

riment. The result showed that 46, 35 and 17 compounds were identified from ripe, half-ripe and raw bayberry volatiles, respectively.  $\beta$ -Caryophyllene was the dominant compound in bayberry fruits at the different ripening stages, and most esters were released from the bayberry fruits at the ripe stage. Five volatile compounds, namely methyl 3-hexenoate, methyl 2-hexenoate, ethyl 2-hexenoate,  $\alpha$ -ylangene,  $\alpha$ -caryophyllene, and an unknown chemical in the bayberry headspace samples, elicited GC-EAD responses from the female flies. Four synthetic compounds, namely 3-hexenoate, methyl 2-hexenoate, ethyl 2-hexenoate and  $\alpha$ -caryophyllene and their mixtures could attract the females. The mixture was attractive to both males and females in a sandal wood orchard (*Osyris wightiana*, Santalaceae). It suggested that the mixture of methyl 3-hexenoate, methyl 2-hexenoate, ethyl hexenoate and  $\alpha$ -caryophyllene is a good candidate for attracting *D. suzukii*.

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### New approaches to apply plant compounds in control strategies: Screening for natural compounds against *Drosophila suzukii*

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*Drosophila suzukii* (Diptera: Drosophilidae) invaded Germany in 2011 and has become a major economic pest in soft and stone fruits. It is highly polyphagous and oviposits in ripe, undamaged fruits. Larvae feed on the fruit pulp, infested fruits collapse quickly, and leave no tolerance threshold for fruit infestation. Since the currently practiced calendar-scheduled treatment with insecticides is not a sustainable means of pest control, alternative monitoring and management options are urgently needed. Behaviour based strategies are often species-specific and require attractive or repellent substances. In order to identify potentially applicable compounds, we tested eight synthetic plant substances from different chemical classes and eight essential oils for toxic, feeding stimulant or – repellent effects on adult *D. suzukii*. Male and female flies with an age of 7–9 d were used in the assays. Compounds were sprayed on bottom and sides of test cups in 2%, 4%, 6%, 8%, and 10% emulsion in lecithin/water. Ten insects were released into the cups after complete evaporation of the spray cover. The lecithin/water solution served as control. Mortality through contact with treated surfaces was evaluated after 1 h, 4 h, and 24 h. Six replications were conducted for each concentration and compound. Capillary feeding assays were used to determine feeding stimulation or inhibition compared to a control without the test compound. Test insects were previously starved and kept with only water for 20 h. Five females (7–9 d old) were used in each test vial. Blue dye was added to the liquid diet to detect consumption of the food mix by each of the test insects. Substances were offered in 0.01%, 0.1%, and 1.0% solutions in the capillaries. After 4 h the amount consumed was measured for each group of flies. Ten replications were evaluated for each concentration and compound. During the assays, cups and vials with capillaries were maintained in a climate chamber. Purity of all substances was verified and composition of essential oils was analy-

zed by GC/MS (Hewlett Packard 890 II/Finnigan Mat SSQ 7000). Several potentially toxic and behaviour modifying compounds were identified. Farnesol and lemongrass oil had lowest contact toxicity and were strongest feeding stimulants, whereas cinnamon oil and eugenol showed highest contact toxicity and strongest feeding repellency. These substances will be further tested in behavioural assays. Their use as bait components in attract & kill or as volatiles in push-pull strategies will be investigated.

### Behavioral rhythms of *Drosophila suzukii* and *Drosophila melanogaster*

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*Drosophila suzukii* and *Drosophila melanogaster* feed on various fruits, causing great economic losses. In order to find the optimum time for controlling *D. suzukii* and *D. melanogaster*, the daily rhythms of oviposition, egg hatch, pupation, adult eclosion, copulation, and feeding of these two pests were studied. We found the circadian rhythm of *D. suzukii* oviposition to have a single pattern with a peak from 20:00–24:00, while the peak oviposition of *D. melanogaster* was from 16:00–4:00 (the next day). Neither *D. suzukii* nor *D. melanogaster* showed a daily pattern of egg hatch. The single peak of egg hatch for *D. suzukii* occurred 24–32 h after oviposition, while that for *D. melanogaster* followed a bimodal pattern with the first peak of egg hatch from 0–4 h after oviposition and the second from 32–36 h after oviposition. Pupation in *D. suzukii* showed a single peak from 8:00–16:00, while in *D. melanogaster* pupation followed a bimodal pattern, with peaks from 4:00–8:00 and 12:00–20:00. Eclosion of *D. suzukii* adults followed a unimodal pattern and generally took place from 0:00–8:00, while that of *D. melanogaster* also showed a single peak, generally from 0:00–12:00. Meanwhile copulation of *D. suzukii*, which showed a bimodal pattern, was concentrated from 0:00–12:00 and 20:00–24:00 (the next day), while copulation of *D. melanogaster* showed a single peak, generally from 0:00–12:00. Both *D. suzukii* and *D. melanogaster* had a preference for feeding in light, and in a 24 h photoperiod the percentages of feeding insects were 80.8 and 81.1, respectively.

### Effect of selected fungi from diet on the growth and development of *Drosophila suzukii* (Diptera: Drosophilidae)

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*Drosophila suzukii* (Diptera: Drosophilidae) is one of the very few *Drosophila* species which are able to lay eggs and feed on healthy ripening fruit. Adults and larvae are all able to obtain the nutrition in the decaying food, which will generate many microorganisms. However, the relationship between *D. suzukii*

and microorganism are poorly understood. In this study, 13 species of fungi were identified in an artificial diet fed by *D. suzukii*. 8 and 7 species of fungi were identified in cherry and grape fed by *D. suzukii*. Short-term and continuously life table experiments were conducted to determine the impact of three of these fungus species including *Geotrichum candidum*, *Talaromyces minioluteus* and *Actinomucor elegans* on the growth and development of *D. suzukii*. Results revealed that, compared to the control, *G. candidum*, *T. minioluteus* and *A. elegans* increased the mortality of *D. suzukii* adults in the short time, while extended the developmental time of pupal *D. suzukii* by 18.00%, 16.22% and 26.44%, respectively in the life table experiment. *T. minioluteus* reduced the total longevity of *D. suzukii* by 15.52%, while *A. elegans* enhanced the total longevity by 25.96%. *G. candidum* and *A. elegans* increased the fecundity by more than two folds. *T. minioluteus* elongated the mean generation time (T) by 31.34%, whereas *G. candidum* shortened it by 15.26% but increased the net reproductive rate (R0) by 217.76%, intrinsic rate of increase (r) by 88.89% and finite rate of increase ( $\lambda$ ) by 9.17%. It was concluded that *G. candidum* and *A. elegans* significantly had a beneficial effect on the growth and reproduction of *D. suzukii*, however, *T. minioluteus* had a negative effect on *D. suzukii*. Our results could provide a new integrated pest management strategy for *D. suzukii* which would be discussed in this study.

### Adult reproductive diapause in *Drosophila suzukii* females

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*Drosophila suzukii* (Diptera: Drosophilidae) is an emerging pest of soft fruits, but in this species diapause has not been thoroughly explored. We examined the effects of different temperatures and photoperiods on diapause induction and termination under laboratory conditions. There was variation in ovarian development and oviposition rate under different photoperiods at 10±1°C, and the percentage of adults with immature ovaries was higher during the short photoperiod (8L: 16D) than other photoperiods at 10±1°C. Adults were most sensitive to photoperiod within three days of eclosion. The optimal combination of photoperiod and temperature for diapause termination was long photoperiod (16L: 8D) at 25±1°C. The supercooling point was significantly reduced in reproductive diapause females, and trehalase, pyruvate kinase, sorbitol dehydrogenase, hexokinase and phosphofructokinase enzyme activities were significantly reduced (36.46%, 57.85%, 32.64%, 54.68% and 24.59%, respectively), and glycogen and triglyceride were significantly increased (42.17% and 120.36%). We conclude that *D. suzukii* is a typical short-day diapause species within a certain photoperiod range. This information might contribute to a more fundamental understanding of adult reproductive diapause for this important pest.

### Developing a molecular approach to analyze the diet of *Drosophila suzukii*

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*Drosophila suzukii* is overwintering as adult fly in a reproductive diapause, getting active at mild days in winter and spring. It has a wide range of host plants, mainly identified by oviposition and developmental experiments in fruits. Unfortunately, identifying the nutrition hosts by those methods is challenging, especially in winter. Observations of feeding activity in the field are problematic due to limited access (e.g. forest canopy, shruberies). The correct identification of moving flies in the field without a stereo microscope is difficult, too. A third problem is that in laboratory feeding-trials insects often feed and/or oviposit on host plants which are not typically used in-field. Thus, there is a big risk of overestimating the range of host plants used by *D. suzukii*. We developed an approach to examine ingested plant DNA in *D. suzukii*. Feeding experiments were established where adult *D. suzukii* from a laboratory colony were fed with raspberry (*Rubus idaeus*), allowing them to digest for up to 72 h. Applying PCR with species-specific primers, the DNA of *R. idaeus* was detectable for up to 48 h post-feeding in whole body extracts of *D. suzukii*. Further, a bleach experiment was conducted to exclude the risk of false-positive detection due to DNA sticking on the flies' body surface. Females fed with *R. idaeus* were contaminated at their tibia or wing-tip with mistletoe (*Viscum album*). Then half of the flies were washed with a bleach-solution and all individuals were tested for DNA of *R. idaeus* and *V. album* again using diagnostic PCR. While the DNA of *V. album* was successfully removed from the fly's body surface, the gut content was not negatively affected by decontamination. In a next step field trapped individuals will be used for next-generation sequencing for further analysis.

### Potential geographical distribution of *Drosophila suzukii* based on MaxEnt

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*Drosophila suzukii* is an important fruit insect pest and its global spread and damage has been paid more attention in recent years. In order to prevent invasion of *D. suzukii* and protect fruit production in China, we studied potential geographical distributions of *D. suzukii* in the world and in China under current and future climate conditions. MaxEnt combined with ArcGIS was applied as technical mode which based on collecting global geographical distributions information and screening main climate variables. Under current climate conditions, *D. suzukii* presented a relative wide potential geographical distribution in the world and 61.68% areas in China with suitability including 7.59% areas of high level, 27.81% areas of medium level and 2628% areas of low level. Under RCP26 and RCP85 climate conditions in 2050, potential geographical distribution of *D. suzukii* enlarged and northern borderline of suitable region expanded northward in the world as well as in China. We suggested related organizations in China to strengthen surveil-