Ecological and agricultural implications of tritrophic level interactions between strawberry plants, the western flower thrips *Frankliniella occidentalis*, and the predatory bug *Orius laevigatus*

Thesis

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By

Inbar Shouster

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Abstract:

The demand for pesticide-free agricultural products has increased both in Israel and throughout the world. Strawberries are considered a problematic crop with respect to pesticide residues. In recent years, therefore, a large part of Israel's strawberry crop has been placed under a biological/integrated pest management (IPM) regime. The Western flower thrips, *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae) (WFT), is thought to be a key pest of strawberries in Israel and has been credited with causing serious damage, mainly through flower drop and fruit distortion. The pest status of WFT on strawberries and the nature of its damage are, however, the subject of debate in many regions of the world. The predatory bug *Orius laevigatus* (Fieber) (Heteroptera: Anthocoridae) is known as an efficient natural enemy of WFT, and is used for control of this pest in a number of agricultural systems.

This study was aimed at improving the reliability of decisions for the control of WFT in strawberries, and to promote biological control of this pest by *Orius laevigatus*. A number of tests were conducted in order to evaluate the importance of WFT as a pest of strawberries under the conditions prevailing in Israel: the species composition of thrips populations in strawberries was determined, population dynamics of the WFT were monitored in the field, damage caused to the strawberry crop by the thrips was characterized, and natural enemies of the pest in the strawberry crop were identified. In order to evaluate the feasibility of using *O. laevigatus* as a biological control agent of WFT in strawberries, its oviposition behavior on the crop was studied and a survey was conducted to identify *Orius* species occurring spontaneously in strawberry fields. The population dynamics of *Orius* spp. in the field were also monitored. In addition, the importance of the wild host plant *Verbesina enceliodies* (Cavanilles) (Compositae) for conservation of *Orius* spp. in proximity to strawberry fields was evaluated.

Weekly sampling of strawberry flowers during the course of two growing seasons showed WFT to be the dominant thrips species on strawberries in Israel. The thrips appeared on the crop during the winter, but the population became well established only in early spring. The peak population density was variable at different locations and in different years, ranging from an average of 2 to 6 mobile individuals per flower. The density of WFT on strawberry flowers began to decrease in April, and its level remained low until the end of the season (an average of < 2 individuals per

flower). Among the natural enemies of WFT appearing spontaneously in the strawberry fields sampled, the most numerous was *Orius* spp., which became established in the crop in April and helped to contain the WFT population. Other natural enemies encountered included predatory thrips of the genus *Aeolothrips* and a few individuals of the hymenopteran parasitoid *Ceranisus menes* (Walker). *Orius* spp. were present throughout the year on wild *V. enceliodies* beside strawberry fields. The dominant species on both strawberry flowers and *V. enceliodies* were *O. niger* (Wolff) and *O. albidipennis* (Reuter). Contrary to expectations, *O. laevigatus* was observed only rarely.

In a field experiment aimed at characterizing the damage caused to strawberries by WFT, the average density of the pest did not exceed a peak of 7.6 individuals per flower and was usually between 3.5 and 6 individuals per flower. The results showed the damage to be mainly cosmetic; bronze spotting of the ripe fruit, which makes it unsuitable for export. The spots rarely covered an area exceeding 15 mm^2 (approx. 1% of fruits examined), thus virtually all the spotted fruits were suitable for the local market. No proof was obtained for involvement of thrips in flower drop, although a trend of increased flower drop in the more infested plots, and a parallel trend of decreased yields in these plots, were observed. No evidence was found to connect WFT with fruit distortion.

Both laboratory experiments and examination of plants taken from the field showed that the predatory bug *O. laevigatus* is able to reproduce on strawberries. Most oviposition takes place on plants that are in the reproductive stages of growth. Preferred ovipositon sites are on the reproductive parts of the plant: flowers, unripe fruits, and ripe fruits. Accordingly, the rate of oviposition observed on flowers was higher than that observed on leaves. In the absence of flowers and fruit, there was a reduction in oviposition. The presence of prey did not increase the rate of oviposition on vegetative plant tissues. The major factor influencing preference of female *Orius* spp. for oviposition sites on the strawberry plant appears to be the suitability of the plant tissues for insertion and development of eggs. In an additional experiment, no visible damage was caused to strawberry fruit in spite of the large number of eggs deposited in experimental fruits and flowers (approx. 70 eggs per plant part). It can be concluded, therefore, that *O. laevigatus* is suitable for use as a biological control agent in strawberries. The bugs should not be released in the field before flowers and fruits

have appeared, or between waves of flowering. Examining oviposition on calyxes of flowers and immature fruits can monitor establishment of the bug in the field.

The results of this study indicate that the western flower thrips is not a key pest of strawberries in Israel, and under most circumstances no measures need be taken for its control. WFT is present on the crop mainly during the second half of the growing season (spring), when the market value of the yield is relatively low and the fruit is destined for the domestic market, which tolerates a moderate level of cosmetic insect damage. Similarly, thrips density on flowers is generally kept in check by endemic natural enemies, which appear spontaneously in biological/IPM plots. The predatory bug *O. laevigatus* has the potential to serve as an effective biological control agent against WFT in strawberries: it reproduces on the crop, its presence is compatible with standard agrotechnical practices, and it causes no damage to flowers or fruit. This study raises questions, however, as to the economic justification for releasing *O. laevigatus* in strawberries, in light of the spontaneous appearance of other species of *Orius,* which migrate from wild vegetation to strawberry fields.