 l/ha), Ekol® + Reldan 22® (1 l/ha + 2.7 l/ha). Ekol® is commonly used at

Table 1. Plant protection products used in treatments and information about distributor, rate, active ingredient

| Treat. No. | Trade name | Distributor | Rate (l/ha/1,000 l water) | Active ingredient |
|---|---|---|---|---|
| 1 | Control | | – | – |
| 2 | Boundary SW | ICAS srl (International Company of Agro Science) | 3.5 | vegetal amino-acids, fatty acids |
| 3 | Konflic | Atlántica Agrícola, S.A. | 3 | *Quassia amara* extract 50% + potassium soap mixture of natural plant fertilization 50% |
| 4 | Ekol | PROXIM s.r.o. | 10 | canola oil 90% |
| 5 | Ekol | PROXIM s.r.o. | 20 | canola oil 90% |
| 6 | Ekol | PROXIM s.r.o. | 30 | canola oil 90% |
| 7 | Ekol + Reldan 22 | PROXIM s.r.o. + Dow AgroSciences s.r.o. | 1 + 2.7 | canola oil 90% + chlorpyrifos-methyl 225 g/l |

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tree rates according to the height of the tree canopy. All three rates of this product were tested in our experiment. All experiments were performed under laboratory conditions at a temperature of 21°C and natural photoperiod (L : D, 16 : 8). Two methods of application were employed. In the first experiment, there were five branches infested with nymphs treated by directly spraying with a sprayer Solo 423 Port (Solo Germany). All agrochemicals were tested at the field recommended concentrations for orchards, according to the product labels and following the instructions provided by the Central Institute for Supervising and Testing in Agriculture (2019). For the second experiment, the immersion method was used for another five branches infested with nymphs. Infested branches were immersed in treatments and control for 5 seconds. Experiments tested six candidate treatments plus a control, each consisting of four replicates; each replicate consisted of 100 nymphs ($n$ = 400 per treatment, total $N$ = 5,600 for both experiments). The nymphs, treatment and distilled water control for each branch were used only once. After treatments, branches were placed into volumetric cylinders with water to prevent drying out. Treatment efficacy was evaluated after 12 days. Live and dead nymphs were counted and recorded under a binocular microscope. The formula used for calculating the percent reduction of pest populations, by the tested products used the following formula after Henderson and Tilton (1955), who referred to it as a modification of Abbott (1925), as commonly used for the calculation of plant protection product efficacy (Nour-Eldin, Sholla 2015; Emami 2016; Rodríguez-González et al. 2017).

Abbott's formula (Abbott 1925):

$$\text{Efficacy (\%)} = (1 - n \text{ in } T \text{ after treatment}/n \text{ in Co after treatment}) \times 100$$

where: $n$ – insect population; $T$ – treated; Co – control

Data were analysed using Past 3.11 statistical software (Hammer 2015). As there were a small number of values in each test, we preferred robust to classical statistical methods. To compare each treatment to the standard Reldan 22® tank mixed with Ekol® separately, the Wilcoxon test was applied. To describe differences in pest population, Horn's pivot method was applied for computation of a 95% confidence interval, which is recommended for small sample sizes (≤ 20) (Horn 1983). Both the pivot half-sum and pivot range methods are robust in addressing outliers in small samples (Dušek et al. 2009).

As there is no variability of Ekol® (1 l/ha) + Reldan 22® values, we were not able to compute, test or express confidence for this treatment.

## RESULTS AND DISCUSSION

Currently, integrated fruit production relies on the incidental control provided by various plant protection products that are applied against other pests and the basis for plum tree pest protection is spray against overwintering pests in the early spring (before leafing out) (Kocourek et al. 2015). Oil plant protection products are widely used in plum orchards and are very effective against a wide range of overwintering pests. The mode of action for many oils is suffocation and water loss (Copping, Duke 2007). We have found that an Ekol® treatment is very effective against overwintering nymphs of European fruit lecanium, ifconcentrate sprays are used (Ekol® at 20 and 30 l). Abbott's efficacy of canola oil (Ekol®) also varied according to the application method and rate (Table 2). The 10 l/ha rate showed a large difference in efficacy: 32.1% from the spray application and 98.0% from immersion. The 20 l/ha rate had 89.0% and 90.1% efficacy respectively. The results of Ekol® as an immersion treatment are comparable and not significantly different in mean number of live nymphs after treatment. As expected, the highest efficacy (98.60% in both experiments) was achieved with Ekol® at the rate of 30 l/ha. Skalský (2016) also reported insufficient efficacy of Ekol® at 10 l/ha against European fruit lecanium. Experiences with other types of oils are also known from Poland and England Gantner et al. (2004) found that paraffin oil (Promanal 60 EC®, Neudorff) reduced the number of European fruit lecanium larvae by an average of about 80%. Also, Wardlow and Ludlam (1975) achieved 100% efficiency by using a suspension of tar oil in a spring application. Tank-mixes of Ekol® (1 l/ha) and Reldan 22® caused 100% mortality of overwintering nymphs. According to the Wilcoxon test, the Ekol® treatment can achieve the same results as the tank mix, when it is applied by immersion (Table 2, Figs 1 and. 2). The other two natural plant protection products, Boundary SW® and Konflic®, had insufficient efficacy when sprayed. There was a statistically significant lower mean number of live nymphs using Ekol 10 and Boundary SW as an immersion. The lowest efficacy was obtained in the Konflic® treat-

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Table 2. Efficacy of products tested against European fruit lecanium 2017. Efficacy computed according to Abbott's formula. Wilcoxon test applied for compare each treatment to the standard (Reldan 22 + Ekol)

| Treatment | 1. test (spray) | | | 2. test (immersion) | | |
|---|---|---|---|---|---|---|
| | Abbott's efficacy (%) | median number of nymphs | 95% Horn's conf. limits for mean number of nymphs | Abbott's efficacy (%) | median number of nymphs | 95% Horn's conf. limits for mean number of nymphs |
| Control | | *89 | (83.1; 94.9) | | 88.5* | (85; 91) |
| Boundary SW | 26.5 | *64 | (47.8; 80.2) | 84.4 | 16* | (1.9; 21.1) |
| Konflic | 6.7 | *83.5 | (71; 96) | 18.7 | 73* | (56.5; 84.5) |
| Ekol 10 | 32.1 | *57.5 | (34.6; 80.4) | 98 | 1 | (0; 6.2) |
| Ekol 20 | 89.0 | *15 | (0; 34.2) | 90.1 | 10* | (2.3; 12.7) |
| Ekol 30 | 98.6 | 2 | (0; 5) | 98.6 | 1 | (0; 3.7) |
| Ekol (1 l/ha) + Reldan 22 | 100.0 | 0 | (0; 0) | 100.0 | 0 | (0; 0) |

*P*-value: *< 0.1. **< 0.05. ***< 0.001

ment, 6.7% as a spray and 18.7% as an immersion. The mean value of live nymphs (ranging from 71% to 96% for spraying and from 56.5% to 84.5% for immersing) is comparable to the results of the Control (roughly between 83% and 95% for both treatments). Boundary SW® also had lower efficacy in the spray experiment (26.5%), but higher in the immersing experiment (efficacy of 84.4%) and the mean is comparable to the canola oil results. Skalský (2016) also found that both products had low efficacy against European fruit lecanium. Boundary SW consists of seaweed and succulent extract, which are effective against mites and also leaf-rolling beetles *Coenorrhinus aequatus* (Coleoptera: Attelabidae) (Germar, 1824) (Hankins, Hockey 1990; Skalský 2017). However, several studies confirm sufficient insecticidal effects of Konflict's® active ingredient, *Quassia amara* (Sapindales: Simaroubaceae) extract. For example, Psota et al. (2010) found that applications of *Quassia amara* wood extract reduced apple sawfly *Hoplocampa testudinea* (Hymenoptera: Tenthredinidae) (Klug, 1814) infestation of fruitlets. Also, Mancebo et al. (2000) recorded the anti-feedant acitivity of mahogany shoot borer *Hypsipyla grandella* (Lepidoptera: Pyralidae) (Zeller). Summer is the second period when it is possible to treat plum trees against European fruit lecanium, because nymphs disperse during this period. In practice, treatment targeted against this pest is not applied in the summer. Rather, there is incidental control provided by the neonicotinoids used (for example Calypso 480 SC®, Mospilan 20 SP®), which are applied against Plum Fruit Moth *Cydia funebrana* (Lepidoptera: Totricidae) (Treitschke, 1835) or aphids (Andreev, Kutinkova 2010;

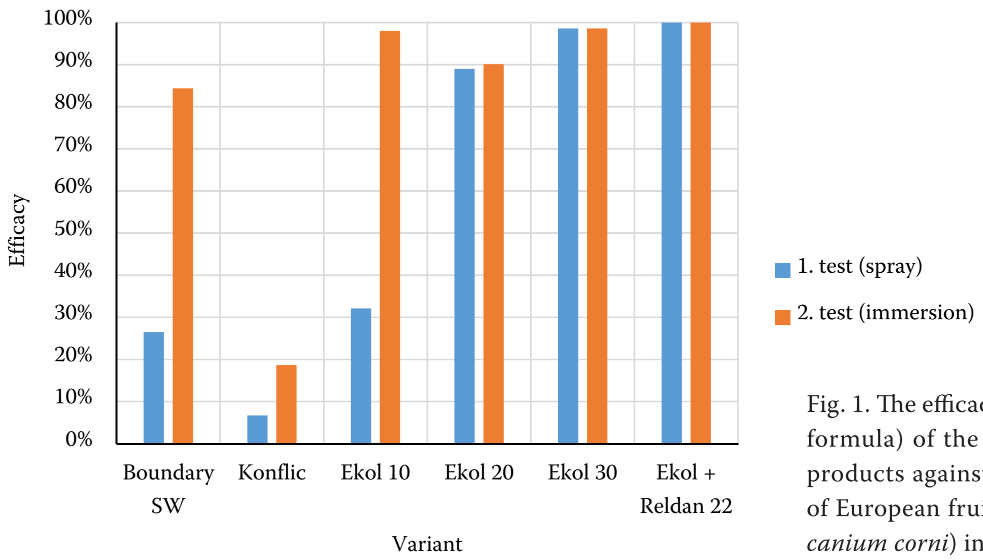


Fig. 1. The efficacy (according to Abbott's formula) of the tested plant protection products against overwintering nymphs of European fruit lecanium (*Parthenolecanium corni*) in 2017

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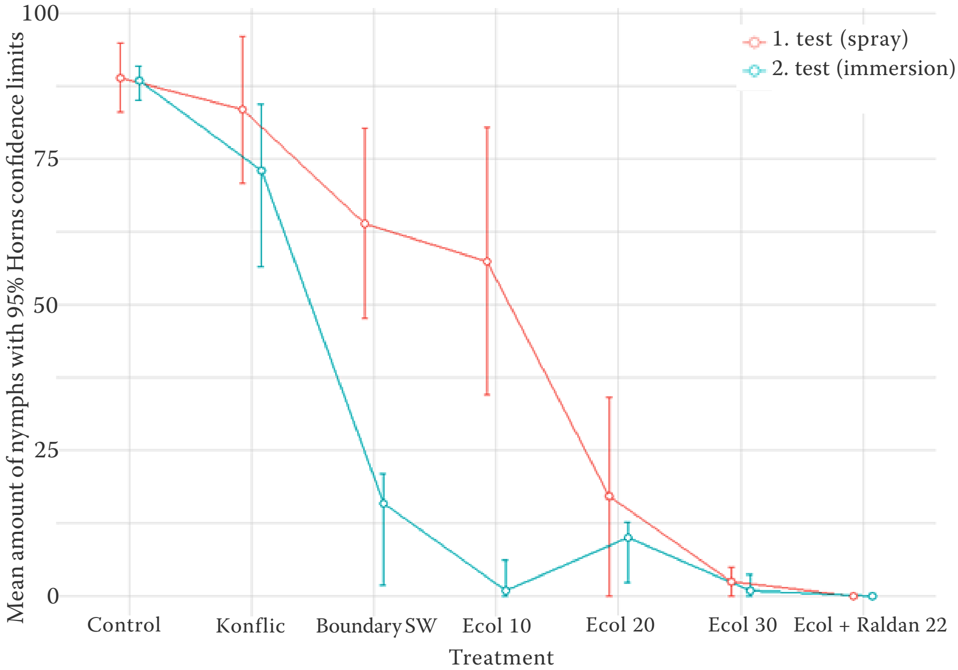


Fig. 2. Number of live nymphs 12 days after treatment along, with 95% confidence limits, Horn's pivot method

Kocourek et al. 2015). Kocourek et al. (2015) summarized active ingredients that are effective against European fruit lecanium: fenoxycarb, spirotetramat, spirodiclofen, sulfoxaflor, buprofezin and sulphur. Only fenoxycarb and sulphur-based preparations are suitable for Integrated Pest Management. Insecticide applications during vegetative periods have many disadvantages. One of the most problematic side effects of insecticide application is the increased mortality of pollinators, which are attracted by honeydew (Santas 1985). The active ingredient chlorpyrifos-methyl is used in many European countries and also in Australia and the USA (Pesticide Properties DataBase 2018). Currently, the active ingredient chlorpyrifos-methyl is formulated to Reldan 22®. Although the tank-mix of Reldan 22® and Ekol® in concentrations of 1 l/ha has been shown to be 100% effective, the use of the higher concentration of Ekol® by itself showed almost the same effectiveness (Table 2, Figs 1 and 2). Therefore, we can recommend the use of higher concentrated Ekol® against European fruit lecanium in orchards in the early spring. The advantages of oil plant protection products are that such products are environmentally friendly and offer the possibility of long-term sustainable methods to protect against this pest. Further investigation is necessary focusing on the effects of oil-based plant protection on antagonists of European fruit lecanium in early spring.

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