Drosophila suzukii migration into orchards: observations and field studies

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Abstract

The invasive spotted wing drosophila, Drosophila suzukii *Matsumura (Diptera: Drosophilidae), is currently established in most of South and Central Europe. This highly polyphagous species is native to southeastern Asia and was first found in southern Europe in 2008. Since then economic damage in soft and stone fruits occurred during several fruiting seasons. The level of damage caused is highly variable due to the influence of climatic conditions, fruit type, fruit cultivars, and surrounding vegetation on fly population dynamics. We report field observations and results of field studies in cherry orchards and raspberry plantations. During three years, flight movement over an open field site was monitored. Flies were able to migrate for short distances in the open, but preferred paths along vegetation. Yearly colonization of a sweet cherry orchard occurred early in the season. Population increase and subsequent cherry damage was correlated with temperature and humidity during spring. Surrounding vegetation including different wild host plants had less influence on immigration and fruit damage than population dynamics within the orchards.*

Keywords: *Drosophila suzukii*, invasive species, migration, spotted wing drosophila, wild host plant

Introduction

The spotted wing drosophila, *Drosophila suzukii* Matsumura (Diptera: Drosophilidae) is native to SE-Asia. In 2008 it was reported for the first time from France and Spain, and in 2011 the fly was also found in southern Germany (Vogt *et al*. 2012). It has now invaded most European countries (Asplen *et al.* 2015). This highly polyphagous, multivoltine species can lay eggs in undamaged, ripe, commercial, and wild fruits. Repeatedly, it caused serious economic damage in soft and stone fruits. Nevertheless, annual population dynamic and subsequent fruit damage are strongly influenced by climatic conditions. The temperatures in spring are decisive for the development of the new population from eggs laid by overwintered females. The flies are present throughout the year in forest areas, gardens, and hedges. Much discussion centers round the argument that *D. suzukii* invades commercial orchards by immigration from these refuge habitats. Published data from studies in the USA could not clearly support or reject this hypothesis (Klick et al. 2016, Pelton et al. 2016, Wang et al. 2016). In order to test the hypothesis for the structurally more diverse landscape in SW-Germany, we conducted field studies to evaluate a potential effect of the surrounding host or non-host vegetation on *D. suzukii* abundance and infestation pressure on commercial orchards. Additionally, we determined the actual level of fruit infestation.

Material and Methods

Paired comparisons of orchards surrounded by habitats either with host plants and high abundance of *D. suzukii* ("hotspot") in the vicinity or without those alternative host plants nearby ("isolated") were conducted by the Julius Kühn-Institut (JKI) in Dossenheim in 2016

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and 2017. The field sites were located in lowlands along the Odenwald mountain range in SW-Germany. Orchards sampled had the same fruit type and variety to be able to determine an effect of the surrounding vegetation on fly abundance and fruit infestation. Sweet cherry and raspberry orchards were chosen for these field studies. At each location between four to nine transparent cups with 200 ml trapping solution (apple cider vinegar: water 2:3) were deployed to monitor fly presence. Traps were exchanged and flies counted at weekly intervals. Also, each time 30 ripe fruits were collected randomly. Cherries were examined visually for oviposition and larval infestation, in the case of raspberries the salt water method was used. Trapped flies were identified, sexed, and counted with a dissecting microscope (M3Z, Wild, Switzerland).

On the west of the Rhine valley, at the State Education and Research Center of Viticulture, Horticulture and Rural Development in Neustadt/Weinstraße (DLR) in the lowlands along the mountain range Pfälzer Wald, the abundance of *D. suzukii* was monitored in four orchards (sweet cherry, blackberry, mixed culture) and in wild, adjacent habitats during three consecutive years since 2015. At each site, the arrival time of the flies in the orchards was determined and climatic parameters such as humidity and temperature were recorded. Liquid bait traps (DroskiDrink = apple cider vinegar:red wine 3:1, plus household sugar) were used for monitoring. Traps were exchanged weekly, and cultivated and wild fruits were examined for oviposition and larval infestation.

Results

At all sites and during all years higher numbers of flies were found in wild habitats and non-cultivated surroundings compared to cultivated orchards. No correlation could be detected between the number of flies caught in traps and the level of fruit damage. All commercial orchards were treated with insecticides as recommended by German IP-standards for these fruits.

In 2016, cherry varieties differed in their susceptibility: the variety "Octavia" was not infested at neither the hotspot nor the isolated site, whereas the variety "Regina" was less infested (0-20% of the fruits sampled) at the isolated orchard than at the hotspot site (>90% of the fruits sampled were infested). The isolated site, however, was partially covered with rain netting and the hotspot site received reduced insecticide treatment.

Fly abundance detected by numbers caught in traps revealed a population increase during the maturation period of host fruits in orchards and in the surrounding vegetation throughout each sampling season (Fig.1, 2, 3).

Fruit infestation could not be detected in mature and marketable sweet cherries nor in raspberries during the entire harvest period in 2017. By contrast, infestation was observed in overripe, no longer marketable raspberries. Infestation in these fruits increased during the season at both sites (2-29 larvae/3 fruits). At the end of the harvest, however, infestation level was higher in raspberries sampled at the "isolated" site (49 ± 9 larvae/3 fruits) than at the "hotspot" site (27 ± 7 larvae/3 fruits).

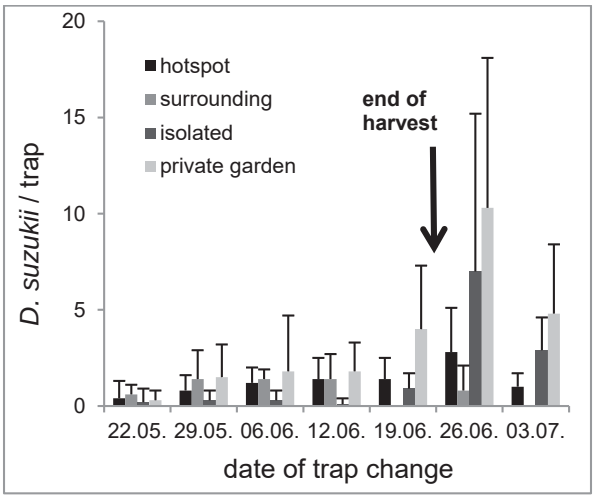

Fig. 1. Numbers of flies caught in sweet cherry orchards (hotspot, isolated), surrounding vegetation and gardens in May to July 2017.

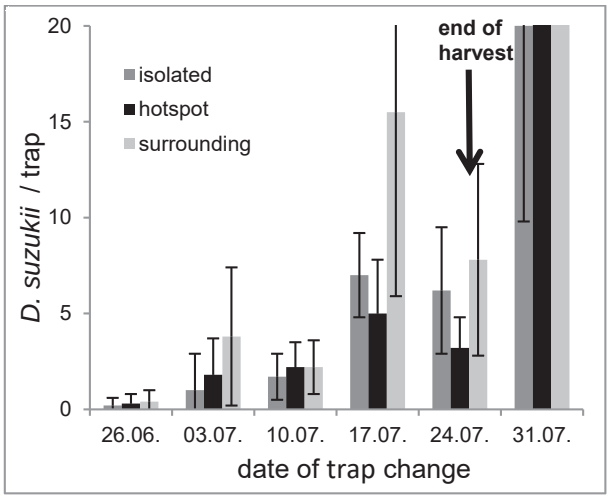

Fig. 2. Numbers of flies caught in raspberry orchards (hotspot, isolated) and surrounding vegetation in June and July 2017.

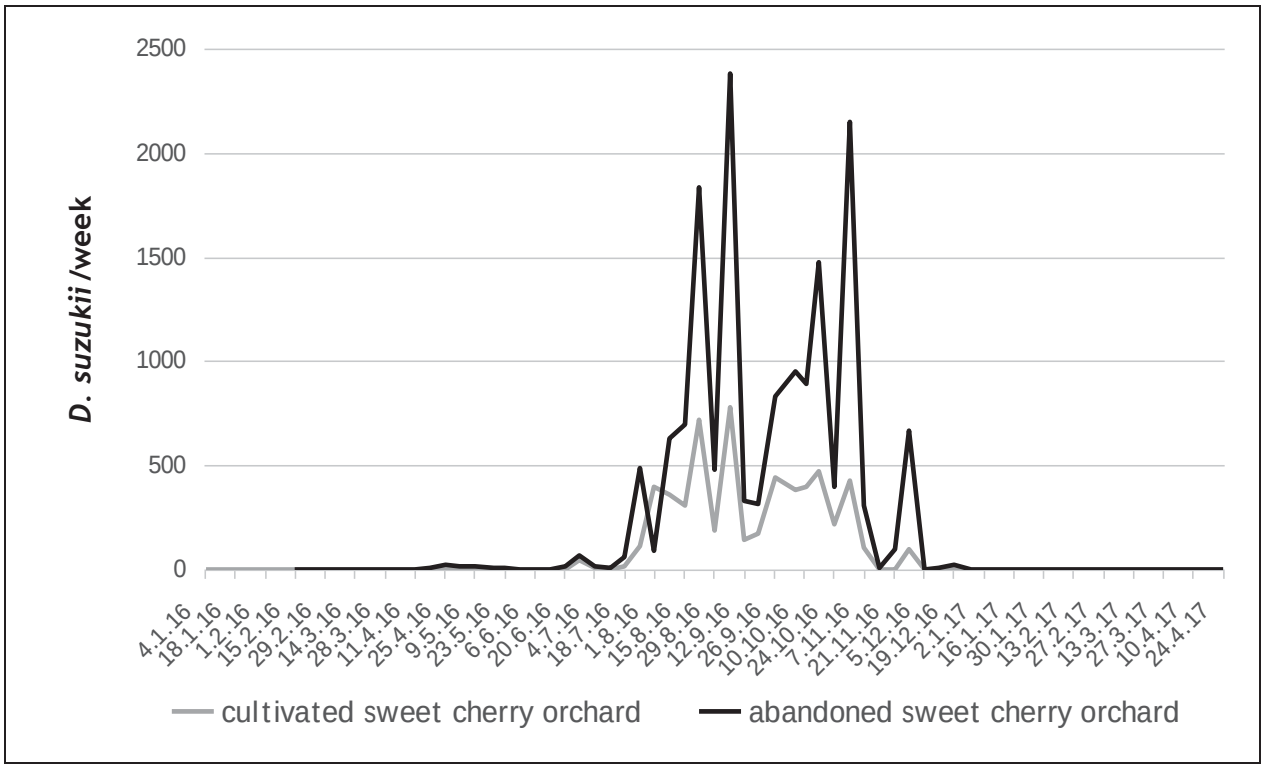

Fig. 3. Comparison of trap catches in a commercial and an abandoned sweet cherry orchard. The sites were located at 34 m distance from each other. Fly numbers caught in traps were determined weekly from January 2016 to April 2017, for better visibility trap catches were depicted bi-weekly.

Discussion

Our field studies could not corroborate the hypothesis that surrounding non-commercial host vegetation and potential refuge habitats caused an increase of *D. suzukii* abundance and subsequently an increased damage level in commercial fruits.

Surrounding wild and cultivated host plants were attractive due to their maturation pattern similar to commercial fruits. Mild and humid weather conditions favoured fly population

growth and might have caused flies from larger populations to migrate from wild host plants onto suitable ripe fruits in orchards. When weather conditions in spring and summer are hot and dry, however, flies probably remain in shadier, cooler, and moister habitats as found in forests and hedges or private gardens. Under such conditions the infestation risk for orchards would be low even when mature and attractive fruits are available.

These results show the importance of annual climatic conditions throughout the fruiting season for regional fly population development and risk potential. Fly populations increased during the course of the season in all locations sampled in our study. This natural dynamic is due to the presence of several overlapping generations with high numbers of reproductively active females in late summer and fall.

Since trap catches are not correlated with fruit damage, fruit sampling and visual determination of egg load and larval infestation are indispensable for risk assessment and timing of control measures.

Chronology of fly movements and colonization patterns throughout the season among various host plants will be further evaluated. The results will be used to interpret previous observations on the influence of surrounding vegetation and landscape structure on population dynamics and level of fruit damage.

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