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Development of an Extended Decision Threshold for the Application of Plant Protection Products in Organic Fruit Growing: A Case Study on the Control of *Anthonomus pomorum* (L.) with Pyrethrins

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Abstract

It is proposed to expand the parameters regarding the economic threshold for pesticide application to include side effects on functional and general biodiversity, cost of measures that reduce the infestation pressure of the pest and thus, the need of treatments and cost of measures for risk mitigation. In a case study on the application of Spruzit® NEU at a rate of 4.6 l/ha in early spring to control the apple blossom weevil Anthonomus pomorum L.*, it was shown that it had little effect on general species diversity. However, populations of* Exochomus quadripustulatus L.*, a relevant antagonist of the woolly apple aphid, were significantly reduced. Another antagonist of the woolly apple aphid,* Aphelinus mali Haldeman *was not affected. Risk mitigation measures must be developed to reduce the impact on E. quadripustulatus.*

Keywords: Pyrethrins, side effects, *Exochomus quadripustulatus*, *Anthonomus pomorum*

Introduction

The EU Biodiversity Strategy 2030 targets a 25% share of organically farmed land by 2030, with the objective of harnessing its positive impacts on biodiversity (European Commission 2020). In 2019, Baden-Württemberg set even higher targets of 30-40% organic farmed land by 2030 (MLR & UM 2019). One of the main reasons for these targets is that studies have identified high biodiversity in the production area as an important quality of organic farming.

Apple production is one of the few crops where plant protection products are regularly used in the organic cultivation system. In fact, substances with broad spectrum effects as pyrethrins are also available. And even organic fruitgrowers have to follow economic considerations in their strategies. They have to consider the benefits of an application but also possible negative side effects on functional biodiversity which may lead to increased damage by others than the target pest. Furthermore, the impact of an application on the "biodiversity service" of the orchard has to be taken into account.

Measures to reduce the infestation pressure and, thus, the need of a treatment are costly and time consuming. The cost of possible side effects of the treatment has to be balanced economically against the cost of such measures. If the species concerned by the side effects of a treatment are known, measures for risk mitigation can be developed and applied. Thus, the classical economic threshold principle which considers cost of the pesticide and benefit of its application should be extended for these parameters.

The aim of these studies was to prepare a data base for the application of pyrethrins in early spring for the control of the apple blossom weevil (*A. pomorum*) to be used in such an "organic" decision support model.

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Material and Methods

Data on side effects were collected using a Before-After-Control-Impact (BACI) design across five pairs of organic apple orchards in 2022 and four pairs in 2023 in the Lake Constance region, Germany. Orchards without known infestation pressure by *A. pomorum* were selected to include an untreated control plot in addition to the treatment. Plot size was at least 0.5 ha. Treatment with Spruzit® NEU (4.6 l/ha) was applied both years at the recommended time for controlling *A. pomorum,* in both years around 20th of March at BBCH 52-53. Pre-impact sampling occurred on treatment day before treatment, with a second sampling one day after treatment. Subsequent samplings were conducted every one to two weeks until the end of May. Samples were collected using a beating tray in tree rows (99 beatings) and a sweep net in interrows (60 sweeps). Samples were sorted by taxonomic groups and identified to morphospecies, with relevant groups identified to species level where possible. Total counts of observed individuals and species for various subgroups were modeled using generalized linear mixed-effects models. Overall treatment effects were assessed using likelihood ratio tests (LRT) on the interaction Treatment x Time. For the effect sizes, the difference between trends was calculated and a one-tailed test was employed to determine the presence of any significant negative changes resulting from the treatment and their duration. Statistical analyses were performed using R.

Results and Discussion

In both years, Araneae, Coleoptera, Formicidae, and Nematocera were the most common groups in the beating tray samples collected previous to the application, besides Acarina, Sternorrhyncha and Collembola (Table 1). Among Coleoptera, the presence of *A. pomorum* and the ladybird *E. quadripustulatus* was notable. Nematocera, Brachycera, and Auchenorrhyncha dominated the sweep net samples in both years. Based on the captured numbers, it was concluded that there was relatively low insect and spider activity at the time of application.

Direct and indirect follow-up costs: side effects

For the assessment of the effect on arthropods in general, the individual and species counts of all recorded groups included in the analysis were combined. To assess effects on arthropods in the tree canopy collected by beating, two time series from the years 2022 and 2023 were analyzed, with both series spanning from the end of March to the end of May. The likelihood ratio test held in both years non-significant results for the counts of observed individuals and species. This indicates that any impact, if present, did not persist throughout the entire monitoring period. Among beneficial arthropods, no significant negative effect on predatory bugs, spiders, and the woolly aphid parasite *A. mali* was observed. *A. mali* did not appear in beating samples until mid-April. However, an effect on ladybugs was observed. The pine ladybird *E. quadripustulatus* was the only species with a notable number of adult individuals at the time of application. It is considered an important predator of *E. lanigerum* in spring (Mols 1995, 2000). The LRT was significant for *E. quadripustulatus* in both years, as was the decline immediately after application.

In 2023, the effect was more pronounced due to higher abundance at the time of application. In both years, convergence between treatments primarily occurred through a gradual decrease in *E. quadripustulatus* in the control, likely due to the natural lifespan of overwintering adults coming to an end.

Conclusions

Regarding overall abundance and species count, the data suggested no significant adverse effect for arthropods inhabiting the tree canopy after application of Spruzit® NEU with 4,6 L/ha to control the apple blossom weevil in early spring (BBCH 52-53). However, a species level analysis showed a significant adverse effect on the abundance of the pine ladybird *E. quadripustulatus* following Spruzit® NEU application. Since the pine ladybird is an important antagonist of the woolly apple aphid, this side effect is of economic relevance. Currently, measures to reduce the infestation pressure of the apple blossom weevil are tested in the region. The cost and potential of these measures will have to be economically balanced with the risk of a higher woolly apple aphid infestation. Furthermore, possible measures to mitigate the risk of side effects on the pine ladybird are identified.

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