An invader supported by a parasite: Mistletoe berries as food and reproduction host for *Drosophila suzukii* in early spring in Germany

F. Briem[1], A. Eben[1], J. Gross[1] and H. Vogt[1]

Abstract

Drosophila suzukii *MATSUMURA (Diptera: Drosophilidae), native to Asia, is an invasive pest species in Europe and the Americas. It is able to feed and reproduce on various fruit crops and numerous wild host plants. To identify overwintering sites and early spring hosts, monitoring traps were installed in forests at two heights. Traps in the canopy of pine trees parasitized by mistletoe captured significantly more individuals of* D. suzukii *than in pine trees without mistletoes. The dissection of ovaries showed mature eggs in spring collected female* D. suzukii*. Simultaneously berries of mistletoe were ripe. Few adults emerged from mistletoe berries incubated in an environmental chamber. Further, under lab conditions, eggs were laid into mistletoe berries and developed to adults, with higher rates in wounded than unwounded berries. Adult females were able to survive on the berries up to eight days without any other food resource. Analysing the volatile organic compounds (VOCs) of mistletoes showed thirty-two peaks. Wounded and unwounded berries differed significantly in the quantity of 11 VOCs and the whole spectrum showed many similarities of typical berry odours.*

Keywords: reproductive status, alternate host, invasion biology, overwintering, volatile compounds

Introduction

As a highly polyphagous pest species, *D. suzukii* has a broad range of host fruits. It infests economically important berry crops (e.g. raspberries & blackberries), stone fruits (e.g. cherries & plums) as well as wild host plants (e.g. *Sambucus* sp., *Prunus serotina* or *Cornus* sp.) (Hauser, 2011; Cini *et al*., 2012; Poyet *et al*., 2014; Lee *et al*., 2015). Penetrating the surface of ripening and ripe fruits with its sclerotized ovipositor the female lays its eggs underneath the fruit skin (Mitsui *et al*., 2010; Hauser, 2011; Lee *et al*., 2011; Cini *et al*., 2012; Bellamy *et al*., 2013; Poyet *et al*., 2014; Lee *et al*., 2015). *D. suzukii* is known to overwinter in sheltered sites. Catches from diverse regions during winter indicate that activity seems to be still possible when mean daily temperatures are around 5 °C (Harris *et al*., 2014; Wiman *et al*., 2014; Briem *et al*., 2015; Shearer, pers. communication). Especially traps at forests capture numerous individuals during the cold period (Hamby *et al*., 2014; Briem *et al*., 2015). Monitoring in forests showed a higher activity of *D. suzukii* in the canopy of pine trees (18 - 20 m) compared to other tree species or at standard height (1.5 m) (Briem *et al*., 2015). Within our landscape monitoring traps in pine trees parasitized by mistletoe captured more individuals in spring than traps in pine trees without mistletoes. We hypothesized that mistletoe might serve as an early food source and host for reproduction.

[1] Federal Research Centre for Cultivated Plants, Julius Kühn-Institut (JKI), Institute for Plant Protection in Fruit Crops and Viticulture, Schwabenheimer Straße 101, 69221 Dossenheim, Germany

Material and Methods

At two forests (Dossenwald & Dossenheim) monitoring traps were installed at the canopy of four pine trees (at ~20 m height; one trap per tree) using bow and arrow**.** In addition, a trap was placed at standard height (~1.5 m) at each of the four trees. Traps were exchanged biweekly throughout the entire year and numbers of individuals captured were determined. A total of 522 female individuals caught during March and May 2015 were dissected to evaluate ovarian development. In no-choice assays the survival rate of *D. suzukii* on unwounded and wounded mistletoe berries as well as without any food resource was determined. Further, initial infestation was determined by incubating spring collected mistletoe berries sampled at Dossenwald and Heddesbach. To compare the profile of volatile organic compounds (VOCs) emitted by wounded and unwounded berries headspace was sampled and VOCs were analyzed using a GC-MS.

Results and Discussion

Higher flight activity in Dossenwald (with mistletoe) compared to Dossenheim (without mistletoe) as well as higher activity in the canopy (~20 m) of pine trees than at standard height (~1.50 m) revealed attraction of mistletoe to *D. suzukii*. The dissection of all trapped female individuals (n = 522) between March 18th and April 28th showed first mature eggs in female flies captured in mid-April at the canopy of pine trees at Dossenwald. At the end of April females at both sites were equipped with mature eggs. Simultaneously, berries of mistletoes sampled on April 14th in Dossenheim were ripe (6.35 pH; Brix: 20.3 °) but no individuals emerged after four weeks of incubation. Eight individuals (7♂, 1♀) emerged from berries sampled at Heddesbach on May 19th. This shows for the first time that mistletoe berries can be used as reproduction host for *D. suzukii* in early spring. In no-choice assays significantly more eggs were laid into wounded than into unwounded berries. The number of emerging adults was significantly higher in wounded than in unwounded berries, as well. The flies were observed feeding on the berries' surface. Female flies survived for eight days in cages equipped with water and mistletoe berries (unwounded/wounded) whereas without berries all females died in the first five days. Thus, *D. suzukii* might use berries of mistletoe as food resource during winter and spring. In the gas chromatographic analysis of the headspace of unwounded and wounded berries 32 peaks of VOCs were detected in the chromatograms. Twenty-four peaks were selected for a statistical comparison between VOCs emitted by unwounded and wounded berries. Of those 19 were identified. Eleven peaks showed significant differences in proportional amounts of each compound between unwounded and wounded berries. Benzaldehyde, octanal, methyl salicylate and farnesene (the isomer could not be precisely determined) could be identified. Seven of the statistically different VOCs detected were found in higher amounts in wounded berries (e.g. benzaldehyde and octanal) whereas four volatile compounds were present in higher amounts in unwounded berries (methyl salicylate and farnesene).

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