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Phenology and occurrence of spotted wing *Drosophila* in Germany and case studies for its control in berry crops

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Abstract: Since *Drosophila suzukii* has been first recorded in Germany in 2011, the pest has rapidly spread out and is now found in most Federal States. In 2013 we observed an immense increase in numbers of individuals and positive sites. Peak numbers of SWD were caught from September onward, resulting particularly in infestation of blackberries and late raspberries. Due to the mild winter, SWD was continuously caught from autumn 2013 to spring 2014, especially in hedges, shrubberies, forest and forest borders, at many sites in high numbers. Monitoring traps in pine tree tops in the forest caught about twice as much SWD than traps at standard height at the same site. Soil emergence traps detected SWD only rarely. With regard to SWD control, neither mass trapping nor bait sprays (a.i. 0.125% thiacloprid and 5% protein bait), both combined with sanitation measures, reduced the infestation level when applied in 0.05 to 0.2 ha raspberry and blackberry plots.

Key words: *Drosophila suzukii*, phenology, biology, overwintering, crop damage, control measures

Introduction

In Germany **s**potted wing *Drosophila* (SWD), *Drosophila suzukii*, has been reported the first time in 2011 (Vogt *et al*., 2012). Since then the pest has rapidly spread through the country and is now found in most Federal States (Vogt & Köppler, 2014). Particular high numbers of adults have been recorded in the South, in Baden-Württemberg and Rhineland-Palatinate. In the North and Northeast in most cases only a few individuals have been detected up to now. Fruit damage occurred in soft fruits, like raspberries, blackberries, blueberries and elderberries, to a large extent and in grapes as well as plums to a smaller extent. Sour and sweet cherries were only affected after harvest in remaining fruits. Control of this pest is very difficult against the background of its high reproduction rate and short generation cycle, the infestation of fruits close to harvests, the lack of authorisation of effective insecticides as well as residue problems. In 2013 we investigated basics of *D. suzukii* biology and ecology as well as approaches for its control using sanitary measures, mass trapping and bait sprays.

Material and methods

Monitoring, phenology and overwintering

Transparent plastic cups (500-800 ml) closed with lids and provided with at least 10 holes (2-3 mm in diameter) in the upper third of the cup were used for monitoring SWD. As bait, apple cider vinegar with water (ratio 1:1 or 2:3) (ACV 1:1, ACV 2:3) or apple cider vinegar with red vine (1:1 or 2:3) was used. Traps were placed in fruit orchards, hedges and forests,

and were checked and renewed weekly or bi-weekly over the whole year. With the aim to find overwintering places, we installed artificial hiding places, such as bamboo tubes (n = 40) and polystyrene cups (n = 48), both filled with corrugated cardboard, as well as soil emergence traps (n = 24). Furthermore we installed ACV-baited cup traps in tree tops of pine, oak and beech trees in the forest (*Pinus sylvestris*, *Fagus sylvatica*, *Quercus* spp.).

Trap types and baits

We tested different trap types and bait mixtures: A) a commercially available ready-to-use trap consisting of a small plastic cup (5.5 cm in height, 7 cm in diameter) filled with 80 ml bait (cider vinegar, red wine, sugar and berry juice; Kehrli *et al.*, 2013). Entrance holes were pierced in the aluminium lid and traps were rain-protected with a white plastic roof (RIGA AG, Switzerland) (http://www.becherfalle.ch); B-E) plastic cup of 12 cm in height and 11 cm in diameter with twenty 2.5 mm entrance holes in two rows in the upper third of the cup, filled with 200 ml bait: B) RIGA AG bait; C) standard ACV bait (2:3); D) cup with black stripes (n = 3) above and below the entrance holes and with standard ACV bait (2:3); E) ACV (1:1) and 10% cherry juice. The test design was a complete randomized block with 5 replicates. Traps were checked, renewed and their position was rotated weekly. Test duration was five weeks (19.9.-24.10.2013). Results of trap captures were analyzed with SAS 9.3, Proc mixed with log-transformed data, multiple significance level $\alpha = 0.05$.

Sanitary measures combined with mass trapping

In a 0.1 ha raspberry and blackberry berry plot at JKI Dossenheim, from August 15th 2013 onward, we examined the effect of sanitary measures in combination with mass trapping. All ripe and ripening fruits were picked twice per week and traps were installed in two sets: 1st 50 traps from RIGA AG, deployed for 3 weeks; 2nd 15 traps (3 replicates from the trap/bait comparison as described above) deployed for 5 weeks. Larval infestation was checked weekly in samples of 50 ripe fruits using 10% salt water for extraction of larvae.

Bait sprays and mass trapping

Bait sprays and mass trapping were tested at the 0.05 ha blackberry plot of LTZ Augustenberg and at a 0.2 ha raspberry field of a commercial orchard. Both plots were divided into three parts: untreated control, mass trapping (using cup traps baited with vinegar and red wine 2:3 in blackberries and with RIGA AG bait in raspberries, resp.) and bait sprays (n = 4, 1 l protein bait with 0.025 l Calypso (a.i. thiacloprid) in 20 l water/ha). Traps were installed before the beginning of fruit ripening in a distance of 2 m in the border rows of the mass trapping plots. Bait spray was applied weekly, in blackberries on already infested fruits (infestation rate approximately 5 larvae/fruit) on 9, 16, 23, 30 August 2013 and on raspberries at the beginning of the infestation period (approximately 0.1 larvae/fruit) on 16, 23, 23 August, 6 September 2013. Larval infestation was checked with the salt water method using 100 or 50 fruits/sample every 3 to 4 days in the blackberry plot, and weekly in the raspberry plot in combination with subsequent harvest as described above.

Results and discussion

Monitoring, phenology and overwintering

Whereas only single individuals were caught in monitoring traps during winter until early summer in 2013, the numbers increased considerably from August onward. Also the number of sites with detection of SWD increased. Peak numbers of adults were recorded in September

and October in fruit crops like blackberries (cultivated and wild) (Figure 1A) and late raspberries. Following, blackberries and late raspberries were most infested crops. With regard to post-harvest phenology, high captures of several hundred to several thousand *D. suzukii*/week were recorded in monitoring traps from October to winter months in harvested crops (cherries, apples, vineyards close to forests) as well as in alternative habitats (e.g. wild blackberries, hedges, shrubberies, forest borders, forests) (Figure 1 B). Compared to 2012 the captures in 2013 were immense: e.g. in the monitoring program of LTZ 1.900 SWD (11/trap) in 2012, and 58.200 (330/trap) in 2013.

With regard to potential overwintering places, we did not find any SDW in the bamboo tubes or the polystyrene cups. Soil emergence traps detected SWD in low numbers at three sites. Monitoring traps in pine tree tops, however, caught several hundred individuals, about twice as much as traps in standard height (ca. 1.80 m) at the same site in the forest: e.g. sum of SWD from January 23rd to April 2nd 2014, Mannheim-Seckenheim: standard trap 181; pine tree top 1: 331, pine tree top 2: 302.

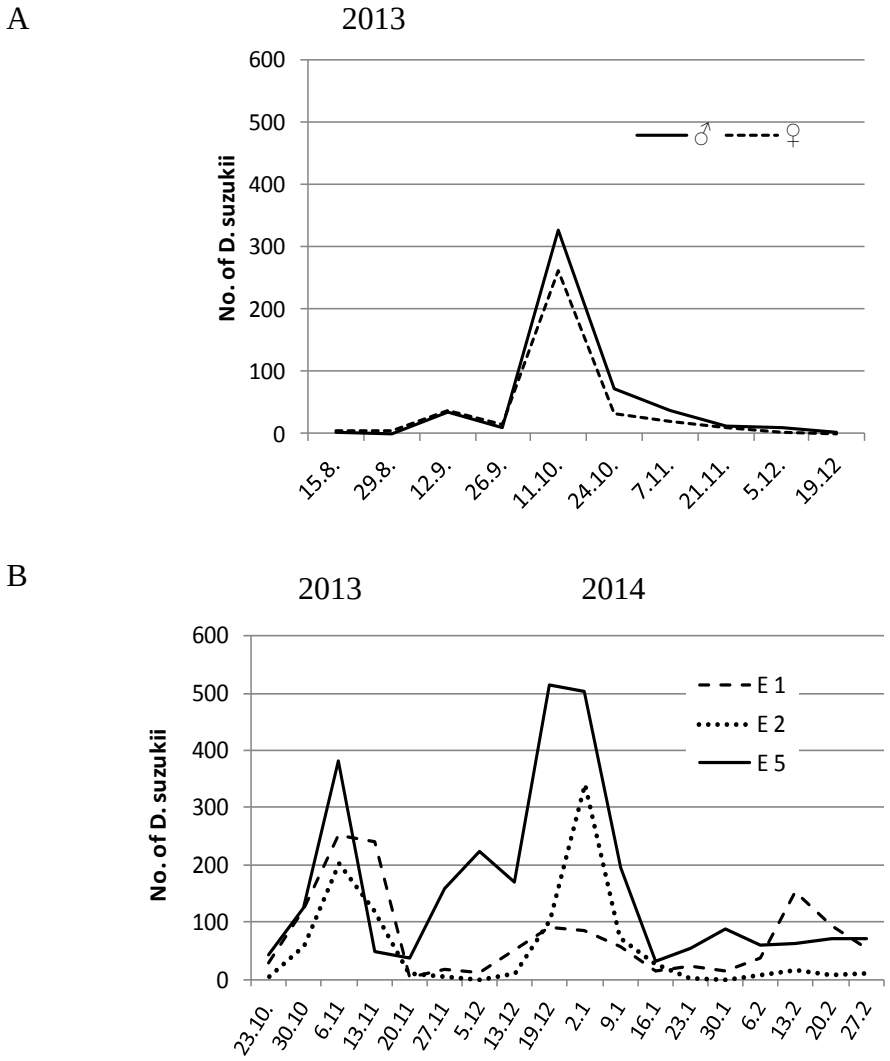

Figure 1. *D. suzukii* captures (A) in 2013 in a monitoring trap in a blackberry hedge at JKI Dossenheim and (B) in autumn/winter 2013/2014 in monitoring traps in diverse habitats (sum males and females); E1, E2: forest near Dossenheim; E5: shrubs amidst vineyards with wild blackberries, close to forest, near Schriesheim.

Trap types and baits
Though variability in trap captures was high within each treatment and between weeks, the commercial bait, when offered in the big cup trap and with higher volume, was most attractive. Over all weeks and blocks SWD captures of variant B (n = 3.643 in total) were significantly higher than C, D or E (n = 1.131, 1.573, 1.527), whereas the small commercial trap with 1.971 SWD in total only differed significantly from variant C over the whole period of the test. The cup trap with black stripes (D) and the ACV/cherry juice mix (E) increased the captures compared to the standard ACV bait (C), but differences were not significant.

Sanitary measures combined with mass trapping
The traps caught about 3.000 SWD. Yet, in spite of the taken measures, both mass trapping and sanitation, infestation steadily increased in all berry varieties (raspberries: Pokusa, Autumn Bliss, Polka, Himbo Top and blackberries: Theodor Reimers and Loch Ness) and amounted to 14 larvae/fruit at maximum.

Bait sprays and mass trapping
Neither mass trapping nor the application of the bait spray resulted in a decrease of the number of larvae per fruit compared to the control. In both trials, in black- and raspberries, a steady increase in larval infestation was observed, attaining a maximum of 12 larvae per fruit. Results for the raspberry trial are shown in Figure 2.

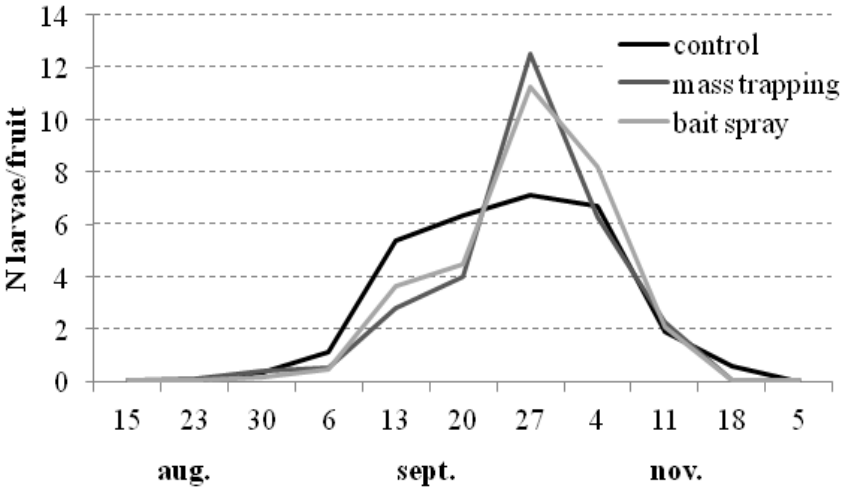

Figure 2. SWD fruit infestation in raspberries, 2013, using different control measures.

SWD has become the main pest in late soft fruits. We expect a further spread in Germany. The observation, that SWD is mainly found during winter months in habitats in the landscape (hedges, shrubberies, forests), supports the assumption that there are spatial shifts to suitable overwintering sites. Pine tree tops seem to be especially attractive. After the mild winter of 2013/2014 a higher initial population can be expected and earlier crops, like strawberries, cherries and blueberries are at risk. According to our own experience and that of others the measures tested in Germany in 2013 (mass trapping, bait treatment, insecticides) or a combination thereof did not result in a sustainable control (Vogt & Köppler, 2014). The situation is most critical in small plots, which are underlying continuous immigration. The commercial bait from RIGA AG was highly attractive, especially when offered in a bigger

cup trap and with a greater bait volume. The increase in captures compared to the standard ACV bait was comparable to bait mixtures of ACV with red wine (Landolt *et al*., 2012, Vogt, 2014). Such mixtures, however, also catch high numbers of non-target *Drosophila*-flies.

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