

## Veille d'informations sur la drosophile à ailes tachetées

### *(Drosophila suzukii)*

***Ce document présente une liste d'articles et de rapports de recherches réalisés au Québec ou en dehors du Québec. Dernière mise à jour : 31 janvier 2017.***

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## Articles parus en 2017

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Andreazza, F., Bernardi, D., Baronio, C. A., Pasinato, J., Nava, D. E., & Botton, M. (2017). Toxicities and effects of insecticidal toxic baits to control *Drosophila suzukii* and *Zaprionus indianus* (Diptera: Drosophilidae). *Pest Management Science*, 73(1), 146-152.

BACKGROUND: *Drosophila suzukii* is a primary insect pest that causes direct damage to fruits with a thin epidermis such as strawberries, cherries and blueberries. In strawberry fields, the co-occurrence of *D. suzukii* and *Zaprionus indianus* has increased production losses. This study evaluated the toxicities and effects of insecticidal baits to control adults and larvae of both *D. suzukii* and *Z. indianus*. RESULTS: Organophosphate (dimethoate and malathion), spinosyn (spinosad and spinetoram), pyrethroid (lambda-cyhalothrin) and diamide (cyantraniliprole) insecticides exhibited high toxicity to both adults and larvae of *D. suzukii* and *Z. indianus* (mortality >80%) in topical and dip bioassays. However, when the insecticides were mixed with a feeding attractant, a positive effect was observed only for adults of *D. suzukii*. Insecticides containing neonicotinoids (acetamiprid and thiamethoxam) and pyrolle (chlorfenapyr) caused intermediate mortality to adults of *D. suzukii* (40–60%) and low mortality for *Z. indianus* (mortality <23%); however, these compounds reduced the larval infestation of the two species by 55–86%. Botanical (azadirachtin) and sulphur insecticides exhibited low toxicity (mortality <40%) on adults and larvae of both species. CONCLUSION: Dimethoate, malathion, spinosad, spinetoram, lambda-cyhalothrin and cyantraniliprole are highly toxic to both larvae and adults of *D. suzukii* and *Z. indianus*. The use of toxic baits for adults of *D. suzukii* could be an alternative in management of this species. © 2016 Society of Chemical Industry

Choi, M. Y., Ahn, S. J., Kim, A. Y., & Koh, Y. (2017). Identification and characterization of pyrokinin and CAPA peptides, and corresponding GPCRs from spotted wing drosophila, *Drosophila suzukii*. *General and Comparative Endocrinology*.

Cette veille bibliographique est réalisée par Nathalie Roullé et Nicolas Chatel-Launay, Pôle d'excellence en lutte intégrée (PELI).

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The family of FXPRLamide peptides serves as a major insect hormone. It is characterized by a core active amino acid sequence conserved at the C-terminal ends, and provides various physiological roles across the Insecta. In this study we identified and characterized pyrokinin (PK) and CAPA cDNAs encoding two FXPRLamide peptides, pyrokinin and CAPA-DH (diapause hormone), and two corresponding G protein-coupled receptors (GPCRs) from spotted wing drosophila (SWD), *Drosophila suzukii*. Expressions of PK and CAPA mRNAs were differentially observed during all life stages except the embryo, and the detection of CAPA transcription was relatively strong compared with the PK gene in SWD. Both *D. suzukii* pyrokinin receptor (DrosuPKr) and CAPA-DH receptor (DrosuCAPA-DHr) were functionally expressed and confirmed through binding to PK and DH peptides. Differential expression of two GPCRs occurred during all life stages; a strong transcription of DrosuPKr was observed in the 3rd instar. DrosuCAPA-DHr was clearly expressed from the embryo to the larva, but not detected in the adult. Gene regulation during the life stages was not synchronized between ligand and receptor. For example, SWD CAPA mRNA has been up-regulated in the adult while CAPA-DHr was down-regulated. The difference could be from the CAPA mRNA translating multiple peptides including CAPA-DH and two CAPA-PVK (periviscerokinin) peptides to act on different receptors. Comparing the genes of SWD PK, CAPA, PKr and CAPA-DHr to four corresponding genes of *D. melanogaster*, SWD CAPA and the receptor are more similar to *D. melanogaster* than PK and the receptor. These data suggest that the CAPA gene could be evolutionally more conserved to have a common biological role in insects. In addition, the effect of Kozak sequences was investigated by the expression of the GPCRs with or without Kozak sequences in Sf9 insect cells. The Kozak sequenced PK receptor was significantly less active than the original (= no Kozak sequenced) receptor. Our results provide a knowledge for potential biological function(s) of PK and CAPA-DH peptides in SWD, and possibly offer a novel control method for this pest insect in the future.

Fraimout, A., Debat, V., Fellous, S., Hufbauer, R. A., Foucaud, J., Pudlo, P., ... & Deprá, M. (2017). Deciphering the routes of invasion of *Drosophila suzukii* by means of ABC random forest. *Molecular Biology and Evolution*, msx050.

Deciphering invasion routes from molecular data is crucial to understanding biological invasions, including identifying bottlenecks in population size and admixture among distinct populations. Here, we unravel the invasion routes of the invasive pest *Drosophila suzukii* using a multi-locus microsatellite dataset (25 loci on 23 worldwide sampling locations). To do this, we use approximate Bayesian computation (ABC), which has improved the reconstruction of invasion routes, but can be computationally expensive. We use our study to illustrate the use of a new, more efficient, ABC method, ABC random forest (ABC-RF) and compare it to a standard ABC method (ABC-LDA). We find that Japan emerges as the most probable source of the earliest recorded invasion into Hawaii. Southeast China and Hawaii together are the most probable sources of populations in western North America, which then in turn served as sources for those in eastern North America. European populations are genetically more homogeneous than North American populations, and their most probable source is northeast China, with evidence of limited gene flow from the eastern US as well. All introduced populations passed through bottlenecks, and analyses reveal five distinct admixture events. These findings can inform hypotheses concerning how this species evolved between different and independent source and invasive populations. Methodological comparisons indicate that ABC-RF and ABC-LDA show concordant results if ABC-LDA is based on a large number of simulated datasets but that ABC-RF out-performs ABC-LDA when using a comparable and more manageable number of simulated datasets, especially when analyzing complex introduction scenarios.

Gao, H. H., Xu, N., Chen, H., Liu, Q., Pu, Q. Y., Qin, D. Y., ... & Yu, Y. (2017). Impact of selected fungi from an artificial diet on the growth and development of *Drosophila suzukii* (Diptera: Drosophilidae). *Journal of Asia-Pacific Entomology*, 20(1), 141-149.

*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 is poorly understood.

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In this study, 13 species of fungi were identified in an artificial diet 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 *Drosophila 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 the beneficial effect on the growth and reproduction of *D. suzukii*, however, *T. minioluteus* had the 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.

Jakobs, R., Ahmadi, B., Houben, S., Garipey, T. D., & Sinclair, B. J. (2017). Cold tolerance of third-instar *Drosophila suzukii* larvae. *Journal of Insect Physiology*, 96, 45-52.

*Drosophila suzukii* is an emerging global pest of soft fruit; although it likely overwinters as an adult, larval cold tolerance is important both for determining performance during spring and autumn, and for the development of temperature-based control methods aimed at larvae. We examined the low temperature biology of third instar feeding and wandering larvae in and out of food. We induced phenotypic plasticity of thermal biology by rearing under short days and fluctuating temperatures (5.5–19 °C). Rearing under fluctuating temperatures led to much slower development (42.1 days egg-adult) compared to control conditions (constant 21.5 °C; 15.7 days), and yielded larger adults of both sexes. *D. suzukii* larvae were chill-susceptible, being killed by low temperatures not associated with freezing, and freezing survival was not improved when ice formation was inoculated externally via food or silver iodide. Feeding larvae were more cold tolerant than wandering larvae, especially after rearing under fluctuating temperatures, and rearing under fluctuating temperatures improved survival of prolonged cold (0 °C) to beyond 72 h in both larval stages. There was no evidence that acute cold tolerance could be improved by rapid cold-hardening. We conclude that *D. suzukii* has the capacity to develop at low temperatures under fluctuating temperatures, but that they have limited cold tolerance. However, phenotypic plasticity of prolonged cold tolerance must be taken into account when developing low temperature treatments for sanitation of this species.

Jang, M., Kim, J., Yoon, K. A., Lee, S. H., & Park, C. G. (2017). Biological activity of Myrtaceae plant essential oils and their major components against *Drosophila suzukii* (Diptera: Drosophilidae). *Pest Management Science*, 73(2), 404-409.

**BACKGROUND:** The spotted-wing drosophila (SWD), *Drosophila suzukii* (Matsumura), is a globally invasive and serious pest of numerous soft-skinned fruit crops. Assessments were made of fumigant and contact toxicities of 12 Myrtaceae plant essential oils (EOs) and their components. For determining the mode of action of major components of active EOs, their activities against acetylcholinesterase (AChE) and Glutathione S-transferase (GST) were also assessed. **RESULTS:** Strong fumigant and contact toxicities were observed from EOs of *Eucalyptus citriodora* and *Melaleuca teretifolia*. The main components of *E. citriodora* were citronellal and isopulegol, whereas those of *M. teretifolia* were neral and geranial. Geranial showed the strongest fumigant activity, followed by citronellal or neral, *M. teretifolia* EO, isopulegol and *E. citriodora* EO. In contact toxicity assays, geranial also exhibited the strongest insecticidal activity, followed by neral or *M. teretifolia* EO, citronellol, citronellal, isopulegol and *E. citriodora* EO. Among the major components, all compounds showed low AChE inhibitory activity, while neral and geranial showed GST inhibitory activity against SWD. **CONCLUSION :** Myrtaceae plant EOs and their components have an excellent potential for being

used in the control of SWD adults and could be useful in the development of more effective natural compounds as alternatives to synthetic pesticides.

Knoll, V., Ellenbroek, T., Romeis, J., & Collatz, J. (2017). Seasonal and regional presence of hymenopteran parasitoids of *Drosophila* in Switzerland and their ability to parasitize the invasive *Drosophila suzukii*. *Scientific Reports*, 7.

Since its introduction into Europe the invasive *Drosophila suzukii* has established and spread widely, thereby entering habitats populated by native *Drosophila* species and their natural enemies. The highly prolific *D. suzukii* will likely interact with these species as a competitor, host or prey. To investigate potential interactions of *D. suzukii* with parasitoids, a field survey was conducted across several fruit-growing regions in Switzerland in two consecutive years. Eight species of hymenopteran parasitoids were collected using *D. melanogaster* as sentinel hosts in field-traps. Parasitoid capture was much higher in 2015 than in 2014 and varied among regions, time of the growing season, and habitat type. Laboratory no-choice assays with the field-collected species demonstrated that the larval parasitoids *Asobara tabida*, *Leptopilina boulandi*, and *L. heterotoma* could not use *D. suzukii* for reproduction, although the latter two reduced the number of emerging *D. suzukii*. In contrast, the pupal parasitoids *Pachycrepoideus vindemmia*, *Trichopria drosophilae*, *Vrestovia fidenas* and *Spalangia erythromera* all developed with *D. suzukii* as hosts. Regional differences between strains were generally not evident, with the exception of two *T. drosophilae* strains that differed in parasitization rate. Thus, native parasitoids may interact with *D. suzukii* and should be regarded when implementing pest control measures.

Little, C. M., Chapman, T. W., Moreau, D. L., & Hillier, N. K. (2017). Susceptibility of selected boreal fruits and berries to the invasive pest *Drosophila suzukii* (Diptera: Drosophilidae). *Pest Management Science*, 73(1), 160-166.

**BACKGROUND:** *Drosophila suzukii* Matsumura has recently emerged as a major invasive pest species in soft-skinned fruits in berries throughout North America and Europe. Its distribution has spread so rapidly that little is known of the extent of fruit susceptibility, particularly in boreal regions. Populations of *D. suzukii* increase dramatically in late summer in boreal regions, concurrent with fruiting seasons for commercially and culturally significant fruits and berries. We tested fruit preference and susceptibility of lingonberry, blueberry, chokecherry, sea buckthorn and raspberry fruits to *D. suzukii*. **RESULTS:** Female *D. suzukii* attempted to oviposit on all fruit types tested. Fruits with lower brix and lower pH levels were preferred in choice tests. Undamaged lingonberries were relatively safe from infestation; however, bruised or frost-damaged fruits were easily penetrated. Sea buckthorn and raspberry fruits were highly preferred. **CONCLUSION:** Although blueberry growers have experienced severe economic crop losses due to *D. suzukii*, we have found that blueberries were the least preferred of the fruits tested. This suggests that *D. suzukii* are largely opportunistic and highlights the importance of fruit phenology in fruit susceptibility. © 2016 Society of Chemical Industry

Smirle, M. J., Zurowski, C. L., Ayyanath, M. M., Scott, I. M., & MacKenzie, K. E. (2017). Laboratory studies of insecticide efficacy and resistance in *Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae) populations from British Columbia, Canada. *Pest management science*, 73(1), 130-137.

**BACKGROUND:** Spotted wing drosophila (SWD), *Drosophila suzukii* (Matsumura), control can be improved with better knowledge of insecticide efficacy, timing of sprays and rotations with registered products during the crop year. An efficacy bioassay was applied to study the dose response of adult laboratory-reared SWD collected from a cherry orchard in British Columbia (BC), Canada, to 11 insecticides. **RESULTS:** Age- and sex-specific toxicities with the most effective insecticide, malathion, determined that older male SWD were significantly more susceptible than females. The selection for polygenic resistance to malathion using repeated exposure to sublethal concentrations with both the original and an additional blueberry-collected population of laboratory-reared SWD determined no significant difference in susceptibility after 30 generations. **CONCLUSION:** Possible reasons reported in *D. melanogaster* studies

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where resistance did not occur after insecticide selection included avoidance and associated microbial complexes. The low level of malathion resistance observed in the selected SWD populations and a field-collected population is useful information in the development of insecticide resistance management programmes.

## Articles parus en 2016

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Aly, M. F., Kraus, D. A., & Burrack, H. J. (2016). Effects of Postharvest Cold Storage on the Development and Survival of Immature *Drosophila suzukii* (Diptera: Drosophilidae) in Artificial Diet and Fruit. *Journal of Economic Entomology*, tow289.

*Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae) attacks a wide range of host plants, including crops such as blueberries, cherries, caneberries, and strawberries. We evaluated the influence of three temperatures (1.1, 3.9, and 5.0 °C) and four exposure durations (6, 12, 24, and 72 h) that were selected to represent typical grower practices on survival and development time of immature *D. suzukii* in artificial diet and one temperature and duration (1.67 °C for 72 h) in fruit (blueberries and raspberries). Cold storage at 1.1 °C for 24 h decreased larval survival, but shorter durations generally did not affect larval survival. No eggs or young larvae survived when held for 72 h at 1.1 °C, and fewer older larvae survived after 72 h at 1.1, 3.9, and 5.0 °C than at 20 °C (control). Development time in diet was longer for all life stages following at least 12 h at any of the storage temperatures. In blueberries, no eggs survived to pupation when stored at 1.67 °C for 72 h, and survival of third instars was reduced by 41%. In raspberries, egg, second instar, and third instar survival was significantly reduced following storage at 1.67 °C for 72 h. *Drosophila suzukii* larval development time was shorter in raspberry than in blueberry, but it was significantly longer in both fruits when stored at 1.67 °C for 72 h. Our results indicate that cold storage can reduce survival and increase development time of immature *D. suzukii*, and it could be a useful part of an integrated program to manage *D. suzukii* infestation.

Arnó, J., Solà, M., Riudavets, J., & Gabarra, R. (2016). Population dynamics, non-crop hosts, and fruit susceptibility of *Drosophila suzukii*. *Journal of Pest Science*, 89(3), 713-723.

In Northeast Spain, the invasive Drosophilidae species *Drosophila suzukii* has become an important agricultural pest, mainly of strawberries and cherries. To improve sustainable management practices, we conducted field surveys and laboratory trials to better understand the pest ecology, identify non-crop hosts, and assess the effect of strawberry variety and fruit ripening stage on the *D. suzukii* development. Our results confirmed that *D. suzukii* adults are active during the winter, and adult populations peaked in spring and autumn. From January to June, adult captures were female-biased, and more females had more mature eggs compared with the period of September–December. We found several non-crop hosts of this pest that are common in Mediterranean forests and margins that can provide food and reproduction resources for *D. suzukii* population growth. These hosts were *Bryonia cretica*, *Prunus mahaleb*, *Rosa canina*, *Rubus ulmifolius*, *Sambucus nigra*, *Solanum chenopodioides*, *Solanum dulcamara*, and *Solanum nigrum*. No-choice and choice laboratory trials demonstrated that *D. suzukii* was able to oviposit in red, blush, or green strawberry fruits but, host suitability of different ripeness stages varied with variety. Data provided may be useful for predicting the risk of pest damage in a specific cropping area, in designing effective *D. suzukii* management programs and in hindering *D. suzukii* population growth.

Benito, N. P., Lopes-da-Silva, M., & dos Santos, R. S. S. (2016). Dispersão e impacto econômico potenciais da invasora *Drosophila suzukii* no Brasil. *Pesquisa Agropecuária Brasileira*, 51(5), 571-578.

O objetivo deste trabalho foi delinear a distribuição e o impacto econômico potenciais de *Drosophila suzukii* (Diptera: Drosophilidae), recente praga invasora, no Brasil. Foram feitos dois mapas de potencial de estabelecimento da espécie

baseados no índice ecolimático (EI), que utiliza as seguintes exigências termicas da espécie: com estresse de temperatura, cenário mais restrito para a expansão; e sem estresse de temperatura. O EI foi classificado em quatro faixas: não favorável,  $\leq 25\%$ ; pouco favorável,  $> 25$  a  $\leq 50\%$ ; favorável,  $> 50$  a  $\leq 75\%$ ; e altamente favorável,  $> 75\%$ . As perdas econômicas foram estimadas a partir do mapa com a distribuição mais restritiva. As áreas consideradas altamente favoráveis foram sobrepostas às dos mapas de produção de cada hospedeiro possível (maçã, uva, pêssego, caqui, figo e pera). Ao se considerar esses seis hospedeiros, a sobreposição das áreas altamente favorável e de produção variou de 45,5% (uva) a 98,3% (maçã). No entanto, a estimativa monetária de perdas potenciais no pior cenário possível (sem medidas de controle) foi possível apenas para figo e pêssego. O Sul do Brasil é a área climaticamente mais favorável para o desenvolvimento de *D. suzukii* e onde as perdas econômicas potenciais podem ser máximas. As temperaturas médias máximas ( $> 30^{\circ}\text{C}$ ) são o principal fator para restringir a dispersão de *D. suzukii* no Brasil.

Bernardi, D., Andrezza, F., Botton, M., Baronio, C. A., & Nava, D. E. (2016). Susceptibility and Interactions of *Drosophila suzukii* and *Zaprionus indianus* (Diptera: Drosophilidae) in Damaging Strawberry. *Neotropical entomology*, 1-7.

*Drosophila suzukii* (Matsumura) has been recently detected causing damage to strawberries in Brazil. Infestation in strawberry culture has often been observed jointly with the presence of *Zaprionus indianus* Gupta. This study investigated the susceptibility of strawberries at three ripening stages to infestation of *D. suzukii* and *Z. indianus* and their interaction. In the laboratory, strawberries cv. Albion at different ripening stages (green, semi-ripe and ripe) were exposed to *D. suzukii* and *Z. indianus* for 24 h in choice and no-choice bioassays. Additionally, we evaluated the effects of mechanical damage incurred artificially or by *D. suzukii* oviposition on *Z. indianus* infestation. In no-choice bioassay, there were no significant differences in fruit susceptibility to *D. suzukii* infestation at different ripening stages. However, in choice bioassay, *D. suzukii* adults preferred to oviposit on R fruit. The presence of mechanical damage did not increase susceptibility of fruit to *D. suzukii* oviposition. For *Z. indianus*, there was greater susceptibility of R fruit in relation to SR and G fruit in both the choice and no-choice bioassays. There was a significant and positive interaction of mechanical damage and damage caused by *D. suzukii* to R fruit and infestation by *Z. indianus*, which was not observed in SR and G fruit. Although infestation of *Z. indianus* is related to attack damaged or decaying fruit, this work shows that this species has the ability to oviposit and develop in healthy strawberry fruit with and increased infestation level when the fruit has damage to its epidermis.

BHATIA, S. (2016). INCIDENCE, BIOLOGY AND MANAGEMENT OF CHERRY FLY, *Drosophila suzukii* (MATSUMURA)(Drosophilidae: Diptera) INFESTING CHERRY, *Prunus avium* (L.) (Doctoral dissertation).

ABSTRACT The studies on incidence, biology and management of cherry fly, *Drosophila suzukii* (Matsumura) infesting cherry, *Prunus avium* (L.) carried for two years i.e. 2015 and 2016 revealed maximum (34-72%) incidence of the fly at Narkanda followed by Baghi (32-56%) and Thanedhar (36-42%). The studies on biology revealed that incubation period ranged from 1-3 days larval between 3-6 days, pupal 4-7 days and adult longevity was found to vary from 18-48 days. The insect completed its life cycle in 8-16 days. The mean fecundity per female was found to be 200.2 and 205.8 eggs during the two years of laboratory experimentation. The observations on various methods of management revealed that exclusion nets provided complete protection against fly infestation. Among different attractant traps CFC (cherry fruit concentrate) proved to be most effective followed by yeast based. Cider based (ACV) traps proved least effective among all the traps tried during the two years. The bio-efficacy study in both the modules proved that among seven chemical treatments, spinosad (0.002 and 0.004%) proved most effective giving (92-95%) control of the drosophilid followed by lambda-cyhalothrin (83-91%), cypermethrin (69-82%) and malathion (56-73%) in decreasing order. Among different chemicals, azadirachtin proved to be least effective followed by two neonicotinoids (imidacloprid and thiamethoxam) in the ascending order of efficacy. The BCR values were highest for lambda-cyhalothrin (264-939.0:1)

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followed by cypermethrin (170.6-520.9:1), spinosad (72-268.5:1) and malathion (64.6-177.6:1) treatments. The neem based insecticide formulation was recorded to be uneconomical for the fly control with BCR value less than 1.0 during both the years of study.

Briem, F., Eben, A., Gross, J., & Vogt, H. (2016). An invader supported by a parasite: Mistletoe berries as a host for food and reproduction of spotted wing *Drosophila* in early spring. *Journal of Pest Science*, 89(3), 749-759.

The Spotted Wing *Drosophila* (SWD), *Drosophila suzukii* Matsumura, an invasive pest species in Europe and the Americas, is able to feed and reproduce on numerous fruit crops and a wide range of wild host plants. SWD is thought to overwinter outside of agricultural fields in forests and hedges. To identify overwintering sites and early spring oviposition hosts, traps were installed in forests. In spring 2015, traps in the canopy of pine trees parasitized by mistletoe, *Viscum album* subsp. *laxum*, captured significantly more SWD than traps in pine trees without mistletoe. We found SWD females with ripe eggs coinciding with ripening and ripe mistletoe berries. We investigated whether mistletoe may serve as a host for SWD. Under laboratory conditions, SWD developed from egg to adult in mistletoe berries. More adults emerged from wounded berries. Females were observed to feed on berries and survived up to eight days without other food. A few adults emerged from wild mistletoe berries. To understand the attraction of SWD to parasitized trees, we analyzed the volatile organic compounds (VOCs) collected from the headspace of mistletoe berries by GC-MS and identified the main components. Thirty-two VOCs were found. Wounded and unwounded berries differed significantly in the quantity of 11 VOCs emitted. The odor spectrum showed many similarities to other typical berry odors. The combination of field surveys and laboratory assays identified a new reproduction host for SWD in spring. This host plant may help SWD to withstand the bottleneck period for survival in winter and spring.

Briem, F., Staudacher, K., Zeisler, C., Eben, A., Traugott, M., & Vogt, H. (2016). Landscape-level movements and a molecular approach to analyze the diet of *Drosophila suzukii*. *Berichte aus dem Julius Kühn-Institut*, (186), 13.

Burrack, H. J., & Bhattarai, K. A. S. (2016). Tracking the movement of spotted wing drosophila (*Drosophila suzukii*) over space and through time to improve management programs.

<http://www.raspberryblackberry.com/wp-content/uploads/Tracking-the-movement-of-SWD-over-space-and-time-to-improve-management-options.pdf>

Cattel, J., Kaur, R., Gibert, P., Martinez, J., Fraimout, A., Jiggins, F., ... & Rota-Stabelli, O. (2016). *Wolbachia* in European populations of the invasive pest *Drosophila suzukii*: regional variation in infection frequencies. *PloS one*, 11(1), e0147766.

The invasive pest *Drosophila suzukii* is characterized by a specific fresh-fruit targeting behavior and has quickly become a menace for the fruit economy of newly infested North American and European regions. *D. suzukii* carries a strain of the endosymbiotic bacterium *Wolbachia*, named *wSuz*, which has a low infection frequency and no reproductive manipulation capabilities in American populations of *D. suzukii*. To further understand the nature of *wSuz* biology and assess its utility as a tool for controlling this pest's populations, we investigated the prevalence of *Wolbachia* in 23 European *D. suzukii* populations, and compared our results with those available in American populations. Our data showed a highly variable infection frequency with a mean prevalence of 46%, which is significantly higher than the 17% found in American populations. Based on Multilocus Sequence Typing analysis, a single *wSuz* strain was diagnosed in all European populations of *D. suzukii*. In agreement with American data, we found no evidence of cytoplasmic incompatibility induced by *wSuz*. These findings raise two questions: a) why *Wolbachia* is maintained in field populations of *D. suzukii* and b) what are the selective forces responsible for the variation in prevalence within populations, particularly between European and American continents? Our results provide new insights into the *D.*

suzukii-Wolbachia association and highlight regional variations that await further investigation and that should be taken into account for using Wolbachia-based pest management programs.

Cattel, J., Martinez, J., Jiggins, F., Mouton, L., & Gibert, P. (2016). Wolbachia-mediated protection against viruses in the invasive pest *Drosophila suzukii*. *Insect molecular biology*, 25(5), 595-603.

The maternally inherited bacterium Wolbachia is well known for spreading in natural populations by manipulating the reproduction of its arthropod hosts, but can also have mutualist effects that increase host fitness. In mosquitoes and *Drosophila* some Wolbachia strains can lead to an increase in survival of virus-infected insects, and in most cases this is associated with reduced accumulation of the virus in host tissues. We investigated if the Wolbachia strain wSuz, which naturally infects *Drosophila suzukii*, is able to confer protection against *Drosophila C* virus and Flock House virus in different host genetic backgrounds. We found that this strain can increase host survival upon infection with these two viruses. In some cases this effect was associated with lower viral titres, suggesting that it confers resistance to the viruses rather than allowing the flies to tolerate infection. Our results indicate that, in *D. suzukii*, the antiviral protection provided by Wolbachia is not correlated to its density as found in other *Drosophila* species. This study demonstrates a phenotypic effect induced by wSuz on its native host which could explain its maintenance in natural populations of *D. suzukii*.

Daane, K. M., Wang, X. G., Biondi, A., Miller, B., Miller, J. C., Riedl, H., ... & Van Achterberg, K. (2016). First exploration of parasitoids of *Drosophila suzukii*. *Journal of Pest Science*, 89(3), 823-835.

The invasive spotted wing drosophila, *Drosophila suzukii* Matsumura (Dipt.: Drosophilidae), a native of East Asia, has widely established in North America and Europe, where it is a serious pest of small and stone fruit crops. The lack of effective indigenous parasitoids of *D. suzukii* in the recently colonized regions prompted the first foreign exploration for co-evolved parasitoids in South Korea during 2013 and 2014. We collected the larval parasitoids *Asobara japonica* Belokobylskij, *A. leverii* (Nixon) and *A. brevicauda* Guerrieri & van Achterberg (Hym.: Braconidae), *Ganaspis brasiliensis* (Ihering), *Leptopilina japonica japonica* Novković & Kimura and *L. j. formosana* Novković & Kimura (Hym.: Figitidae); and the pupal parasitoids *Pachycrepoideus vindemiae* (Rondani) (Hym.: Pteromalidae) and *Trichopria drosophilae* Perkins (Hym.: Diapriidae). From UC Berkeley quarantine records, percentage parasitism ranged from 0 to 17.1 % and varied by geography, season, and collection methods. *Asobara japonica* was the most common parasitoid species. Higher numbers of parasitoids were reared from field-picked fruit as opposed to traps baited with uninfested fruit. Quarantine bioassays confirmed that *A. japonica*, *G. brasiliensis*, *L. j. japonica*, *P. vindemiae*, and *T. drosophilae* developed from *D. suzukii*. Female individuals of the endoparasitoid, *A. japonica*, were larger when reared on the larger *D. suzukii* larvae compared with those reared on the smaller larvae of *D. melanogaster* Meigen. Larger parasitoid size was associated with longer developmental time. Several of the South Korean parasitoid species have the potential for use in classical biological control and may contribute to the suppression of *D. suzukii* in the newly invaded regions.

Daniel, C., Schärer, H. J., & Cahenzli, F. (2016). Influence de certains produits minéraux sur la vinification.

La drosophile du cerisier (*Drosophila suzukii*), qui est arrivée en Europe en 2008 depuis le sud-est de l'Asie, peut provoquer des dégâts considérables. Elle s'attaque à tous les fruits tendres comme les baies, les cerises, les prunes et le raisin. Et de nombreuses plantes sauvages comme le sureau et la viorne obier lui servent de plantes-hôtes. Les dégâts sont principalement causés par les larves qui mangent les fruits de l'intérieur. Vu que le cycle de reproduction est très court et que plusieurs générations apparaissent en parallèle, c'est en fin d'été et en automne que la pression d'attaque est la plus forte. Il faut s'attendre à une pression d'attaque particulièrement forte dans les vignes puisque le raisin est récolté plus tard que la plupart des autres baies et que les vendanges se font en automne. Les conditions météorologiques ont provoqué en 2014 les premiers gros dégâts constatés sur du raisin. L'OFAG avait autorisé pour

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2014 par voie de dérogation le kaolin (nom commercial Surround, un produit de la société Stähler), mais avec la remarque suivante: «Les influences d'un traitement sur la fermentation du moût de raisins traités n'ont pas été étudiées.» En 2014, de nombreux producteurs ont aussi utilisé des produits à base de chaux. Des essais de vinification menés en 2014 avec des raisins des vignes du FiBL à Frick ont testé différents produits utilisés à hautes doses (180 kg/ha) en procédant à un pressurage de la grappe entière sans préclarification. Le Klinospray (à base de clinoptilolithe, un produit de la société Unipoint) et le Surround n'ont pas influencé la vinification tandis que le produit calcique utilisé (CaCO<sub>3</sub>) a eu une influence négative sur la qualité du vin. On mentionnera en outre que les résidus importants de tous les produits utilisés ont fortement compliqué le tri des raisins abîmés. À la dégustation, le procédé traité au Klinospray a cependant obtenu de meilleurs résultats que le contrôle non traité. L'OFAG a renouvelé en 2015 la dérogation pour l'utilisation du kaolin dans les vignes. Sur la base des quantités de kaolin autorisées et des modifications des recommandations d'utilisation pour la chaux éteinte, un nouvel essai de vinification a été réalisé en 2015 avec l'application sur vigne de quantités nettement inférieures des produits minéraux Surround, Klinospray, Nekapur (hydroxyde de calcium, fabrique de chaux Netstal) et avec un produit à l'essai. Le but de cet essai était de constater l'influence de ces substances sur la vinification. Cet essai a utilisé des quantités usuelles de Surround (kaolin), Klinospray (clinoptilolithe) et de Nekapur (chaux éteinte). Malgré les faibles pluies entre le dernier traitement et la récolte et malgré l'absence de préclarification pour la vinification, peu de différences de vinification et de qualité ont été observées. Les résultats obtenus avec Surround et Klinospray correspondent à l'essai de l'année précédente où des quantités plus de sept fois supérieures à la normale avaient été appliquées en suivant un scénario «worst case». La chaux éteinte a été testée cette année pour la première fois en essai de vinification, où elle est d'ailleurs passée inaperçue après avoir été utilisée en quantités usuelles. L'utilisation de Surround (kaolin), Klinospray (clinoptilolithe) et de Nekapur (chaux éteinte) en quantités usuelles dans la pratique ne pose pas de problèmes pour la vinification.

Diepenbrock, L. M., & Burrack, H. J. (2016). Variation of within-crop microhabitat use by *Drosophila suzukii* (Diptera: Drosophilidae) in blackberry. *Journal of Applied Entomology*.

*Drosophila suzukii* Matsumara (Diptera: Drosophilidae) is an invasive vinegar fly that infests ripe and ripening soft skinned fruits. In the south-eastern United States, blackberry (*Rubus* spp.) crops are heavily impacted by *D. suzukii*, and current management tactics rely on the use of broad-spectrum insecticides targeted to adult populations. An improved understanding of *D. suzukii* biology and ecology are necessary to create sustainable management options. Knowledge of how *D. suzukii* interacts with resources will enable targeted management actions in the future. In this present study, we monitored larval infestation throughout the blackberry canopy and found that infestation was highest in the inner portion of the canopy and lower in more exposed locations. We also documented higher humidity within the cane canopy relative to the edge of the field. A difference in abiotic conditions may create within-crop microhabitats that *D. suzukii* is able to exploit. Future research will explore how to take advantage of these microhabitats in pest management programs.

Diepenbrock, L. M., Rosensteel, D. O., Hardin, J. A., Sial, A. A., & Burrack, H. J. (2016). Season-long programs for control of *Drosophila suzukii* in southeastern US blueberries. *Crop Protection*, 81, 76-84.

*Drosophila suzukii* is an invasive insect pest which has major impacts on small fruit production throughout North America. Current control programs use frequent applications of broad-spectrum insecticides. To prevent resistance, modes of action must be rotated. This study examines the acute and residual efficacy of rotational treatment programs designed to meet the needs of commercial growers in the southeastern United States, a region which experiences significant precipitation throughout the growing season. All insecticide applications had greater adult acute mortality than controls, and some had residual efficacy for three or more days after treatment. Programs had no residual effects at seven days after treatment. Within programs, organophosphates (phosmet and malathion) and pyrethroids (zeta-

cypermethrin and fenprothrin) were the most effective. Some programs also resulted in less offspring production by *D. suzukii* in bioassays and reduced field infestation compared to controls. Results show that effective, season-long rotational chemical treatment programs can be designed to minimize crop damage, meet exportation requirements and manage for resistance. Understanding the effect of regional climate on the performance of individual insecticide treatments and their efficacy will be critical for widespread implementation of effective control programs for *D. suzukii*.

Diepenbrock, L. M., Swoboda-Bhattarai, K. A., & Burrack, H. J. (2016). Ovipositional preference, fidelity, and fitness of *Drosophila suzukii*. *Journal of Pest Science*, 89(3), 761-769.

*Drosophila suzukii* (Matsumura) is a devastating pest of soft-skinned fruits including blackberries and raspberries. Management of this pest is focused on preventing infestation in crops, but non-crop hosts may play an important role in enabling *D. suzukii* to persist in the absence of cultivated hosts. *Drosophila suzukii* may also infest fruits of both crop and non-crop hosts concurrently. Our goals were to determine whether (1) *D. suzukii* prefers to oviposit in cultivated blackberry, *Rubus L. subgenus rubus* Watson, or American pokeweed, *Phytolacca americana*, a non-crop host commonly found along field edges, (2) *D. suzukii* prefers to oviposit into the same host from which it emerged, and (3) performance differs between *D. suzukii* progeny that develop in blackberries or pokeweed berries. Although the pest was able to infest both hosts at the same rate, we found that *D. suzukii* females emerging from pokeweed preferred to oviposit into blackberries, while females emerging from blackberry had no preference. Progeny that developed in blackberries were more fit than progeny that developed in pokeweed berries based on several measures. In field locations, cultivated blackberries and pokeweed berries only overlapped in availability for a short period of time, and infestation rates were variable between blackberries and pokeweed berries collected during that period. Nonetheless, these results suggest that non-crop hosts may facilitate the invasion of *D. suzukii* and perpetuate infestation of cultivated hosts under certain circumstances.

Dweck, H. K., Ebrahim, S. A., Khallaf, M. A., Koenig, C., Farhan, A., Stieber, R., ... & Hansson, B. S. (2016). Olfactory channels associated with the *Drosophila* maxillary palp mediate short- and long-range attraction. *Elife*, 5, e14925.

The vinegar fly *Drosophila melanogaster* is equipped with two peripheral olfactory organs, antenna and maxillary palp. The antenna is involved in finding food, oviposition sites and mates. However, the functional significance of the maxillary palp remained unknown. Here, we screened the olfactory sensory neurons of the maxillary palp (MP-OSNs) using a large number of natural odor extracts to identify novel ligands for each MP-OSN type. We found that each type is the sole or the primary detector for a specific compound, and detects these compounds with high sensitivity. We next dissected the contribution of MP-OSNs to behaviors evoked by their key ligands and found that MP-OSNs mediate short- and long-range attraction. Furthermore, the organization, detection and olfactory receptor (Or) genes of MP-OSNs are conserved in the agricultural pest *D. suzukii*. The novel short and long-range attractants could potentially be used in integrated pest management (IPM) programs of this pest species.

Emmanuel, G. P. D. (2016). Implication de la niche écologique et des indices environnementaux liés à la localisation de la ressource dans le succès invasif du ravageur *Drosophila suzukii*: des pistes pour le développement du piégeage massif (Doctoral dissertation, Lyon).

Ces dernières années ont vu le développement du commerce international entraînant une accélération des mouvements intercontinentaux d'espèces. Ces multiples introductions sont à l'origine de nombreux cas d'invasion, où les espèces s'établissent et se dispersent. Dans le nouvel environnement, étudier les facteurs liés à la niche écologique permet de comprendre comment se déroule l'établissement des espèces introduites au sein de la communauté d'espèces résidentes. L'hypothèse de la niche vide, qui prédit que l'invasion est possible car un espace vide existe au sein des niches écologiques de la communauté résidente, est un des facteurs facilitants de nombreux cas d'invasion.

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Par ailleurs, la stratégie d'exploitation de la ressource par l'espèce invasive au sein de la niche écologique peut aussi expliquer la propension d'une espèce à envahir ou non le nouvel environnement. L'objectif de cette thèse est d'explorer l'importance de ces hypothèses dans le succès invasif, au travers de l'exemple de *Drosophila suzukii*. Introduite en 2008 en Europe et aux Etats-Unis, cette espèce a envahi chacun des continents en moins de 7 ans. Elle est la seule espèce européenne de drosophiles capable de pondre à l'intérieur de fruits sains omniprésents, au sein d'une niche écologique vide de tout compétiteur. Elle est à l'origine de gros problèmes pour la culture de fruits cultivés et se retrouve être l'un des ravageurs majeurs en production de fruits rouges. Mieux comprendre son invasion, sa niche écologique et sa stratégie de sélection d'habitat permet de mieux lutter contre l'insecte, notamment par des méthodes permettant de perturber la localisation des fruits dans l'environnement. Cet aspect appliqué est aussi un objectif important de cette thèse CIFRE, financée pour optimiser la lutte par piégeage massif

Gautam, B. K., Little, B. A., Taylor, M. D., Jacobs, J. L., Lovett, W. E., Holland, R. M., & Sial, A. A. (2016). Effect of simulated rainfall on the effectiveness of insecticides against spotted wing drosophila in blueberries. *Crop Protection*, 81, 122-128.

The current spotted wing drosophila, *Drosophila suzukii* Matsumura (Diptera: Drosophilidae) management strategy relies on routine application of insecticides during the fruit ripening and harvesting period. The amount and frequency of insecticide spray needed to maintain continuous protection of fruits may depend on a variety of factors including the level of rainfall. Studies were conducted to determine the effects of simulated rainfall (0, 12.5, 25 and 37.5 mm) and adjuvant – Nu Film (with and without) on the residual efficacy of commonly used insecticides against *D. suzukii* in blueberries during the fruiting season of 2014 and 2015. Spray applications were made using an air-assisted backpack (2014) or airblast (2015) sprayer. Insecticide spray residues were allowed to dry for ~2 h before simulated rainfalls were applied using central pivot irrigation system. Semi-field bioassays were conducted to assess mortality at 1, 3 and 7 days after treatment (DAT). Results showed that simulated rainfall caused a significant reduction in *D. suzukii* mortality in all chemical treatments, particularly at 1 and 3 DAT in the 2014 study, and at 1 DAT in the 2015 study. In general, higher rainfall resulted in lower mortality in 2014, however such a clear trend was not observed in 2015. Addition of adjuvant, Nu Film 17, significantly increased mortality at 3 DAT in the zeta-cypermethrin treatment with 25 mm of simulated rainfall (2014). In 2015, the addition of Nu Film P significantly increased mortality at 1 DAT in the spinetoram and spinosad treatments with 12.5 mm, and in the malathion treatment with 25 mm of simulated rainfall. These results suggest that although frequent rainfall incidents increase the need for more frequent spray of insecticides, addition of adjuvants helps to prolong the residual efficacy of some insecticides.

Gibert, P., Hill, M., Pascual, M., Plantamp, C., Terblanche, J. S., Yassin, A., & Sgrò, C. M. (2016). *Drosophila* as models to understand the adaptive process during invasion. *Biological Invasions*, 18(4), 1089-1103.

The last few decades have seen a growing number of species invasions globally, including many insect species. In drosophilids, there are several examples of successful invasions, i.e. *Zaprionus indianus* and *Drosophila subobscura* some decades ago, but the most recent and prominent example is the invasion of Europe and North America by the pest species, *Drosophila suzukii*. During the invasive process, species often encounter diverse environmental conditions that they must respond to, either through rapid genetic adaptive shifts or phenotypic plasticity, or by some combination of both. Consequently, invasive species constitute powerful models for investigating various questions related to the adaptive processes that underpin successful invasions. In this paper, we highlight how *Drosophila* have been and remain a valuable model group for understanding these underlying adaptive processes, and how they enable insight into key questions in invasion biology, including how quickly adaptive responses can occur when species are faced with new environmental conditions.

Gong, X., Bräcker, L., Bölke, N., Plata, C., Zeitlmayr, S., Metzler, D., ... & Parniske, M. (2016). Strawberry Accessions with Reduced *Drosophila suzukii* Emergence From Fruits. *Frontiers in Plant Science*, 7.

*Drosophila suzukii* is threatening soft fruit production worldwide due to the females' ability to pierce through the intact skin of ripe fruits and lay eggs inside. Larval consumption and the associated microbial infection cause rapid fruit degradation, thus drastic yield and economic loss. Cultivars that limit the proliferation of flies may be ideal to counter this pest; however, they have not yet been developed or identified. To search for potential breeding material, we investigated the rate of adult *D. suzukii* emergence from individual fruits (fly emergence) of 107 accessions of *Fragaria* species that had been exposed to egg-laying *D. suzukii* females. We found significant variation in fly emergence across strawberries, which correlated with accession and fruit diameter, and to a lesser extent with the strawberry species background. We identified accessions with significantly reduced fly emergence, not explained by their fruit diameter. These accessions constitute valuable breeding material for strawberry cultivars that limit *D. suzukii* spread.

Guerrieri, E., Giorgini, M., Cascone, P., Carpenito, S., & van Achterberg, C. (2016). Species diversity in the parasitoid genus *Asobara* (Hymenoptera: Braconidae) from the native area of the fruit fly pest *Drosophila suzukii* (Diptera: Drosophilidae). *PLoS one*, 11(2), e0147382.

*Drosophila suzukii* (Matsumura), commonly known as Spotted Wing *Drosophila* (SWD), is a worldwide serious economic threat to the production of berries and stone fruits. The chemical control widely used against this pest is often not able to preventing yield losses because wild flora offers an abundance of fruits to *D. suzukii* where the pest is able to reproduce and from where it recolonizes neighbouring cultivated fields. Alternatively, within Integrated Pest Management protocols for *D. suzukii*, biological control could play a key role by reducing its populations particularly in non-cultivated habitats, thus increasing the effectiveness and reducing the side negative effects of other management strategies. Because of the scarcity and of the low efficiency of autochthonous parasitoids in the new invaded territories, in the last few years, a number of surveys started in the native area of *D. suzukii* to find parasitoid species to be evaluated in quarantine structures and eventually released in the field, following a classical biological control approach. This paper reports the results of these surveys carried out in South Korea and for the first time in China. Among the parasitoids collected, those belonging to the genus *Asobara* Foerster resulted dominant both by number and species diversity. By combining morphological characters and the mitochondrial COI gene as a molecular marker, we identified seven species of *Asobara*, of which two associated with *D. suzukii*, namely *A. japonica* and *A. leverii*, and five new to science, namely *Asobara brevicauda*, *A. elongata*, *A. mesocauda*, *A. unicolorata*, *A. triangulata*. Our findings offer new opportunity to find effective parasitoids to be introduced in classical biological control programmes in the territories recently invaded by *D. suzukii*.

Gutierrez, A. P., Ponti, L., & Dalton, D. T. (2016). Analysis of the invasiveness of spotted wing *Drosophila* (*Drosophila suzukii*) in North America, Europe, and the Mediterranean Basin. *Biological Invasions*, 18(12), 3647-3663.

The polyphagous Asian vinegar fly *Drosophila suzukii* (spotted wing *Drosophila*) is a native of Eastern and Southeastern Asia. It emerged as an important invasive insect pest of berries and stone fruits in the Americas and Europe beginning in 2008. Species distribution models are commonly used for analyzing the extant and potential range expansion of invasive species. Previous modeling efforts for *D. suzukii* include a degree-day model, a MaxEnt ecological niche model, a demographic model incorporating the effects of temperature, and a preliminary mechanistic physiologically-based demographic model (PBDM). In the present analysis, we refine the PBDM for *D. suzukii* based on biological data reported in the literature. The PBDM is used to assess the effects of temperature and relative humidity from a recently published global climate dataset (AgMERRA) on the prospective geographic distribution and relative abundance of the pest in the USA and Mexico, and in Europe and the Mediterranean Basin. Our focus is on areas of recent invasion and of predicted higher invasiveness in these areas. Although the species is native to Asia and is of putative temperate

origins, it has established in subtropical to north temperate zones worldwide where it infests a wide range of wild and domesticated berries and stone fruits. The model captures the observed phenology of *D. suzukii* at specific locations, as well as the potential geographic distribution and relative favorability across larger regions. The main limiting factor is cold winter temperature in northern areas, though high temperatures and low relative humidity may be limiting in arid areas. The effect of greater cold tolerance in winter morph adults is explored.

Hamby, K. A., & Becher, P. G. (2016). Current knowledge of interactions between *Drosophila suzukii*. *Journal of Pest Science*, 89(3), 621-630.

Insects exhibit complex symbiotic interactions with microorganisms, which provide an opportunity for developing novel pest management strategies. Closely related to *Drosophila melanogaster*, which is commonly used as a model to explore insect-microbe interactions, *Drosophila suzukii* is an important invasive insect pest of fruit crops in the Americas and Europe. We provide an overview of *Drosophila*-microbe interactions and review current research with *D. suzukii*. Recent studies revealed yeast and bacterial species associated with *D. suzukii* flies, fly guts and infested fruit. The ecological importance of these insect-microbe interactions is under investigation. Microbes have a strong impact on insect physiology and *D. suzukii* responds both positively and aversively to microbial volatiles. We highlight potential pest management strategies that take advantage of *D. suzukii*-microbe ecology, including improved monitoring as well as management using behavioural manipulation, phagostimulants and biotechnology.

Hamby, K. A., Bellamy, D. E., Chiu, J. C., Lee, J. C., Walton, V. M., Wiman, N. G., ... & Biondi, A. (2016). Biotic and abiotic factors impacting development, behavior, phenology, and reproductive biology of *Drosophila suzukii*. *Journal of Pest Science*, 89(3), 605-619.

Spotted wing drosophila, *Drosophila suzukii*, is a devastating invasive pest of small and stone fruits in the Americas and Europe. To better understand the population dynamics of *D. suzukii*, we reviewed recent work on juvenile development, adult reproduction, and seasonal variation in life history parameters including the abiotic/biotic factors that influence these processes. Juvenile development is optimal at moderately warm temperatures, and larvae exhibit some immunity to parasitism. Adults use visual cues and substrate-borne vibrations for courtship and exhibit a bimodal locomotor activity pattern (except mated females). Under 20–27 °C and various conditions, development from egg to adult can take 10–17 days, females first lay eggs within 1–8 days and their lifetime fecundity varies from <100 to >400. Oviposition is consistently high in raspberry hosts and fruits with lower penetration force, and the presence of *Wolbachia* endosymbionts can lower fertility. *Drosophila suzukii* exhibit seasonal variation with a darker winter morph that is more cold tolerant. Also, *D. suzukii* likely undergo reproductive diapause in the fall, with colder temperatures and shorter day lengths influencing reproduction. To develop viable IPM programs for *D. suzukii*, knowledge of abiotic and biotic conditions that impact *D. suzukii* life history parameters and population dynamics is critical, and gaps in the current knowledge are discussed.

Haye, T., Girod, P., Cuthbertson, A. G. S., Wang, X. G., Daane, K. M., Hoelmer, K. A., ... & Desneux, N. (2016). Current SWD IPM tactics and their practical implementation in fruit crops across different regions around the world. *Journal of Pest Science*, 89(3), 643-651.

After its arrival in 2008, the Spotted Wing *Drosophila* (SWD), *Drosophila suzukii*, has emerged as a harmful invasive insect pest in North America and Europe. This highly polyphagous pest is a major threat to many economically important fruit crops and is also known to develop on a wide variety of natural host plants. In Asia, Europe and North America, different control measures are applied against SWD, such as chemical, biological, and cultural control. Current controls of SWD rely primarily on the application of insecticides, but cultural management tactics such as sanitation and the use of nets provide a good alternative in some crops. Biological control measures, such as conservation of existing

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natural enemies in invaded areas, introduction of specialized larval parasitoids from Asia for classical biological control and the use of indigenous parasitoids for augmentative control, are currently being investigated and may become an important management tool in the near future for an area-wide control of SWD.

Hemer, S., Briem, F., Hecht, A., Herzog, K., Eben, A., & Vogt, H. (2016). Variety-dependence susceptibility of cherries to *Drosophila suzukii* according to fruit firmness and other ripening parameters. *Berichte aus dem Julius Kühn-Institut*, (186), 12.

Karageorgi, M. (2016). EVOLUTION D'UN NOUVEAU COMPORTEMENT DE PONTE CHEZ *DROSOPHILA SUZUKII*.

Kenis, M., Tonina, L., Eschen, R., van der Sluis, B., Sancassani, M., Mori, N., ... & Helsen, H. (2016). Non-crop plants used as hosts by *Drosophila suzukii*. *Journal of pest science*, 89(3), 735-748.

The invasive spotted wing drosophila *Drosophila suzukii*, a fruit fly of Asian origin, is a major pest of a wide variety of berry and stone fruits in Europe. One of the characteristics of this fly is its wide host range. A better knowledge of its host range outside cultivated areas is essential to develop sustainable integrated pest management strategies. Field surveys were carried out during two years in Italy, the Netherlands and Switzerland. Fruits of 165 potential host plant species were collected, including mostly wild and ornamental plants. Over 24,000 *D. suzukii* adults emerged from 84 plant species belonging to 19 families, 38 of which being non-native. Forty-two plants were reported for the first time as hosts of *D. suzukii*. The highest infestations were found in fruits of the genera *Cornus*, *Prunus*, *Rubus*, *Sambucus* and *Vaccinium* as well as in *Ficus carica*, *Frangula alnus*, *Phytolacca americana* and *Taxus baccata*. Based on these data, management methods are suggested. Ornamental and hedge plants in the vicinity of fruit crops and orchards can be selected according to their susceptibility to *D. suzukii*. However, the widespread availability and abundance of non-crop hosts and the lack of efficient native parasitoids suggest the need for an area-wide control approach.

Kim, J., Jang, M., Shin, E., Kim, J., Lee, S. H., & Park, C. G. (2016). Fumigant and contact toxicity of 22 wooden essential oils and their major components against *Drosophila suzukii* (Diptera: Drosophilidae). *Pesticide Biochemistry and Physiology*, 133, 35-43.

Fumigant and contact toxicities of 22 plant essential oils (EOs) from 14 families and their constituents against the adult spotted wing drosophila (SWD), *Drosophila suzukii* were examined. Analyses by GC, GC-MS, and NMR led to the identification of 2, 16, 13, 4, 6, 9, and 10 compounds from *Gaultheria fragrantissima*, *Croton anistatum*, *Illicium verum*, *Liquidambar orientalis*, *Cinnamomum cassia*, *Rosa damasena*, and *Santalum album*, respectively. In fumigant toxicity test, *G. fragrantissima*, *C. anistatum*, and *I. verum* exhibited 100, 93.8, and 95.8, and 100, 70.0, and 80.0% mortalities against the adult male and female SWD at 4.41 mg/L air, respectively. LC50 values (mg/L air) of *G. fragrantissima*, *C. anistatum*, and *I. verum* were 3.46, 3.67, and 3.16 against male, and 3.48, 4.31, and 4.01 against female SWD. LC50 values (mg/L air) of methyl salicylate and trans-anethole were 2.17 and 1.75 against male and 2.65 and 3.00 against female SWD, respectively. In contact toxicity tests, *L. orientalis*, *C. cassia*, *R. damasena*, and *S. album* showed insecticidal activity with LD50 values ( $\mu\text{g}/\text{fly}$ ) of 2.64, 1.84, 3.40 and 2.18 against male SWD and of 3.74, 2.24, 8.91 and 5.61 against female SWD, respectively. 2-Phehy-1-ethanol, 3-phenyl-1-propanol, trans-cinnamaldehyde, trans-cinnamyl alcohol, and  $\alpha$ -santalol also exhibited insecticidal activity with LD50 values of 9.79, 5.52, 2.39, 3.02 and 2.37 against male SWD and of 11.77, 7.04, 2.94, 3.32, and 3.99 against female SWD, respectively. trans-Cinnamaldehyde exhibited the highest AChE inhibition but its inhibition is likely due to a non-specific chemical inhibition. Our results indicate that wooden EOs and their components can be used as fumigants or spray-type control agents against SWD.

Kim, Y. H., Hur, J. H., Lee, G. S., Choi, M. Y., & Koh, Y. H. (2016). Rapid and highly accurate detection of *Drosophila suzukii*, spotted wing *Drosophila* (Diptera: Drosophilidae) by loop-mediated isothermal amplification assays. *Journal of Asia-Pacific Entomology*, 19(4), 1211-1216.

Cette veille bibliographique est réalisée par Nathalie Roullé et Nicolas Chatel-Launay, Pôle d'excellence en lutte intégrée (PELI).

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*Drosophila suzukii*, the spotted wing drosophila (SWD), is currently a major pest that causes severe economic losses to thin-skinned, small fruit growers in North America and Europe. The monitoring and early detection of SWD in the field is of the utmost importance for its proper management. Although SWD traps using various attractants have been developed and used for SWD monitoring in the field, they are not specific to SWD; consequently, other insects, including *Drosophilidae* flies that share high morphological similarities with SWD, are also easily trapped. Thus, all captured flies need to be identified under microscopes by an expert in fly morphological characteristics. In this study, we developed a simple molecular detection tool that rapidly and accurately identifies SWD without sophisticated instruments or expertise. We first identified a gene, Ds10\_00012111, that is present in the SWD genome but not in that of any other insect species. Then, we developed the loop-mediated isothermal amplification (LAMP) assay, which was designed based on genomic DNA of the Ds10\_00012111 gene. This LAMP assay detected only genomic DNA from SWD—not from *Drosophila melanogaster*. The minimum amount of genomic DNA required for the LAMP assay was 1.0 picogram, and the duration of this assay at temperatures ranging from 58 °C to 62 °C was 30 min. In addition, this assay could detect genomic DNA in SWD geographical strains collected from 8 different locations in Asia, Europe, Hawaii, and the USA. Our LAMP assay could be a useful detection tool for identifying SWD rapidly in the field.

Kiss, B., Kis, A., & Kákai, Á. (2016). The rapid invasion of spotted wing drosophila, *Drosophila suzukii* (Matsumura)(Diptera: *Drosophilidae*), in Hungary. *Phytoparasitica*, 44(3), 429-433.

The invasive spotted wing drosophila, *Drosophila suzukii* (Matsumura) (Diptera: *Drosophilidae*), native to South-East Asia, is a recent threat for fruit production of temperate zones worldwide. The fly was detected in 2008 for the first time in Europe (Italy and Spain) and four years later, in 2012, it was found in Hungary at a highway rest area. In this study, the results of a countrywide survey of *D. suzukii* in Hungarian highway rest areas in 2012–2014 are summarized and supplementary trapping results are also represented for three cities. In 2012 and 2013 the species was found only in low numbers and in a few sites in the western part of the country, while in 2014 an outbreak of *D. suzukii* populations was detected. Adult flies were found at most of the trapping sites all over the country. Additionally, they were also present in the three monitored cities. Our results show that *D. suzukii* has practically settled in the whole country in 2014.

Klick, J., Yang, W. Q., Lee, J. C., & Bruck, D. J. (2016). Reduced spray programs for *Drosophila suzukii* management in berry crops. *International Journal of Pest Management*, 62(4), 368-377.

Since the arrival of *Drosophila suzukii* M. (Diptera: *Drosophilidae*), field applications of broad-spectrum insecticides have increased in berry crop production to protect susceptible fruits from infestation. Field studies were conducted from 2011 to 2013 to determine whether alternate row middle or border spray programs could manage *D. suzukii* as well as complete sprays and have less of an impact on non-target arthropods. Four raspberry sites and one blueberry site were alternate row middle and border sprayed, respectively. Adult and larva counts of *D. suzukii* were compared to conventional complete spray programs. Non-target arthropods were evaluated 7 d post-harvest. In both reduced spray trials, no differences in mean adult numbers and larvae of *D. suzukii* were detected between treatments. Mean counts immediately after sprays (i.e. 3–12 d after treatment) were also similar in complete and alternate row sprays. Both reduced spray strategies had significantly more *Stethorus* spp.; additionally, alternate row sprays had significantly more *Psyllobora* spp. These reduced pesticide strategies are additional tools to consider in *D. suzukii* IPM programs that can reduce the area sprayed, application time, and input costs while conserving natural enemies.

Klick, J., Yang, W. Q., Walton, V. M., Dalton, D. T., Hagler, J. R., Dreves, A. J., ... & Bruck, D. J. (2016). Distribution and activity of *Drosophila suzukii* in cultivated raspberry and surrounding vegetation. *Journal of applied entomology*, 140(1-2), 37-46.

Spotted wing drosophila, *Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae), may utilize wild 'Himalaya' blackberry (HB) *Rubus armeniacus* Focke or other non-crop plants as refugia and possibly exploit adjacent field margins before colonizing cultivated fruiting crops. Studies were conducted to determine the role of field margins containing HB and their effect on *D. suzukii* activity, density and distribution in an adjacent commercial red raspberry crop. One-ha plots adjacent to field margins containing HB or known non-host (NH) grass crops were established in 2011 and 2012 and replicated three times. Each plot contained two transects with monitoring traps for *D. suzukii* in the field margin (0 m) and spaced approximately 10 (crop boundary), 40, 70 and 100 m into the adjacent crop ( $n = 10$  traps/plot). Field margin vegetation was treated with a 10% chicken egg white mark solution weekly from pre-harvest until the end of harvest using a cannon sprayer. Adult *D. suzukii* were collected from traps weekly and analysed for the presence of the egg white mark using an egg white-specific enzyme-linked immunosorbent assay (ELISA). During both years, marked flies and total flies were captured in higher numbers in HB field margins, whereas virtually no flies were captured in field margins containing no known alternative host. Similarly, more flies were captured in the crop near HB than near NH. Spatial Analysis by Distance IndicEs (SADIE) and mean *D. suzukii* trap captures additionally displayed significantly higher fly densities in the raspberry field near HB than near NH. These results suggest that HB may contribute to elevated *D. suzukii* populations and pest pressure in comparison with field margins containing no known alternate host vegetation for *D. suzukii*. Having closely adjacent non-crop alternate host landscapes may result in increased *D. suzukii* pest pressure.

Langille, A. B., Arteca, E. M., Ryan, G. D., Emiljanowicz, L. M., & Newman, J. A. (2016). North American invasion of Spotted-Wing *Drosophila* (*Drosophila suzukii*): A mechanistic model of population dynamics. *Ecological Modelling*, 336, 70-81.

*Drosophila suzukii* is a relatively new threat to the soft-skinned fruit industry in North America. The presence of this pest in North America is a concern and assessing the risk of potential infestation and damage can help guide regional management strategies. We have developed a continuous time stage structured population model parameterized with empirical data based on laboratory observations. The principle environmental driver of vital rates (mortality, fecundity and development) for the model is temperature though our results suggest that reproductive diapause and quality of fruit available to the population may also have significant effect on population size. The model was run with several generalized temperature profiles and various observed temperature data sets for locations known to be important for berry production. While southern regions appear to be most suitable for supporting high population densities due to warm temperatures throughout the year, northern regions with moderate temperatures may also be susceptible due to a lack of extreme cold or heat, both of which limit development and increase mortality.

Leach, H., Van Timmeren, S., & Isaacs, R. (2016). Exclusion Netting Delays and Reduces *Drosophila suzukii* (Diptera: Drosophilidae) Infestation in Raspberries. *Journal of Economic Entomology*, tow157.

*Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae) is a new frugivorous pest of raspberries and other soft fruits in North America, causing infestation of fruit at harvest time. Control of this pest has primarily been through the application of broad-spectrum insecticides to prevent oviposition and larval development, and there is an urgent need for alternative approaches. Over two growing seasons, we compared *D. suzukii* control in a research planting with insecticide and exclusion treatments in a factorial design, monitoring first-, second-, and third-instar *Drosophila* larvae in ripening, ripe, and overripe berries. Each of the two control approaches provided significant reduction of infestation in raspberry fruit, but the combination treatment had the lowest overall abundance of larvae in fruit. This pattern was seen for all larval instars in both years. The combination treatment also delayed the first detected larval infestation by 10 d compared to the untreated plots. Exclusion netting applied to commercial size high tunnels resulted in a significant reduction in overall *D. suzukii* infestation in raspberries, as well as a 3-wk delay in the average first detectable fruit infestation. Raspberry size and quality were not affected by the exclusion treatments, indicating that

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this approach can be an important component of growers' response to invasion by *D. suzukii* in temperate climates. We discuss the opportunities and limitations for implementing exclusion netting in raspberry production.

Lee, J. C., Dalton, D. T., Swoboda-Bhattarai, K. A., Bruck, D. J., Burrack, H. J., Strik, B. C., ... & Walton, V. M. (2016). Characterization and manipulation of fruit susceptibility to *Drosophila suzukii*. *Journal of Pest Science*, 89(3), 771-780.

*Drosophila suzukii* (Matsumura) is an economic pest of small fruits and cherries that attacks intact ripening fruits. Host susceptibility may be influenced by characteristics such as flesh firmness, penetration force of the skin, total soluble solids (TSS, also known as °Brix), and pH. Improved knowledge of factors affecting fruit susceptibility is needed for developing thresholds and risk prediction models for IPM. A combination of laboratory and field studies was conducted to develop prediction and potential management tools. First, a direct bioassay was used to calculate the probability of oviposition in a given fruit based on various characteristics as determined across laboratory and field trials in Oregon and North Carolina, US. When multiple characteristics were evaluated simultaneously, oviposition probability consistently increased as penetration force decreased and pH increased. Oviposition probability sometimes increased as TSS increased. Second, raspberries and blueberries in unsprayed fields had substantially lower infestation in ripening fruit compared to ripe fruit. There was no or minimal infestation in green fruit. Third, given that skin penetration force influences oviposition, practices used to improve fruit quality were examined in laboratory no-choice cages for potential reduction of oviposition. Blueberry fruit sprayed with calcium silicate in the field had greater penetration force and firmness and reduced number of eggs laid by *D. suzukii* compared to untreated fruit. Other calcium-based treatments increased Ca content and firmness of fruit relative to untreated fruit. Timing of insecticide spray for *D. suzukii* might be delayed until fruit become susceptible.

Li, F., & Scott, M. J. (2016). CRISPR/Cas9-mediated mutagenesis of the white and Sex lethal loci in the invasive pest, *Drosophila suzukii*. *Biochemical and biophysical research communications*, 469(4), 911-916.

*Drosophila suzukii* (commonly called spotted wing *Drosophila*) is an invasive pest of soft-skinned fruit (e.g. blueberries, strawberries). A high quality reference genome sequence is available but functional genomic tools, such as used in *Drosophila melanogaster*, remain to be developed. In this study we have used the CRISPR/Cas9 system to introduce site-specific mutations in the *D. suzukii* white (*w*) and Sex lethal (*Sxl*) genes. Hemizygous males with *w* mutations develop white eyes and the mutant genes are transmissible to the next generation. Somatic mosaic females that carry mutations in the *Sxl* gene develop abnormal genitalia and reproductive tissue. The *D. suzukii* *Sxl* gene could be an excellent target for a Cas9-mediated gene drive to suppress populations of this highly destructive pest.

Mazzetto, F., Gonella, E., Crotti, E., Vacchini, V., Syrpas, M., Pontini, M., ... & Alma, A. (2016). Olfactory attraction of *Drosophila suzukii*. *Journal of Pest Science*, 89(3), 783-792.

Some species of acetic acid bacteria (AAB) play relevant roles in the metabolism and physiology of *Drosophila* spp. and in some cases convey benefits to their hosts. The pest *Drosophila suzukii* harbors a set of AAB similar to those of other *Drosophila* species. Here, we investigate the potential to exploit the ability of AAB to produce volatile substances that attract female *D. suzukii*. Using a two-way olfactometer bioassay, we investigate the preference of *D. suzukii* for strains of AAB, and using solid-phase microextraction gas chromatography–mass spectrometry we specifically characterize their volatile profiles to identify attractive and non-attractive components produced by strains from the genera *Acetobacter*, *Gluconobacter*, and *Komagataeibacter*. Flies had a preference for one strain of *Komagataeibacter* and two strains of *Gluconobacter*. Analyses of the volatile profiles from the preferred *Gluconobacter* isolates found that acetic acid is distinctively emitted even after 2 days of bacterial growth, confirming the relevance of this volatile in the profile of this isolate for attracting flies. Analyses of the volatile profile from the preferred *Komagataeibacter* isolate showed that a different volatile in its profile could be responsible for attracting *D. suzukii*. Moreover, variation in the

concentration of butyric acid derivatives found in some strains may influence the preference of *D. suzukii*. Our results indicate that *Gluconobacter* and *Komagataeibacter* strains isolated from *D. suzukii* have the potential to provide substances that could be exploited to develop sustainable mass-trapping-based control approaches.

Mazzetto, F., Marchetti, E., Amiresmaeili, N., Sacco, D., Francati, S., Jucker, C., ... & Tavella, L. (2016). *Drosophila* parasitoids in northern Italy and their potential to attack the exotic pest *Drosophila suzukii*. *Journal of Pest Science*, 89(3), 837-850.

*Drosophila suzukii* is an invasive alien pest recently introduced into Europe and North and South America. Several control methods have been tested, and the ability of natural enemies to control this pest has been investigated. This study aimed to identify the main parasitoids of drosophilids in North Italy via field surveys, and to evaluate the ability of some of those species emerged to parasitize *D. suzukii* compared to indigenous *D. melanogaster*. A nine-site survey from July to October 2014 that exposed fruit (banana and blueberry) for 7 and 14 days obtained six parasitoid species, ranked from highest abundance: *Leptopilina boulardi*, *L. heterotoma* (Hymenoptera: Figitidae), *Pachycrepoideus vindemiae* (Hymenoptera: Pteromalidae), *Trichopria cf. drosophilae* (Hymenoptera: Diapriidae), *Asobara tabida* (Hymenoptera: Braconidae), and *Spalangia erythromera* (Hymenoptera: Pteromalidae). The presence and abundance of these species varied greatly among the sites and across the season. The field survey results showed a relationship between parasitoids and indigenous *Drosophila* communities and a high host competition. The ability of larval parasitoids *L. boulardi* and *L. heterotoma* and pupal parasitoid *T. cf. drosophilae* to parasitize the exotic and indigenous hosts was laboratory tested. Both larval parasitoids failed to develop on *D. suzukii*, but high mortality was recorded in larvae exposed to *L. heterotoma*. On the contrary, *T. cf. drosophilae* developed successfully on *D. suzukii*, with no significant differences between the exotic and indigenous hosts. These results beg further investigations of indigenous enemies, particularly *T. cf. drosophilae*, for effective biological control of *D. suzukii*.

Mori, B. A., Whitener, A. B., Leinweber, Y., Revadi, S., Beers, E. H., Witzgall, P., & Becher, P. G. (2016). Enhanced yeast feeding following mating facilitates control of the invasive fruit pest *Drosophila suzukii*. *Journal of Applied Ecology*.

The highly invasive spotted wing *Drosophila suzukii* is a key pest of soft fruit and berries in Europe and North America, and development of control techniques is an urgent research challenge. *Drosophila suzukii* is widely associated with the yeast *Hanseniaspora uvarum*. Yeasts are symbionts of drosophilid flies and communicate with insects through volatile metabolites for spore dispersal. Accordingly, yeasts and behaviour-modifying chemicals produced by yeasts are prospective tools for environmentally sound insect management. We first bioassayed flight attraction, feeding and oviposition of *D. suzukii* females in response to *H. uvarum* yeast and blueberries, which are a preferred host fruit. We then investigated the combined effect of yeast and insecticide on adult female oviposition behaviour and mortality towards the development of a yeast-based control method. Following mating, attraction of female flies to blueberry and yeast odour cues was strongly enhanced. Yeast feeding significantly increased in mated females, while yeast did not increase oviposition on blueberries. This observation suggests that mated flies become attracted to yeast for feeding and to fruit for egg laying. A combined feeding-oviposition assay demonstrated different roles and interference between yeast and fruit stimuli: during the day after mating, females laid fewer eggs when yeast was available. The post-mating yeast-feeding response is an opportunity for the development of an attract-and-kill technique for population control of *D. suzukii*. Exposing flies to a blend of yeast and insecticide reduced oviposition and greatly enhanced adult fly mortality compared with an insecticide treatment alone. Synthesis and applications. Mated females are the key life stage for *Drosophila suzukii* population control. Egg-laying females perforate fruit skin and fungal infestations ensue, even when eggs and larvae are killed off by insecticide sprays. Behaviour-modifying chemicals, including yeast metabolites, enable environmentally safe insect management via manipulation of olfactory-mediated reproductive behaviour. Our results highlight that yeast and yeast semiochemicals hold potential for *D. suzukii* management and that response modulation to olfactory stimuli following mating is a vital element for the

development of *D. suzukii* control methods. Yeast feeding is enhanced in mated *D. suzukii* females, and this change in post-mating behaviour can be exploited by an attract-and-kill strategy, combining a fly-associated yeast with an insecticide. Furthermore, using the *D. suzukii* yeast mutualist, *H. uvarum*, may reduce non-target effects and increase species specificity, which further contributes to the development of an efficient and safe control method.

Murphy, K. A., Tabuloc, C. A., Cervantes, K. R., & Chiu, J. C. (2016). Ingestion of genetically modified yeast symbiont reduces fitness of an insect pest via RNA interference. *Scientific reports*, 6.

RNA interference has had major advances as a developing tool for pest management. In laboratory experiments, double-stranded RNA (dsRNA) is often administered to the insect by genetic modification of the crop, or synthesized in vitro and topically applied to the crop. Here, we engineered genetically modified yeast that express dsRNA targeting  $\gamma$ -Tubulin in *Drosophila suzukii*. Our design takes advantage of the symbiotic interactions between *Drosophila*, yeast, and fruit crops. Yeast is naturally found growing on the surface of fruit crops, constitutes a major component of the *Drosophila* microbiome, and is highly attractive to *Drosophila*. Thus, this naturally attractive yeast biopesticide can deliver dsRNA to an insect pest without the need for genetic crop modification. We demonstrate that this biopesticide decreases larval survivorship, and reduces locomotor activity and reproductive fitness in adults, which are indicative of general health decline. To our knowledge, this is the first study to show that yeast can be used to deliver dsRNA to an insect pest.

Murphy, K. A., West, J. D., Kwok, R. S., & Chiu, J. C. (2016). Accelerating research on Spotted Wing *Drosophila*. *Journal of Pest Science*, 89(3), 631-641.

Spotted Wing *Drosophila* (*Drosophila suzukii*) is an invasive species and a serious pest of berry and soft-skinned fruit crops. The close genetic relationship between *D. suzukii* and other well-studied *Drosophila* species has provided researchers with an already extensive genetic toolkit. The reference genome and transcriptome of this insect have been annotated and made publicly available since 2013, and facilitate basic and applied research. In this review, we present a synthesis of recent research that implements next-generation sequencing and genomic technologies to better understand biological questions concerning this important pest. Much of the work performed is directly applicable to improving agricultural management practices, and includes topics such as insecticide response and resistance, invasion demographics, seasonal biology, and RNA interference technologies for pest control.

Nguyen, P., Kim, A. Y., Jung, J. K., Donahue, K. M., Jung, C., Choi, M. Y., & Koh, Y. H. (2016). The biochemical adaptations of spotted wing *Drosophila* (Diptera: Drosophilidae) to fresh fruits reduced fructose concentrations and glutathione-S transferase activities. *Journal of economic entomology*, tow019.

Spotted wing drosophila, *Drosophila suzukii* Matsumura, is an invasive and economically damaging pest in Europe and North America. The females have a serrated ovipositor that enables them to infest almost all ripening small fruits. To understand the physiological and metabolic basis of spotted wing drosophila food preferences for healthy ripening fruits, we investigated the biological and biochemical characteristics of spotted wing drosophila and compared them with those of *Drosophila melanogaster* Meigen. We found that the susceptibility to oxidative stressors was significantly increased in spotted wing drosophila compared with those of *D. melanogaster*. In addition, we found that spotted wing drosophila had significantly reduced glutathione-S transferase (GST) activity and gene numbers. Furthermore, fructose concentrations found in spotted wing drosophila were significantly lower than those of *D. melanogaster*. Our data strongly suggest that the altered food preferences of spotted wing drosophila may stem from evolutionary adaptations to fresh foods accompanied by alterations in carbohydrate metabolism and GST activities.

Orhan, A., ASLANTAŞ, R., ÖNDER, B. Ş., & TOZLU, G. (2016). First record of the invasive vinegar fly *Drosophila suzukii* (Matsumura)(Diptera: Drosophilidae) from eastern Turkey. *Turkish Journal of Zoology*, 40(2), 290-293.

*Drosophila suzukii* (Matsumura, 1931) (Diptera: Drosophilidae) is native to East Asia and invasive on the European and American continents. The first records in both Europe and the United States were in 2008. Since that year, it has widely moved across these continents. As *D. suzukii* females lay eggs in healthy ripening fruits of several species, particularly in small soft fruits and berries, the species causes agricultural damage. The soft thin-skinned fruit pest, identified as *D. suzukii*, has been found in Erzurum, Turkey, where damaged strawberry crops were observed and cultured in the middle of August and September 2014. Initially, 2 adults, 3 pupae, and several larvae were observed. Emergence of male and female adults continued for 10 more days. Here we report the first finding of *D. suzukii* in Turkey.

Park, C. G., Jang, M., Yoon, K. A., & Kim, J. (2016). Insecticidal and acetylcholinesterase inhibitory activities of Lamiaceae plant essential oils and their major components against *Drosophila suzukii* (Diptera: Drosophilidae). *Industrial Crops and Products*, 89, 507-513.

*Drosophila suzukii* is recognized as an economically important pest in North America and Europe as well as Asia. Assessments were made of fumigant and contact toxicities of 12 Lamiaceae plant essential oils (EOs) and their components. The possible mode of action of the major components of the active EOs was pursued by evaluating their activities against acetylcholinesterase (AChE) of *D. suzukii*. Among the EOs tested, effective fumigant activity was observed with EOs of *Mentha piperita* and *Perilla frutescens*. Menthone and menthol, and perilla aldehyde were identified as major components of *M. piperita* and *P. frutescens*, respectively. LD50 (mg/L) values of *M. piperita*, *P. frutescens*, menthone, menthol and perilla aldehyde was 3.87, 2.44, 5.76, 1.88, and 0.99 against males and 4.10, 3.31, 5.13, 1.94, and 1.15 against females, respectively. EOs of *Satureja montana* and *Thymus zygis* showed effective contact toxicity. Thymol, carvacrol, and p-cymene were the most major components of these two EOs. LD50 (µg/fly) values for contact toxicity of *S. montana*, *T. zygis*, thymol, and carvacrol were 2.95, 2.93, 1.63, and 1.30 for male, and 4.59, 5.09, 2.68 and 2.60 for female, respectively. p-Cymene was not effective in contact toxicity. Fumigant and contact toxicities of the effective EOs and their major compounds were compared with those of two commercial insecticides. Among the 6 major components which showed fumigant and contact toxicity, perilla aldehyde showed most active inhibition against AChE of both sexes of SWD. Our result indicated that Lamiaceae plant EOs and their components can be used as alternatives to conventional insecticides.

Pavlova, A. K., Dahlmann, M., Hauck, M., & Reineke, A. (2016). Laboratory Bioassays with Three Different Substrates to Test the Efficacy of Insecticides against Various Stages of *Drosophila suzukii* (Diptera: Drosophilidae). *Journal of Insect Science*, 16(1), 100.

Rapid worldwide spread and polyphagous nature of the spotted wing *Drosophila suzukii* Matsumura (Diptera: Drosophilidae) calls for efficient and selective control strategies to prevent severe economic losses in various fruit crops. The use of insecticides is one option for management of this invasive pest insect. Efficacy of insecticides is usually assessed first in laboratory bioassays, which are compounded by the cryptic nature of *D. suzukii* larvae and the fact that fruits used in bioassays often start to rot and dissolve before larvae have reached the adult stage. Here, we report on laboratory bioassays using three different types of substrates allowing a thorough screening of insecticides for their potential effects against *D. suzukii* eggs, larvae and adults. Suitability of our bioassays was validated in an assessment of the efficacy of four bioinsecticides and one synthetic insecticide against various developmental stages of *D. suzukii*. Water-apple juice agar used as a bioassay substrate allowed egg counting and observation of larval development due to its transparency, while apple-nutrition medium allowed complete metamorphosis. Use of grape berries in bioassays made it possible to assess effects of an insecticide present on a fruit's surface on oviposition and larval hatch from eggs. Insecticides tested in these three different bioassays with acetamiprid, spinosad or natural pyrethrins as active ingredients achieved a significant *D. suzukii* control if they were applied before egg deposition.

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Number of adult flies was significantly reduced if the bioassay medium was treated with an azadirachtin A containing insecticide both before or after egg deposition.

Pelton, E., Gratton, C., Isaacs, R., Van Timmeren, S., Blanton, A., & Guédot, C. (2016). Earlier activity of *Drosophila suzukii*. *Journal of Pest Science*, 89(3), 725-733.

Natural habitats can affect the population dynamics of mobile insects, and the spatial and temporal effects on agricultural pest species may be especially relevant for tailoring management strategies to the farm context. *Drosophila suzukii* Matsumura (Diptera: Drosophilidae) is suspected to utilize woodland habitat for wild hosts and overwintering with possible adverse effects of woods on adjacent fruit crops. A two-year study in the Upper Midwest, USA examined if the amount of woodland in the landscape affects early season activity and relative abundance of *D. suzukii* in raspberry fields. Thirty-five farms were selected to span a gradient of low-to-high woodland area at the 1.5 km scale. The first capture of *D. suzukii* occurred earlier at farms in high woodland landscapes. However, woodland area was not correlated with metrics of *D. suzukii* abundance in raspberry (growth rate, peak, fall, or total fly catch) suggesting similar crop infestation risk across landscapes. However, woodland area was negatively correlated with fall fly catch in the adjacent woods and significantly more flies were captured in the woods than raspberry. This study suggests woodland landscapes affect early season crop risk and the high numbers of *D. suzukii* in the woods have implications for understanding overwintering.

Plantamp, C., Estragnat, V., Fellous, S., Desouhant, E., & Gibert, P. (2016). Where and what to feed? Differential effects on fecundity and longevity in the invasive *Drosophila suzukii*. *Basic and Applied Ecology*.

Successful establishment of invasive species requires that the species meet environmental conditions favouring their longevity and fecundity. When juveniles and adults consume different resources, gravid females may have to choose whether to feed or to reproduce. We used a successful invasive species to test whether female life history traits are affected by the potential nutrients found in reproductive sites. The pest species, *Drosophila suzukii*, lays eggs in fruits that could provide nutrients since fruit exudates are generated during oviposition. We demonstrated that *D. suzukii* adults cannot survive when they have only access to reproductive sites (i.e. undamaged fruits). But they can find the nutrients necessary for longevity on these reproductive sites if there are larger holes in the exocarp. Egg maturation is low when *D. suzukii* feeds on nutrients from fruits, even when damaged, suggesting that females cannot acquire sufficient nutrients for egg maturation where they lay their eggs. Finally, a field experiment supported our laboratory results: wild females have a low degree of egg maturation, even when captured near reproductive sites. Our study hence shows constraints on egg production, and therefore on fruit infestation, determined by the nutritional ecology of pest females.

Plantamp, C., Salort, K., Gibert, P., Dumet, A., Mialdea, G., Mondy, N., & Voituron, Y. (2016). All or nothing: Survival, reproduction and oxidative balance in Spotted Wing *Drosophila* (*Drosophila suzukii*) in response to cold. *Journal of insect physiology*, 89, 28-36.

Winter severity and overwintering capacity are key ecological factors in successful invasions, especially in ectotherms. The integration of physiological approaches into the study of invasion processes is emerging and promising. Physiological information describes the mechanisms underlying observed survival and reproductive capacities, and it can be used to predict an organism's response to environmental perturbations such as cold temperatures. We investigated the effects of various cold treatments on life history and physiological traits of an invasive pest species, *Drosophila suzukii*, such as survival, fertility and oxidative balance. This species, a native of temperate Asian areas, is known to survive where cold temperatures are particularly harsh and has been recently introduced into Europe and North America. We found that cold treatments had a strong impact on adult survival but no effect on female's fertility.

Cette veille bibliographique est réalisée par Nathalie Roullé et Nicolas Chatel-Launay, Pôle d'excellence en lutte intégrée (PELI).

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Although only minor changes were observed after cold treatment on studied physiological traits, a strong sex-based difference was observed in both survival and physiological markers (antioxidant defences and oxidative markers). Females exhibited higher survival, reduced oxidative defences, less damage to nucleic acids, and more damage to lipids. These results suggest that *D. suzukii* relies on a pathway other than oxidative balance to resist cold injury. Altogether, our results provide information concerning the mechanisms of successful invasion by *D. suzukii*. These findings may assist in the development of population models that predict the current and future geographic ranges of this species.

Ramasamy, S., Ometto, L., Crava, C. M., Revadi, S., Kaur, R., Horner, D. S., ... & Rota-Stabelli, O. (2016). The evolution of olfactory gene families in *Drosophila* and the genomic basis of chemical-ecological adaptation in *Drosophila suzukii*. *Genome Biology and Evolution*, 8(8), 2297-2311.

How the evolution of olfactory genes correlates with adaptation to new ecological niches is still a debated topic. We explored this issue in *Drosophila suzukii*, an emerging model that reproduces on fresh fruit rather than in fermenting substrates like most other *Drosophila*. We first annotated the repertoire of odorant receptors (ORs), odorant binding proteins (OBPs), and antennal ionotropic receptors (aIRs) in the genomes of two strains of *D. suzukii* and of its close relative *Drosophila biarmipes*. We then analyzed these genes on the phylogeny of 14 *Drosophila* species: whereas ORs and OBPs are characterized by higher turnover rates in some lineages including *D. suzukii*, aIRs are conserved throughout the genus. *Drosophila suzukii* is further characterized by a non-random distribution of OR turnover on the gene phylogeny, consistent with a change in selective pressures. In *D. suzukii*, we found duplications and signs of positive selection in ORs with affinity for short-chain esters, and loss of function of ORs with affinity for volatiles produced during fermentation. These receptors—Or85a and Or22a—are characterized by divergent alleles in the European and American genomes, and we hypothesize that they may have been replaced by some of the duplicated ORs in corresponding neurons, a hypothesis reciprocally confirmed by electrophysiological recordings. Our study quantifies the evolution of olfactory genes in *Drosophila* and reveals an array of genomic events that can be associated with the ecological adaptations of *D. suzukii*.

Reineke, A., & Thiéry, D. (2016). Grapevine insect pests and their natural enemies in the age of global warming. *Journal of Pest Science*, 89(2), 313-328.

We review direct and indirect effects of climate change on both the grapevine plant as a host for phytophagous insects, as well as on grape insect pests, their natural enemies and corresponding future grape plant protection strategies. Phenology, voltinism and distribution ranges are well known traits of many arthropods influenced by temperature as the key abiotic factor and thus by current and future climate change scenarios. Case studies of grapevine pests based on data from three decades point to clear changes in phenology of grape berry moths, shifts in distribution ranges of leafhoppers as vectors of grapevine diseases and range expansion of grapevine mealybugs. These case studies also illustrate the need to include data on putatively changed tri-trophic interactions in vineyards when predicting impacts of climate change on grapevine pest insects. Hence, future pest management strategies should be based on a sound set of field data obtained for both pests and antagonists under changed abiotic conditions, which can also build the basis for refining and extending currently existing models for forecasting population levels of respective insect pests.

Renkema, J. M., Wright, D., Buitenhuis, R., & Hallett, R. H. (2016). Plant essential oils and potassium metabisulfite as repellents for *Drosophila suzukii* (Diptera: Drosophilidae). *Scientific reports*, 6.

Spotted wing drosophila, *Drosophila suzukii*, is a globally invasive pest of soft-skinned fruit. Females oviposit into ripening fruit and larvae cause direct destruction of tissues. As many plant essential oils are permitted food additives, they may provide a safe means of protecting fruit from *D. suzukii* infestation in both conventional and organic

production systems. Twelve oils and potassium metabisulfite (KMS) were screened in the laboratory as repellents for *D. suzukii* flies. Most essential oils deterred *D. suzukii* flies from cotton wicks containing attractive raspberry juice. Peppermint oil was particularly effective, preventing almost all flies from contacting treated wicks and remaining 100% repellent for 6 d post-application. Thyme oil was unique because it caused high male mortality and reduced the number of responding flies compared to other oils. KMS was not found to be repellent to *D. suzukii*, but may have fumigant properties, particularly at high concentrations. Peppermint oil appears to be the best candidate for field testing to determine the effectiveness and feasibility of using essential oils as part of a push-pull management strategy against *D. suzukii*. This is the first time that essential oils have been evaluated and proven effective in preventing fruit-infesting flies from contacting attractive stimuli.

Rogers, M. A., Burkness, E. C., & Hutchison, W. D. (2016). Evaluation of high tunnels for management of *Drosophila suzukii*. *Journal of Pest Science*, 89(3), 815-821.

*Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae) is an invasive pest of soft-skinned fruit causing significant damage on a variety of fruit crops in North America, Europe, and Asia. In North America, fall-bearing fruit, such as primocane raspberries, ripen when *D. suzukii* populations peak and thus are vulnerable to high levels of infestation. In recent years, growers in northern climates have increased raspberry production under protected culture (high tunnels), resulting in season extension, increased yield, and improved fruit quality. High tunnels may be used as a pest management tool by physically excluding insect pests. This study investigated whether *D. suzukii* can be excluded from fall-bearing raspberries cultivated under tunnels covered with plastic or fine mesh netting, and whether this production technique can improve fruit marketability and serve as an alternative to insecticide application. We found that berries in plastic-covered tunnels had low season-long levels of infestation by *D. suzukii* (mean = 2 %), compared to netted tunnels (35 %), insecticide-treated open plots (60 %) and untreated open plots (81 %). Our microclimate data show that temperature and humidity levels inside the plastic-covered tunnels were often outside the previously published optimal temperature range for development, mating, and/or oviposition for *D. suzukii*, and may have therefore limited overall population growth. We conclude that exclusion and modification of microclimate may be effective and complementary pest management strategies for fall-fruiting raspberry and serve as an alternative to insecticide applications, particularly for small-acreage and organic production systems.

Rossi-Stacconi, M. V., Kaur, R., Mazzoni, V., Ometto, L., Grassi, A., Gottardello, A., ... & Anfora, G. (2016). Multiple lines of evidence for reproductive winter diapause in the invasive pest *Drosophila suzukii*. *Journal of Pest Science*, 89(3), 689-700.

Successful management of invasive pests, such as *Drosophila suzukii*, relies on a fine understanding of their biology. Genomic and physiological studies have suggested that the invasive success of *D. suzukii* is strongly associated with its ability to overwinter in a reproductive diapause state. Here, we coupled field surveys with comparative morphology and genetics to increase our understanding of *D. suzukii* overwintering behavior and provide useful indications for its management. The results of a 4-year-long field trapping in an Italian mountain region indicate that *D. suzukii* is continuously captured during winter months and that the number of captures is correlated with temperature. Capture patterns are also contrasting between sexes: while females are more abundantly caught during winter and summer, males are more abundant in spring and autumn. We found that overwintering could occur not only in natural environments, such as woods, but also in anthropic shelters. Comparative morphology and genetics further indicate that spermathecae may play an important adaptive role during winter. Our results unveil complex winter biology in *D. suzukii* and highlight how the number of overwintering females is an earlier predictor of summer population size. We hence propose that in a given year infestation may be better forecasted by taking into account the captures of the previous winter. We recommend that control methods be diapause-aware. For instance, they should take place in late winter/early spring and close to natural environments, and not only in fruit ripening season and close to orchards.

Cette veille bibliographique est réalisée par Nathalie Roullé et Nicolas Chatel-Launay, Pôle d'excellence en lutte intégrée (PELI).

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Ryan, G. D., Emiljanowicz, L., Wilkinson, F., Kornya, M., & Newman, J. A. (2016). Thermal tolerances of the spotted-wing *Drosophila Drosophila suzukii* (Diptera: Drosophilidae). *Journal of economic entomology*, tow006.

The spotted-wing drosophila (*Drosophila suzukii* Matsumura) is an invasive species of Asian origin that is now widely distributed in North America and Europe. Because of the female's serrated ovipositor, eggs are laid in preharvest fruit, causing large economic losses in cultivated berries and stone fruit. Modeling *D. suzukii* population dynamics and potential distribution will require information on its thermal tolerance. Large summer populations have been found in regions with severe winter conditions, though little is known about responses to prolonged low-temperature exposure. We used controlled chambers to examine *D. suzukii* fecundity, development rate, and mortality across a range of temperatures encompassing the upper and lower thresholds (5–35°C). Optimal temperatures ( $T_{opt}$ ) were found to be 28.2°C for the development of the egg-to-adult stage, and 22.9°C for reproductive output. No adult eclosion occurred below 8.1°C ( $T_{lower}$ ) or above 30.9°C ( $T_{upper}$ ). We also investigated survival outcomes following prolonged (42-d) low-temperature exposure to a simulated cold winter (–5, –3, –1, 1, 3, and 5°C). Adult survival was dependent on temperature, with a mean LT 50 of 4.9°C. There were no effects of sex, mating status, geographic strain, and photoperiod preexposure on overwintering survival. Thirty-eight percent of females that were mated prior, but not after, prolonged low-temperature exposure produced viable offspring, suggesting that this species may undergo sperm storage. This study provides data on the thermal tolerances of *D. suzukii*, which can be used for models of *D. suzukii* population dynamics, degree-day, and distribution models.

Saccaggi, D. L., Karsten, M., Robertson, M. P., Kumschick, S., Somers, M. J., Wilson, J. R., & Terblanche, J. S. (2016). Methods and approaches for the management of arthropod border incursions. *Biological Invasions*, 18(4), 1057-1075.

Biological invasions are increasing and are strongly associated with negative agricultural, economic and ecological impacts. It is increasingly recognized that the primary focus in minimizing biological invasions should be to prevent initial entry of alien species. However, exclusion of terrestrial arthropods such as insects and mites is difficult, in part because of their relatively small size, cryptic habits, broad physiological tolerances and close association with various internationally traded goods. Here we discuss methods, approaches, management and intervention systems used by border biosecurity agencies to prevent entry of inadvertently transported arthropods. We examine the at-border systems that exist for the detection and identification of and response to alien arthropods, and discuss the constraints and challenges present in these systems. We critically review current border biosecurity systems and discuss their relative efficacy. We then discuss additional measures and key areas that could be addressed that may further improve these systems. These include: (1) the application of appropriate sampling strategies; (2) employment of suitable inspection methods adequate to detect small and hidden arthropods; and (3) thorough recording of methods, organisms detected and both negative and positive results of inspections. We emphasize that more research is needed on taxonomy, biology, genetics, distribution, host and disease associations, impacts and pathways of introductions for invasive arthropods. Of critical importance is the compilation of complete and accurate invasive species lists and high-risk species watch-lists. The adoption of these recommendations will contribute to improved biosecurity systems for the exclusion of alien, invasive and pest arthropods.

Sampson, B. J., Mallette, T., Adesso, K. M., Liburd, O. E., Iglesias, L. E., Stringer, S. J., ... & Adamczyk Jr, J. J. (2016). Novel aspects of *Drosophila suzukii* (Diptera: Drosophilidae) biology and an improved method for culturing this invasive species with a modified *D. melanogaster* diet. *Florida Entomologist*, 99(4), 774-780.

*Drosophila suzukii* (Matsumara) (Diptera: Drosophilidae), the spotted wing drosophila, is a global pest of soft fruits now rearable on a standard *D. melanogaster* (Meigen) diet containing the fly's own natural food: soft-skinned berries. The techniques tested here can save 40% of cultures from microbial contamination that develops after combining artificial

food sources (e.g., standard drosophila media) with unsterilized host plant material (berries). A suitable ratio for mixing dietary ingredients for a vial or test-tube rearing system includes, by weight, 1 part berry tissue for oviposition, 1.5 parts dry diet media for carbohydrate, 7 parts clean water for moisture, and ~5 grains (0.8 mg) of dry yeast for protein. One or two blackberry or blueberry fruits used by spotted wing drosophila as edible oviposition substrates doubled and tripled pupal and adult production in standard 68 mL culturing vials. To prevent mold from spoiling the diet, the exocarp of berries was sterilized in an 80 or 90% ethanol bath at room temperature for ~5 min, followed by a thorough rinsing with deionized water to remove residual alcohol, which can be acutely toxic to *D. suzukii*, a highly ethanol-intolerant species. Sterilized fruit and a larger fly population in vials disrupted the growth of microbial biofilms capable of suffocating adults. Identical body size in reared adults and locally caught wild flies of *D. suzukii* substantiates nutritional similarity between the fruit-media-based diet and the fly's own natural food (i.e., whole berries). Triethylamine (50%), a common fly anesthetic, was acutely toxic to *D. suzukii* adults but not to *D. melanogaster* adults.

Shearer, P. W., West, J. D., Walton, V. M., Brown, P. H., Svetec, N., & Chiu, J. C. (2016). Seasonal cues induce phenotypic plasticity of *Drosophila suzukii* to enhance winter survival. *BMC ecology*, 16(1), 11.

Background: As global climate change and exponential human population growth intensifies pressure on agricultural systems, the need to effectively manage invasive insect pests is becoming increasingly important to global food security. *Drosophila suzukii* is an invasive pest that drastically expanded its global range in a very short time since 2008, spreading to most areas in North America and many countries in Europe and South America. Preliminary ecological modeling predicted a more restricted distribution and, for this reason, the invasion of *D. suzukii* to northern temperate regions is especially unexpected. Investigating *D. suzukii* phenology and seasonal adaptations can lead to a better understanding of the mechanisms through which insects express phenotypic plasticity, which likely enables invasive species to successfully colonize a wide range of environments. Results: We describe seasonal phenotypic plasticity in field populations of *D. suzukii*. Specifically, we observed a trend of higher proportions of flies with the winter morph phenotype, characterized by darker pigmentation and longer wing length, as summer progresses to winter. A laboratory-simulated winter photoperiod and temperature (12:12 L:D and 10 °C) were sufficient to induce the winter morph phenotype in *D. suzukii*. This winter morph is associated with increased survival at 1 °C when compared to the summer morph, thus explaining the ability of *D. suzukii* to survive cold winters. We then used RNA sequencing to identify gene expression differences underlying seasonal differences in *D. suzukii* physiology. Winter morph gene expression is consistent with known mechanisms of cold-hardening such as adjustments to ion transport and up-regulation of carbohydrate metabolism. In addition, transcripts involved in oogenesis and DNA replication were down-regulated in the winter morph, providing the first molecular evidence of a reproductive diapause in *D. suzukii*. Conclusions: To date, *D. suzukii* cold resistance studies suggest that this species cannot overwinter in northern locations, e.g. Canada, even though they are established pests in these regions. Combining physiological investigations with RNA sequencing, we present potential mechanisms by which *D. suzukii* can overwinter in these regions. This work may contribute to more accurate population models that incorporate seasonal variation in physiological parameters, leading to development of better management strategies.

Stemberger, T. L. (2016). Survey of hanging and fallen cherry fruit use by spotted wing drosophila, *Drosophila suzukii* (Matsumura, 1931)(Diptera: Drosophilidae), and other Drosophilidae species. *The Pan-Pacific Entomologist*, 91(4), 347-31.

Takahara, B., & Takahashi, K. H. (2016). Associative learning of color and firmness of oviposition substrates in *Drosophila suzukii*. *Entomologia Experimentalis et Applicata*.

*Drosophila suzukii* Matsumura (Diptera: Drosophilidae), also known as the spotted-wing drosophila, is a global pest fly. The degree of infestation of *D. suzukii* varies greatly among host plants, possibly depending on the physical properties

of the fruits. Because some of the physical properties of fruits can only be judged by touching them, *D. suzukii* may choose to oviposit based on the physical properties of fruits and remote sensory information such as visual cues. Here, we conducted associative learning experiments with artificial substrates consisting of water, cornmeal, fructose, and agarose with different colors and firmness. We assessed associative learning by conditioning flies with combinations of two colors (purple or green) and degrees of firmness (firm or soft), and comparing their choice between the conditioned color and the other color afterward. We demonstrated that *D. suzukii* had an associative learning ability but it was limited to the association between green and soft. *Drosophila suzukii* conditioned with green and soft substrate preferred green as the first choice in the test phase. The proximate cause of this asymmetrical associative learning ability is completely unknown, but the pattern of learning coincides with *D. suzukii*'s preference for immature fruits on the tree in nature, possibly to avoid competition with other fruit flies. The associative learning ability of *D. suzukii* was found to be limited to a certain combination of color and firmness. It suggests that the asymmetrical association of the natural fruit color and physical properties played a role in the evolution of color-specific associative learning ability of *D. suzukii*.

Taning, C. N. T., Christiaens, O., Berkvens, N., Casteels, H., Maes, M., & Smagghe, G. (2016). Oral RNAi to control *Drosophila suzukii*. *Journal of Pest Science*, 89(3), 803-814.

The spotted wing *Drosophila* (*Drosophila suzukii*) is an invasive and serious economic pest to small and stone fruits and its control is difficult. RNA interference (RNAi) or double-stranded RNA (dsRNA)-mediated gene silencing is rapidly becoming a widely used functional genomics tool in insects and holds great potential for insect pest control. This study investigates whether RNAi is functional in *D. suzukii* and whether oral delivery of dsRNA can elicit gene silencing and insecticidal activity. Firstly, microinjection of dsRNA targeting two essential genes (*alpha COP* and *shrb*) into the haemolymph of adult flies was performed, confirming that the RNAi system is functional and that gene silencing results in mortality. Secondly, dsRNA targeting *alpha-COP* and two extra essential genes, *rpl13* and *vha26*, was mixed with artificial diet and fed to the larval and adult stages of *D. suzukii*. With naked dsRNA, no clear silencing and mortality were scored. However, combining dsRNA with a transfection reagent led to a significant increase in gene silencing and insect mortality. The best results were obtained with ds-*Vha26*. The results are discussed in relation to future optimization of the production, formulation, combinations and delivery of dsRNA.

Tochen, S., Walton, V. M., & Lee, J. C. (2016). Impact of floral feeding on adult *Drosophila suzukii*. *Journal of Pest Science*, 89(3), 793-802.

*Drosophila suzukii*, spotted wing drosophila, is a serious pest of small fruits and cherries in many regions of the world. While host usage has been well studied at the ovipositional and larval feeding stages, little is known about the feeding ecology and nutrient requirements of adults. This study addressed the impact of feeding on the survival and nutrient reserves of adult *D. suzukii* in laboratory assays. First, access to cherry blossoms increased survival rates of both adult males and females compared to water only. This suggests that these early spring blossoms may provide a food source for *D. suzukii* in fields that may be devoid of other food sources. Second, *D. suzukii* reared on a standard laboratory diet as larvae emerged as adults with minimal glycogen and sugar levels. Adults with continued access to a carbohydrate-protein diet showed rapidly elevated carbohydrate reserves, and adults with continued access to only water showed a decline in total sugars. Third, females with access to cherry or blueberry blossoms showed elevated carbohydrate reserves when compared to those with access to water only. These results illustrate the importance of adult feeding in enhancing survival and carbohydrate reserves among *D. suzukii*.

Tochen, S., Woltz, J. M., Dalton, D. T., Lee, J. C., Wiman, N. G., & Walton, V. M. (2016). Humidity affects populations of *Drosophila suzukii* (Diptera: Drosophilidae) in blueberry. *Journal of applied entomology*, 140(1-2), 47-57.

Cette veille bibliographique est réalisée par Nathalie Roullé et Nicolas Chatel-Launay, Pôle d'excellence en lutte intégrée (PELI).

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Temperature and humidity affect insect physiology, survival, fecundity, reproductive status and behaviour. Complementing previous work investigating the effects of temperature on adult survival and fecundity of the invasive frugivorous pest, *Drosophila suzukii* (Matsumura), this study was conducted to determine the effect of humidity on *D. suzukii* larval development, adult survival, fecundity and reproductive status using blueberry as a host substrate. The five constant humidity levels in laboratory bioassays were 20, 33, 71, 82 and 94% RH at  $20.6 \pm 0.2^\circ\text{C}$ . As RH increased, fecundity and longevity increased. At the higher humidity levels, RH had limited impact on mean generation times (T), larval development and eclosion times. The highest net reproductive rate ( $R_0 = 68$ ) and highest intrinsic rate of population increase ( $r_m = 0.17$ ) were both recorded at 94% RH. The reproductive status of females, as indicated by the number of mature oocytes per female, was significantly greater at 82 and 94% RH, compared to 71% RH. In addition to the laboratory procedures, we correlated field trap captures over an 81-day summer period to relative humidity (RH) levels in close proximity to those traps. In the field, low ambient humidity levels resulted in decreased trap captures. A humidity-dependent population model predicted lower densities of *D. suzukii* relative to populations at higher humidity. This study supports the hypothesis that cultural practices that minimize lower humidity levels in crops can contribute to the management of *D. suzukii*. Such methods may include open pruning, drip irrigation and field floor management.

Tonina, L., Mori, N., Giomi, F., & Battisti, A. (2016). Development of *Drosophila suzukii*. *Journal of Pest Science*, 89(3), 667-678. As a fly tracking the availability of fruits along climatic gradients, *Drosophila suzukii* is deemed to be rather flexible in relation to environmental factors, among which temperature is a major player. We sampled potential wild host fruits of *D. suzukii* along two elevational gradients in mountain areas of north-eastern Italy, in order to measure fly performance in relation to temperature. In addition, we used a strong natural temperature gradient in an open-top cave, covering the lower range of temperatures known for *D. suzukii*, to deploy laboratory stock colonies to mimic conditions existing along elevational gradients. At least nine wild host species yielded adults of *D. suzukii* in the mountain area (*Daphne mezereum*, *Lonicera alpigena*, *Lonicera caerulea*, *Lonicera nigra*, *Lonicera xylosteum*, *Rubus caesius*, *Rubus saxatilis*, *Sambucus nigra*, and *Sambucus racemosa*) when the daily average temperature in the three preceding weeks was at least  $11.1^\circ\text{C}$ . Similar results were obtained with the laboratory colonies reared on an artificial medium in the cave, where oviposition and development from egg to adult occurred at above  $11.6^\circ\text{C}$ . Both values are lower than previously recorded lower thresholds for development at both constant and fluctuating temperatures. These findings indicate that *D. suzukii* performs well at low temperatures, suggesting that population buildup may occur even under these conditions, with likely consequences on crops and wild host reproduction.

Toxopeus, J., Jakobs, R., Ferguson, L. V., Garipey, T. D., & Sinclair, B. J. (2016). Reproductive arrest and stress resistance in winter-acclimated *Drosophila suzukii*. *Journal of insect physiology*, 89, 37-51.

Overwintering insects must survive the multiple-stress environment of winter, which includes low temperatures, reduced food and water availability, and cold-active pathogens. Many insects overwinter in diapause, a developmental arrest associated with high stress tolerance. *Drosophila suzukii* (Diptera: Drosophilidae), spotted wing drosophila, is an invasive agricultural pest worldwide. Its ability to overwinter and therefore establish in temperate regions could have severe implications for fruit crop industries. We demonstrate here that laboratory populations of Canadian *D. suzukii* larvae reared under short-day, low temperature, conditions develop into dark 'winter morph' adults similar to those reported globally from field captures, and observed by us in southern Ontario, Canada. These winter-acclimated adults have delayed reproductive maturity, enhanced cold tolerance, and can remain active at low temperatures, although they do not have the increased desiccation tolerance or survival of fungal pathogen challenges that might be expected from a more heavily melanised cuticle. Winter-acclimated female *D. suzukii* have underdeveloped ovaries and altered transcript levels of several genes associated with reproduction and stress. While superficially indicative of reproductive

diapause, the delayed reproductive maturity of winter-acclimated *D. suzukii* appears to be temperature-dependent, not regulated by photoperiod, and is thus unlikely to be 'true' diapause. The traits of this 'winter morph', however, likely facilitate overwintering in southern Canada, and have probably contributed to the global success of this fly as an invasive species.

Wallingford, A. K., Lee, J. C., & Loeb, G. M. (2016). The influence of temperature and photoperiod on the reproductive diapause and cold tolerance of spotted-wing drosophila, *Drosophila suzukii*. *Entomologia Experimentalis et Applicata*, 159(3), 327-337.

Knowledge regarding the reproductive status of spotted-wing drosophila, *Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae), is of critical importance in predicting potential infestations of this invasive pest, as eggs are laid in ripe or ripening fruit of several commercially important small-fruit crops. Token environmental stimuli for the induction of reproductive diapause and improved cold tolerance were identified for *D. suzukii*. Diapause induction was evaluated by assessing, via dissection, the number of mature eggs carried by field-captured *D. suzukii* and laboratory-reared *D. suzukii* held under various temperature and photoperiod regimes. Egg load decreased over time in females trapped from July to December at sites in Benton County, OR, and Ontario County, NY, both USA, and reached zero eggs by December at all sites. Photoperiods below 14 h of day length led to reduced egg maturation in laboratory-reared flies held at moderate temperatures (15 or 20 °C). Whereas very few mature eggs were found in females held at 10 °C under short- or long-day photoperiods for several weeks after eclosion, a spontaneous return to ovarian maturity was observed in short-day-entrained females after 7 weeks. Diapause termination was investigated by evaluating fecundity in diapausing females returned to optimal environmental conditions. Whereas long-day-entrained flies began producing offspring immediately upon return to optimal conditions, short-day-entrained flies returned after 1 and 6 weeks at 10 °C were slower to produce offspring than colony flies or short-day-entrained flies returned after 7 weeks. Cold tolerance was evaluated by observing chill coma recovery rates after 24 h exposure to -1 °C. Cold-acclimated (diapausing) females recovered from chill coma faster than cold-hardened or unacclimated females.

Wallingford, A. K., & Loeb, G. M. (2016). Developmental Acclimation of *Drosophila suzukii* (Diptera: Drosophilidae) and Its Effect on Diapause and Winter Stress Tolerance. *Environmental Entomology*, 45(4), 1081-1089.

We investigated the influence of developmental conditions on adult morphology, reproductive arrest, and winter stress tolerance of the invasive pest of small fruit, *Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae). Cooler rearing temperatures (15 °C) resulted in larger, darker "winter morph" (WM) adults than "summer morph" flies reared at optimal temperatures (25 °C). Abdominal pigmentation scores and body size measurements of laboratory-reared WMs were similar to those of *D. suzukii* females captured in late autumn in Geneva, NY. We evaluated reproductive diapause and cold hardiness in live-captured *D. suzukii* WMs as well as WMs reared in the laboratory from egg to adult under four developmental conditions: static cool temperatures (SWM; 15 °C, 12:12 h L:D), fluctuating temperatures (FWM; 20 °C L: 10 °C D, 12:12 h L:D), and static cool temperatures (15 °C, 12:12 h L:D) followed by posteclosion chilling (CWM; 10 °C) under short-day (SD; 12:12 h L:D) or long-day photoperiods (LD; 16:8 h L:D). Live-captured *D. suzukii* WMs and CWMs had longer preoviposition times than newly eclosed summer morph adults, indicating a reproductive diapause that was not observed in SWMs or FWMs. Additionally, recovery after acute freeze stress was not different between CWM-SD females and live captured WM females. More 7-d-old CWMs survived 0, -1, or -3 °C freeze stress than summer morph adults, and more CWM-SD adults survived -3 °C freeze stress than CWM-LD adults. Survival after -3 °C freeze stress was significantly higher in diapausing, CWMs than nondiapausing SWMs and FWMs.

Walse, S. S., Jimenez, L. R., Hall, W. A., Tebbets, J. S., & Obenland, D. M. (2016). Optimizing postharvest methyl bromide treatments to control spotted wing drosophila, *Drosophila suzukii*, in sweet cherries from Western USA. *Journal of Asia-Pacific Entomology*, 19(1), 223-232.

Cette veille bibliographique est réalisée par Nathalie Roullé et Nicolas Chatel-Launay, Pôle d'excellence en lutte intégrée (PELI).

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Methyl bromide (MB) chamber fumigations were evaluated for postharvest control of spotted wing drosophila (SWD), *Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae), in fresh sweet cherry exports from Western USA. Sweet cherries were infested with SWD, incubated to maximize numbers of the most MB-tolerant specimens (ca. 60 to 108-h old at fumigation, 88% 3rd & 2nd instars), buried amongst uninfested fruit in bins consistent with commercial practice, cooled to an average pulp temperature  $\geq 8.3$  °C, and then fumigated in a chamber. Treatment efficacy was diagnosed by the percentage of survivors emerging as adults from fumigated cherries relative to that from non-fumigated control cherries. A kinetic model of sorption was developed based on the measurement of MB and how calculated exposures varied across the fumigation trials. The model describes how to manipulate the applied MB dose, fumigation duration, and the load factor so that the resultant exposure is adequate for SWD control across various pulp temperatures when cherries are fumigated in wooden versus plastic bins. Results are discussed in the context of graduation toward optimized quarantine fumigation schedules for control of SWD, which will promote more strategic technical and economic Quarantine Pre-shipment (QPS) use of MB.

Wang, X. G., Kaçar, G., Biondi, A., & Daane, K. M. (2016). Foraging efficiency and outcomes of interactions of two pupal parasitoids attacking the invasive spotted wing drosophila. *Biological Control*, 96, 64-71.

Two generalist pupal drosophilid parasitoids, *Pachycrepoideus vindemiae* (Rondani) (Hymenoptera: Pteromalidae) and *Trichopria drosophilae* Perkins (Hymenoptera: Diapriidae), are sympatric and among only a few parasitoid species attacking the invasive *Drosophila suzukii* Matsumura (Diptera: Drosophilidae) in many regions of the world. In this study, we evaluated their foraging efficiency when attacking *D. suzukii* infesting cherry fruit in a laboratory cage experiment; and we examined their potential interspecific interactions, including outcomes of intrinsic competition, host discrimination, and the impact of their interaction on pest control. We show that both parasitoids readily parasitized *D. suzukii* pupae located inside fruit or buried in soil. However, *T. drosophilae* was more efficient than *P. vindemiae* and that parasitism by either parasitoid species was higher in the fruit than in the soil. Generally, the parasitoid species that oviposited first in the host out-competed the later parasitoid in multi-parasitized hosts, we assume, through physiological suppression. Both parasitoids discriminated against hosts parasitized previously by the other species. In an additive-series design experiment with single (*D. suzukii*) or two (*D. suzukii* and *Drosophila melanogaster* Meigen) host species, *T. drosophilae* performed similarly regardless of the presence of a competitor, while *P. vindemiae* achieved a higher parasitism when alone. The observed parasitism when the two parasitoid species were present together was always lower than the expected one, assuming each species acted independently. This indicates a negative effect by *P. vindemiae* on interspecific competition on host suppression.

Wang, X. G., Kaçar, G., Biondi, A., & Daane, K. M. (2016). Life-history and host preference of *Trichopria drosophilae*. *BioControl*, 61(4), 387-397.

*Trichopria drosophilae* is a cosmopolitan pupal parasitoid that attacks many species of Drosophilidae, including the invasive *Drosophila suzukii*. This study reports on the life-history traits and host preferences of a Californian population of *T. drosophilae* and compares its life-time fecundity with a South Korean population of *T. drosophilae*. Female parasitoids emerge with a high mature egg-load ( $47.6 \pm 2.3$  eggs per female). The number of mature eggs of female *T. drosophilae* was affected by the female age and body size but not by the interaction between these two factors. The parasitoid did not show preference among differently aged (1–4 days old) *D. suzukii* pupae and host age did not affect the parasitoid's fitness, except that offspring developmental time slightly increased with host age. In a choice test, more offspring successfully developed from the larger *D. suzukii* than the smaller *D. melanogaster*, and adult females reared from *D. suzukii* were larger than those that were reared from *D. melanogaster*, apparently at no cost in parasitoid fitness. *T. drosophilae* females from the Californian and the South Korean populations survived 27.5 and 20.2 days,

produced a total of 63.8 and 52.0 offspring, and had an intrinsic rate of increase of 0.124 and 0.113, respectively, when provided with adult food and *D. suzukii* pupae as host material.

Wang, X. G., Stewart, T. J., Biondi, A., Chavez, B. A., Ingels, C., Caprile, J., ... & Daane, K. M. (2016). Population dynamics and ecology of *Drosophila suzukii*. *Journal of Pest Science*, 89(3), 701-712.

*Drosophila suzukii* is a serious pest of several fruit crop systems in California's Central Valley, which is one of the world's major fruit-growing regions. This study followed *D. suzukii* seasonal population dynamics in multiple cropping and riparian systems in four cherry-producing counties of the Valley. Apple cider vinegar baited traps were used to monitor *D. suzukii* adults weekly, from April 2013 to July 2014, in 28 fields. Results show peak captures in the spring and fall seasons. In cherry orchards, adult trap counts were the highest near harvest (June) and declined thereafter, as fly populations moved to other crop (e.g., citrus) or non-crop habitats. The number of captured adults was positively related between pairs of sampled sites based on their proximity but was negatively related to differences in fruit ripening periods between different crops, suggesting that fly populations moved among crop and/or non-crop habitats during the year or had varying population dynamics on different crops and in different seasons. Mature egg load per female was higher during the fruiting season but lower during the winter season, with the majority of winter-captured females not containing mature eggs. This survey also reports for the first time the presence of trapped *D. suzukii* adults bearing melanized and encapsulated parasitoids in North America, non-target captures of larval drosophilid parasitoids in the traps, as well as the occurrence of larvae in the ovaries of adult female *D. suzukii*.

Wiman, N. G., Dalton, D. T., Anfora, G., Biondi, A., Chiu, J. C., Daane, K. M., ... & Grassi, A. (2016). *Drosophila suzukii* population response to environment and management strategies. *Journal of Pest Science*, 89(3), 653-665.

*Drosophila suzukii* causes economic damage to berry and stone fruit worldwide. Laboratory-generated datasets were standardized and combined on the basis of degree days (DD), using Gompertz and Cauchy curves for survival and reproduction. Eggs transitioned to larvae at 20.3 DD; larvae to pupae at 118.1 DD; and pupae to adults at 200 DD. All adults are expected to have died at 610 DD. Oviposition initiates at 210 DD and gradually increases to a maximum of 15 eggs per DD at 410 DD and subsequently decreases to zero at 610 DD. These data were used as the basis for a DD cohort-level population model. Laboratory survival under extreme temperatures when DD did not accumulate was described by a Gompertz curve based on calendar days. We determined that the initiation of the reproductive period of late dormant field-collected female *D. suzukii* ranged from 50 to 800 DD from January 1. This suggests that *D. suzukii* females can reproduce early in the season and are probably limited by availability of early host plants. Finally, we used the DD population model to examine hypothetical stage-specific mortality effects of IPM practices from insecticides and parasitoids at the field level. We found that adulticides applied during the early season will result in the largest comparative population decrease. It is clear from model outputs that parasitism levels comparable to those found in field studies may have a limited effect on population growth. Novel parasitoid guilds could therefore be improved and would be valuable for IPM of *D. suzukii*.

Zhai, Y., Lin, Q., Zhang, J., Zhang, F., Zheng, L., & Yu, Y. (2016). Adult reproductive diapause in *Drosophila suzukii*. *Journal of Pest Science*, 89(3), 679-688.

*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 the ovarian development and oviposition rate under different photoperiods at  $10 \pm 1$  °C, and the percentage of adults with immature ovaries was higher during the short photoperiod (8L:16D) than other photoperiods at  $10 \pm 1$  °C. Adults were most sensitive to photoperiod within 3 days of eclosion. The optimal combination of photoperiod and temperature for diapause termination was a long photoperiod

(16L:8D) at  $25 \pm 1$  °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); glycogen and triglyceride levels were significantly increased (42.17 and 120.36 %). We conclude that *D. suzukii* is typical of 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.

## Articles parus en 2015

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Abraham, J., A. Zhang, S. Angeli, S. Abubeker, C. Michel, Y. Feng and C. Rodriguez-Saona (2015). "Behavioral and Antennal Responses of *Drosophila suzukii* (Diptera: Drosophilidae) to Volatiles From Fruit Extracts." *Environmental Entomology* 44(2): 356-367.

Native to Southeast Asia, the spotted wing drosophila, *Drosophila suzukii* Matsumura (Diptera: Drosophilidae), has become a serious pest of soft-skinned fruit crops since its introduction into North America and Europe in 2008. Current monitoring strategies use baits based on fermentation products; however, to date, no fruit-based volatile blends attractive to this fly have been identified. This is particularly important because females are able to cut into the epicarp of ripening fruit for oviposition. Thus, we conducted studies to: 1) investigate the behavioral responses of adult *D. suzukii* to volatiles from blueberry, cherry, raspberry, and strawberry fruit extracts; 2) identify the antennally active compounds from the most attractive among the tested extracts (raspberry) using gas chromatography (GC) mass spectrometry and coupled gas chromatography -electroantennographic detection (GC-EAD); and 3) test a synthetic blend containing the EAD-active compounds identified from raspberry extract on adult attraction. In olfactometer studies, both female and male *D. suzukii* were attracted to all four fruit extracts. The attractiveness of the fruit extracts ranks as: raspberry  $\geq$  strawberry  $>$  blueberry  $\geq$  cherry. GC analyses showed that the fruit extracts emit distinct volatile compounds. In GC-EAD experiments, 11 raspberry extract volatiles consistently elicited antennal responses in *D. suzukii*. In choice test bioassays, a synthetic EAD-active blend attracted more *D. suzukii* than a blank control, but was not as attractive as the raspberry extract. To our knowledge, this is the first report of a behaviorally and antennally active blend of host fruit volatiles attractive to *D. suzukii*, offering promising opportunities for the development of improved monitoring and behaviourally based management tools.

Andreazza, F., Bernardi, D., Botton, M., & Nava, D. E. (2015). Índice de infestação natural de *Drosophila suzukii* e *Zaprionus indianus* (Diptera: Drosophilidae) em frutíferas nativas no município de Pelotas, 4p.

Asplen, M. K., G. Anfora, A. Biondi, D. S. Choi, D. Chu, K. M. Daane, P. Gibert, A. P. Gutierrez, K. A. Hoelmer, W. D. Hutchison, R. Isaacs, Z. L. Jiang, Z. Karpati, M. T. Kimura, M. Pascual, C. R. Phillips, C. Plantamp, L. Ponti, G. Vetek, H. Vogt, V. M. Walton, Y. Yu, L. Zappala and N. Desneux (2015). "Invasion biology of spotted wing *Drosophila* (*Drosophila suzukii*): a global perspective and future priorities." *Journal of Pest Science* 88(3): 469-494.

The Asian vinegar fly *Drosophila suzukii* (spotted wing *Drosophila* [SWD]) has emerged as a major invasive insect pest of small and stone fruits in both the Americas and Europe since the late 2000s. While research efforts have rapidly progressed in Asia, North America, and Europe over the past 5 years, important new insights may be gained in comparing and contrasting findings across the regions affected by SWD. In this review, we explore common themes in the invasion biology of SWD by examining (1) its biology and current pest status in endemic and recently invaded regions; (2) current efforts and future research needs for the development of predictive models for its geographic expansion; and (3) prospects for both natural and classical (=importation) biological control of SWD in invaded habitats, with emphasis on the role of hymenopteran parasitoids. We conclude that particularly fruitful areas of research should include fundamental studies of its overwintering, host-use, and dispersal capabilities; as well as applied studies of alternative, cost-effective management techniques to complement insecticide use within the integrated pest

management framework. Finally, we emphasize that outreach efforts are critical to effective SWD management by highlighting successful strategies and insights gained from various geographic regions.

Audsley, N., & Down, R. E. (2015). G Protein coupled receptors as targets for next generation pesticides. *Insect biochemistry and molecular biology*, 67, 27-37.

There is an on-going need for the discovery and development of new pesticides due to the loss of existing products through the continuing development of resistance, the desire for products with more favourable environmental and toxicological profiles and the need to implement the principles of integrated pest management. Insect G protein coupled receptors (GPCRs) have important roles in modulating biology, physiology and behaviour, including reproduction, osmoregulation, growth and development. Modifying normal receptor function by blocking or over stimulating its actions may either result in the death of a pest or disrupt its normal fitness or reproductive capacity to reduce pest populations. Hence GPCRs offer potential targets for the development of next generation pesticides providing opportunities to discover new chemistries for invertebrate pest control. Such receptors are important targets for pharmaceutical drugs, but are under-exploited by the agro-chemical industry. The octopamine receptor agonists are the only pesticides with a recognized mode of action, as described in the classification scheme developed by the Insecticide Resistance Action Committee, that act via a GPCR. The availability of sequenced insect genomes has facilitated the characterization of insect GPCRs, but the development and utilization of screening assays to identify lead compounds has been slow. Various studies using knock-down technologies or applying the native ligands and/or neuropeptide analogues to pest insects *in vivo*, have however demonstrated that modifying normal receptor function can have an insecticidal effect. This review presents examples of potential insect neuropeptide receptors that are potential targets for lead compound development, using case studies from three representative pest species, *Tribolium castaneum*, *Acyrtosiphon pisum*, and *Drosophila suzukii*. Functional analysis studies on *T. castaneum* suggest that GPCRs involved in growth and development (eclosion hormone, ecdysis triggering hormone and crustacean cardioacceleratory peptide receptors) as well as the dopamine-2 like, latrophilin-like, starry night, frizzled-like, methuselah-like and the smoothed receptors may be suitable pesticide targets. From *in vivo* studies using native ligands and peptide analogues, receptors which appear to have a role in the regulation of feeding in the pea aphid, such as the PISCF-allatostatin and the various "kinin" receptors, are also potential targets. In *Drosophila melanogaster* various neuropeptides and their signalling pathways have been studied extensively. This may provide insights into potential pesticide targets that could be exploited in *D. suzukii*. Examples include the sex peptide receptor, which is involved in reproduction and host seeking behaviours, and those responsible for osmoregulation such as the diuretic hormone receptors. However the neuropeptides and their receptors in insects are often poorly characterized, especially in pest species. Although data from closely related species may be transferable (e.g. *D. melanogaster* to *D. suzukii*), peptides and receptors may have different roles in different insects, and hence a target in one insect may not be appropriate in another. Hence fundamental knowledge of the roles and functions of receptors is vital for development to proceed.

Audsley, N., R. E. Down and R. E. Isaac (2015). "Genomic and peptidomic analyses of the neuropeptides from the emerging pest, *Drosophila suzukii*." *Peptides* 68: 33-42.

*Drosophila suzukii* is a highly polyphagous invasive pest which has been recently introduced into Europe and North America, where it is causing severe economic losses through larval infestations of stone and berry fruits. The peptidome of the selected nervous tissues of adult *D. suzukii* was investigated as a first step in identifying potential targets for the development of novel insecticides. Through *in silico* analyses of the *D. suzukii* genome databases 28 neuropeptide families, comprising more than 70 predicted peptides were identified. Using a combination of liquid chromatography and mass spectrometry of tissue extracts, 33 predicted peptides, representing 15 different peptide families were identified by their molecular masses and a total of 17 peptide sequences were confirmed by ion fragmentation. A comparison between the peptides and precursors of *D. suzukii* and *D. melanogaster* shows they are highly conserved, with differences only identified in the amino acid sequences of the peptides encoded in the FMRamide, hugin and ecdysis triggering hormone precursors. All other peptides predicted and identified from *D. suzukii* appear to be identical to those previously characterized from *D. melanogaster*. Adipokinetic hormone was only identified in the corpus cardiacum, other peptides present included short neuropeptide F, a pyrokinin and myosuppressin, the latter of which was the only peptide identified from the crop nerve bundle. Peptides present in extracts of the brain and/or

Cette veille bibliographique est réalisée par Nathalie Roullé et Nicolas Chatel-Launay, Pôle d'excellence en lutte intégrée (PELI).

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thoracico-abdominal ganglion included allatostatins, cardioacceleratory peptide 2b, corazonin, extended FMRFamides, pyrokinins, myoinhibitory peptides, neuropeptide-like precursor 1, SIFamide, short neuropeptide F, kinin, sulfakinins and tachykinin related peptides. Crown Copyright (C) 2014 Published by Elsevier Inc. All rights reserved.

Bahder, B. W., L. D. Bahder, K. A. Hamby, D. B. Walsh and F. G. Zalom (2015). "Microsatellite Variation of two Pacific Coast *Drosophila suzukii* (Diptera: Drosophilidae) Populations." *Environmental Entomology* 44(5): 1449-1453.

The vinegar fly, *Drosophila suzukii* (Diptera: Drosophilidae), is a recent invader in North America that has become a serious threat to small fruit production. It was first detected in California in 2008 and in Washington state in 2009. In this study, *D. suzukii* populations from the area of the original detection on California's central coast and from eastern Washington, the United States, were sampled over a 3-year period to determine genetic variation in both using microsatellite markers. Six different loci were successfully amplified and included in the analysis. These loci included *nanos*, *elf1*, *antennapedia*, *mastermind*, *z600*, and *tenA*. The population from eastern Washington was highly monomorphic with one locus, *mastermind*, having multiple alleles. There was greater genetic variation in the coastal California population with all loci having multiple alleles, with the exception of *tenA*. Owing to the relatively low levels of genetic variation in the eastern Washington population compared with the coastal California population, it appears that the *D. suzukii* population in the eastern Washington region has undergone a significant bottleneck.

Baser, N., M. Ouantar, O. Broutou, F. Lamaj, V. Verrastro and F. Porcelli (2015). "First finding of *Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae) in Apulia, Italy, and its population dynamics throughout the year." *Fruits* 70(4): 225-230.

Introduction. *Drosophila suzukii* Matsumura (Spotted Wing *Drosophila*, SWD) is a pest that has been indicated as a major threat to European and Mediterranean fruit production. Its finding in Southern Italy offers interesting data to elaborate an efficient and sustainable control strategy. Materials and methods. The fly was collected during the "overhead" survey of an IAMB organic table grape vineyard by apple vinegar/wine/brown sugar bottle traps placed in and around the field. Once the presence of this pest was confirmed, traps were also hung on different host plants surrounding the vineyard, namely fig (*Ficus carica* L.), jujube (*Ziziphus jujuba* Mill.), pomegranate (*Punica granatum* L.), wild bramble (*Rubus fruticosus* L.) and rough bindweed (*Smilax aspera* L.). Collected *Drosophila* adults were identified via morphological parameters by comparison with published descriptions and drawings. The SWD adult population was monitored per month throughout the year and related to the average values of the temperature (degrees C) and minimum relative humidity (mRH%). The survey was carried out from September 2012 to August 2013. Results and discussion. We report the finding of *Drosophila suzukii* in Southern Italy, Apulia Region, and its population dynamics throughout the year in the area. In addition to *D. suzukii*, *D. melanogaster* (Meigen), *D. simulans* (Sturtevant) and similar species were also scored. The *D. suzukii* dynamics appeared to be strictly correlated with the temperature and relative humidity changes throughout the year, with a great summer population decrease. This behaviour is quite different from that of other indigenous *drosophilas*, both pest and non-pest. Conclusion. *D. suzukii* has, at present, a prominent pest status and may represent a key pest of soft fruit orchards in the South-Eastern part of Italy and, namely, in Apulia. However, further investigation on the marked decrease in the SWD summer population is needed to support effective pest control strategies, which include baited-lure mass trapping in Mediterranean and other warm climate areas. Such strategies should also take into consideration pest reservoirs such as secondary and semi-wild fruit species bred in the areas tested.

Bernert, A. (2015). Antifungal Properties of Spotted Wing *Drosophila* (*Drosophila suzukii*) Larvae (Doctoral dissertation).

Spotted wing *drosophila*, *Drosophila suzukii*, is a recently introduced, invasive pest in Oregon. It oviposits in near-mature and mature fruit, and thus is an important concern for the small fruit industry. A crop consultant observed that mature raspberry fruit with *D. suzukii* larvae do not show symptoms of molds as readily as fruit without larvae. We attempted to replicate these observations in the laboratory. A cage of *D. suzukii* was reared and then used for exposing raspberry fruit to ovipositing adults. Fruit were randomly assigned to control or exposed groups. Exposed fruit were placed in the cage for 1 hr and then incubated individually in 6-ml plastic cups with ventilated lids for 7 days (16-hr photoperiod) at 25°C. After incubation, fruit were assessed for number of fungal colonies and mold severity. Fruit with larvae had significantly fewer fungal colonies (paired t-test,  $P = 0.02$ ). A well diffusion test of the supernatant from *D. suzukii* infested raspberry fruit was likewise capable of significant radial growth inhibition in a saprobic fungus (paired t-

test,  $P < 0.05$ ). Future research could determine the mechanism of fungal inhibition. The implications of this study include a potential new antifungal agent as well as a better understanding of the *D. suzukii* life strategy.

Bjelis, M., I. Buljubasic, L. Popovic and T. M. Milek (2015). "Spread of the spotted wing drosophila - *Drosophila suzukii* (Diptera, Drosophilidae) and new distribution records in Dalmatia region of Croatia." *Bulletin OEPP* 45(2): 214-217.

A specific survey for the detection of *Drosophila suzukii* Matsumura 1931 (Diptera, Drosophilidae) in Dalmatia region of the Republic of Croatia during 2013, confirmed that the pest is present and widespread. Adults were detected in traps suspended in *Prunus cerasus* L. (sour cherry), *Prunus persica* L. (peach), *Ficus carica* L. (fig) and *Morus alba* L. (mulberry) orchards and individual trees, during the fruit maturation period, in 16 (of the 51 locations) where traps were placed in Dubrovako-neretvanska, Splitsko-dalmatinska, Sibensko-kninska and Zadarska counties. This confirmed the rapid spread of *D. suzukii* in Croatia and this pest is a great concern for areas that are not yet infested that have favourable conditions for the pests' development. The results of the survey highlight the importance of the development and implementation of long-term sustainable control.

Briem, F., Breuer, M., & Köppler Vogt, H. (2015). Phenology and occurrence of spotted wing *Drosophila* in Germany and case studies for its control in berry crops. *IOBC-WPRS Bull*, 109, 233-237.

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.

Burrack, H. J., M. Asplen, L. Bahder, J. Collins, F. A. Drummond, C. Guedot, R. Isaacs, D. Johnson, A. Blanton, J. C. Lee, G. Loeb, C. Rodriguez-Saona, S. van Timmeren, D. Walsh and D. R. McPhie (2015). "Multistate Comparison of Attractants for Monitoring *Drosophila suzukii* (Diptera: Drosophilidae) in Blueberries and Caneberries." *Environmental Entomology* 44(3): 704-712.

*Drosophila suzukii* Matsumura, also referred to as the spotted wing drosophila, has recently expanded its global range with significant consequences for its primary host crops: blueberries, blackberries, raspberries, cherries, and strawberries. *D. suzukii* populations can increase quickly, and their infestation is difficult to predict and prevent. The development of effective tools to detect *D. suzukii* presence in new areas, to time the beginning of activity within a crop, to track seasonal activity patterns, and to gauge the effectiveness of management efforts has been a key research goal. We compared the efficiency, selectivity, and relationship to fruit infestation of a range of commonly used homemade baits and a synthetic formulated lure across a wide range of environments in 10 locations throughout the United States. Several homemade baits were more efficient than apple cider vinegar, a commonly used standard, and a commercially formulated lure was, in some configurations and environments, comparable with the most effective homemade attractant as well as potentially more selective. All alternative attractants also captured flies between 1 and 2 wk earlier than apple cider vinegar, and detected the presence of *D. suzukii* prior to the development of fruit infestation. Over half the *Drosophila* spp. flies captured in traps baited with any of the attractants were not *D. suzukii*, which may complicate their adoption by nonexpert users. The alternative *D. suzukii* attractants tested are improvement on apple cider vinegar and may be useful in the development of future synthetic lures.

Carrillo, G. M., B. R. Velez, J. A. S. Gonzalez and H. C. A. Bernal (2015). "Trapping and Recording of the Parasitoid *Pachycrepoideus vindemmiae* (Rondani) (Hymenoptera: Pteromalidae) of *Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae) in Mexico." *Southwestern Entomologist* 40(1): 199-203.

Cha, D. H., S. P. Hesler, S. Park, T. B. Adams, R. S. Zack, H. Rogg, G. M. Loeb and P. J. Landolt (2015). "Simpler is better: fewer non-target insects trapped with a four-component chemical lure vs. a chemically more complex food-type bait for *Drosophila suzukii*." *Entomologia Experimentalis Et Applicata* 154(3): 251-260.

Cette veille bibliographique est réalisée par Nathalie Roullé et Nicolas Chatel-Launay, Pôle d'excellence en lutte intégrée (PELI).

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Baits - fermented food products - are generally attractive to many types of insects, which makes it difficult to sort through non-target insects to monitor a pest species of interest. We test the hypothesis that a chemically simpler and more defined attractant developed for a target insect is more specific and attracts fewer non-target insects than a chemically more complex food-type bait. A four-component chemical lure isolated from a food bait and optimized for the spotted wing drosophila (SWD), *Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae), was compared to the original wine/vinegar bait to assess the relative responses of non-target insects. In several field experiments in Washington State, USA, it was shown that numbers of pest muscid flies, cutworm and armyworm moths, and pest yellowjackets were reduced in traps baited with the chemical lure compared to the wine/vinegar bait. In other field experiments in the states of Washington, Oregon, and New York, numbers of non-target drosophilid flies were also reduced in traps baited with the chemical lure relative to wine/vinegar bait. In Washington, numbers of *Drosophila melanogaster* Meigen and *Drosophila obscura* Fallen species groups and *Drosophila immigrans* Sturtevant were reduced in the chemical lure traps, whereas in New York, *D.melanogaster* and *D.obscura* species groups, *D.immigrans*, *Drosophila putrida* Sturtevant, *Drosophila simulans* Sturtevant, *Drosophila tripunctata* Loew, and *Chymomyza* spp. numbers were reduced. In Oregon, this same effect was observed with the *D.melanogaster* species group. Taken together, these results indicate that the four-component SWD chemical lure will be more selective for SWD compared to fermentation baits, which should reduce time and cost involved in trapping in order to monitor SWD.

Collins, J. A., & Drummond, F. A. (2015). Spotted Wing *Drosophila* Control in the Laboratory, 2014. *Arthropod Management Tests*, 40(1), L1.

Colomar, L. A. E. (2015). Estudios desarrollados sobre los métodos biotecnológicos disponibles para el seguimiento y control de *Drosophila suzukii* en España. *Phytoma España: La revista profesional de sanidad vegetal*, (269), 20.

Cormier, D., Veilleux, J., & Firlej, A. (2015). Exclusion net to control spotted wing *Drosophila* in blueberry fields. *IOBC-WPRS Bull*, 109, 181-184.

In 2012, the populations of spotted wing drosophila, *Drosophila suzukii*, caused high levels of damage in soft fruit production in Quebec, Canada. In an organic blueberry field, we tested exclusion nets as a physical control method against *D. suzukii* adults. Exclusion nets were compared with insecticide treatments and control. Baited traps were placed to catch *D. suzukii* adults and blueberries were harvested regularly to evaluate different parameters. No *D. suzukii* adults were collected from traps and blueberries of the exclusion net treatment. However, adults were caught in traps and infested blueberries outside the nets. Nets had no significant effect on sugar content, yield and damage from other pests. Blueberries harvested inside the nets were significantly larger than blueberries from control plots. The results for this first year demonstrate the effectiveness of exclusion nets to protect blueberry plants from *D. suzukii* infestations.

Cowles, R. S., C. Rodriguez-Saona, R. Holdcraft, G. M. Loeb, J. E. Elsensohn and S. P. Hesler (2015). "Sucrose Improves Insecticide Activity Against *Drosophila suzukii* (Diptera: Drosophilidae)." *Journal of Economic Entomology* 108(2): 640-653.

The addition of sucrose to insecticides targeting spotted wing drosophila, *Drosophila suzukii* (Matsumura), enhanced lethality in laboratory, semifield, and field tests. In the laboratory, 0.1% sucrose added to a spray solution enhanced spotted wing drosophila feeding. Flies died 120 min earlier when exposed to spinosad residues at label rates enhanced with sucrose. Added sucrose reduced the LC50 for dried acetamiprid residues from 82 to 41 ppm in the spray solution. Laboratory bioassays of spotted wing drosophila mortality followed exposure to grape and blueberry foliage and/or fruit sprayed and aged in the field. On grape foliage, the addition of 2.4 g/liter of sugar with insecticide sprays resulted in an 11 and 6% increase of spotted wing drosophila mortality at 1 and 2 d exposures to residues, respectively, averaged over seven insecticides with three concentrations. In a separate experiment, spinetoram and cyantraniliprole reduced by 95-100% the larval infestation of blueberries, relative to the untreated control, 7 d after application at labeled rates when applied with 1.2 g/liter sucrose in a spray mixture, irrespective of rainfall; without sucrose infestation was reduced by 46-91%. Adding sugar to the organically acceptable spinosyn, Entrust, reduced larval infestation of strawberries by >50% relative to without sugar for five of the six sample dates during a season-long field trial. In a small-plot field test with blueberries, weekly applications in alternating sprays of sucrose plus reduced-risk insecticides,

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spinetoram or acetamiprid, reduced larval infestation relative to the untreated control by 76%; alternating bifenthrin and phosmet (without sucrose) reduced infestation by 65%.

Dekker, T., S. Revadi, S. Mansourian, S. Ramasamy, S. Lebreton, P. G. Becher, S. Angeli, O. Rota-Stabelli and G. Anfora (2015). "Loss of *Drosophila* pheromone reverses its role in sexual communication in *Drosophila suzukii*." Proceedings of the Royal Society B-Biological Sciences 282(1804).

The *Drosophila* pheromone cis-11-octadecenyl acetate (cVA) is used as pheromone throughout the melanogaster group and fulfils a primary role in sexual and social behaviours. Here, we found that *Drosophila suzukii*, an invasive pest that oviposits in undamaged ripe fruit, does not produce cVA. In fact, its production site, the ejaculatory bulb, is atrophied. Despite loss of cVA production, its receptor, Or67d, and cognate sensillum, T1, which are essential in cVA-mediated behaviours, were fully functional. However, T1 expression was dramatically reduced in *D. suzukii*, and the corresponding antennal lobe glomerulus, DA1, minute. Behavioural responses to cVA depend on the input balance of Or67d neurons (driving cVA-mediated behaviours) and Or65a neurons (inhibiting cVA-mediated behaviours). Accordingly, the shifted input balance in *D. suzukii* has reversed cVA's role in sexual behaviour: perfuming *D. suzukii* males with *Drosophila melanogaster* equivalents of cVA strongly reduced mating rates. cVA has thus evolved from a generic sex pheromone to a heterospecific signal that disrupts mating in *D. suzukii*, a saltational shift, mediated through offsetting the input balance that is highly conserved in congeneric species. This study underlines that dramatic changes in a species' sensory preference can result from rather 'simple' numerical shifts in underlying neural circuits.

De Ros, G., Conci, S., Pantezzi, T., & Savini, G. (2015). The economic impact of invasive pest *Drosophila suzukii* on berry production in the Province of Trento, Italy. *Journal of Berry Research*, 5(2), 89-96.

**BACKGROUND:** The fly *Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae) is an endemic pest, native to Southern Asia which has recently invaded western countries. Since its detection in 2008 in California and Spain, it is now established in North America and in many European countries. **OBJECTIVE:** This paper aims to evaluate the pest's economic impact on the soft fruit industry in the Province of Trento, a region in the North East of Italy, which is one of the most productive soft fruit areas in Europe. **METHODS:** The evaluation takes into account both the growers' potential revenue losses and the costs of pest control and uses a partial budgeting approach. Two scenarios are evaluated: the one before and the one after the implementation of an integrated control strategy for *D. suzukii*. **RESULTS:** Before the adoption of an integrated pest control strategy, the estimated revenue losses amounted to about 13% of the industry's output. After the implementation of an integrated strategy this loss decreased to about 7% of the industry's output. **CONCLUSIONS:** The adopted strategy seems effective in mitigating the pest's economic impact. The knowledge about *D. suzukii*'s impact and its management would benefit from further analysis encompassing a larger geographical scope and longer time series.

Erland, L. A., Rheault, M. R., & Mahmoud, S. S. (2015). Insecticidal and oviposition deterrent effects of essential oils and their constituents against the invasive pest *Drosophila suzukii* (Matsumura)(Diptera: Drosophilidae). *Crop Protection*, 78, 20-26.

Spotted wing drosophila (SWD), *Drosophila suzukii* (Matsumura), is an important new invasive pest of stone and berry fruits in North America and current control methods require frequent application of synthetic pesticides. This has created a need for new and environmentally friendly biopesticides for the control of SWD. This paper investigated the potential of nine essential oils from avocado (*Persea americana* Mill.), neem (*Azadirachta indica* A. Juss), kukui nut (*Aleurites moluccana* L.), macadamia nut (*Macadamia integrifolia* Maiden & Betche), spike lavender (*Lavandula latifolia* Vill.), Grosso lavandin leaf and flower (*Lavandula* × *intermedia* cv 'Grosso'), and Provence lavandin leaf and flower (*Lavandula* × *intermedia* cv 'Provence') as well as three major monoterpene constituents of lavender essential oils: 1,8-cineole, 3-carene and linalool for their ability to control SWD through fumigation and contact toxicity assays as well as oviposition deterrent activity. Linalool was found to be the most effective monoterpene in fumigation assays (EC50 1.85 µL/L air) and spike lavender floral essential oil was found to be the most effective whole oil (EC50 3.79 µL oil/L air). In contact toxicity assays 1,8-cineole (EC50 0.67%) was the most effective monoterpene while avocado (EC50 0.54%) and spike lavender (EC50 0.69%) oils were the most effective whole oils. No significant oviposition deterrent activity was observed. This report indicates that *L. latifolia* essential oil and commercially available avocado oil are strong lead candidates for management of SWD. Furthermore the activity of *L. latifolia* essential oil is likely due to the high content

of 1,8-cineole and linalool. This is the first report of significant insecticidal activity by these oils and compounds against SWD.

Everman, E. R., Cloyd, R. A., Copland, C., & Morgan, T. J. (2015). First Report of Spotted Wing *Drosophila*, *Drosophila suzukii* Matsumura (Diptera: Drosophilidae) in Kansas. *Journal of the Kansas Entomological Society*, 88(1), 128-133.

Ferguson, C. T. J., N. Audsley and R. E. Isaac (2015). "Sex peptide and the post-mating response in female *Drosophila suzukii*." *Amino Acids* 47(8): 1634-1635.

Ferguson, C. T., O'Neill, T. L., Audsley, N., & Isaac, R. E. (2015). The sexually dimorphic behaviour of adult *Drosophila suzukii*: elevated female locomotor activity and loss of siesta is a post-mating response. *Journal of Experimental Biology*, 218(23), 3855-3861.

The polyphagous *Drosophila suzukii* is a highly invasive species that causes extensive damage to a wide range of berry and stone fruit crops. A better understanding of its biology and especially its behaviour will aid the development of new control strategies. We investigated the locomotor behaviour of *D. suzukii* in a semi-natural environment resembling a typical summer in northern England and show that adult female *D. suzukii* are at least 4-fold more active during daylight hours than adult males. This result was reproduced in several laboratory environments and was shown to be a robust feature of mated, but not virgin, female flies. Both males and virgin females kept on a 12 h light:12 h dark (12LD) cycle and constant temperature displayed night-time inactivity (sleep) followed by weak activity in the morning, an afternoon period of quiescence (siesta) and then a prominent evening peak of activity. Both the siesta and the sharp evening peak at lights off were severely reduced in females after mating. Flies of either sex entrained in 12LD displayed a circadian pattern of activity in constant darkness confirming the importance of an endogenous clock in regulating adult activity. This response of females to mating is similar to that elicited in female *Drosophila melanogaster* by the male sex peptide (SP). We used mass spectrometry to identify a molecular ion ( $m/z$ , 5145) corresponding to the poly-hydroxylated SP of *D. suzukii* and to show that this molecule is transferred to the female reproductive tract during copulation. We propose that the siesta experienced by male and virgin female *D. suzukii* is an adaptation to avoid unnecessary exposure to the afternoon sun, but that mated females faced with the challenge of obtaining resources for egg production and finding oviposition sites take greater risks, and we suggest that the change in female behaviour is induced by the male SP.

Fraimout, A., Loiseau, A., Price, D. K., Xuéreb, A., Martin, J. F., Vitalis, R., ... & Estoup, A. (2015). New set of microsatellite markers for the spotted-wing *Drosophila suzukii* (Diptera: Drosophilidae): a promising molecular tool for inferring the invasion history of this major insect pest. *European Journal of Entomology*, 112(4), 855.

Historical and observational data for invasive species are often sparse and incomplete, so molecular genetic markers are increasingly used and have proved to be efficient tools to make inferences about invasion histories. Here, we report the development of 28 polymorphic microsatellite markers in the invasive spotted-wing drosophila, *Drosophila suzukii* (Matsumura, 1931) (Diptera: Drosophilidae) designed from recent genomics resources, and their cross-amplification in closely related *Drosophila* species of the *suzukii* subgroup. The markers, located on autosomal chromosomes, were characterized in two distinct invasive populations from France and Hawaii (USA), and in four sister species of the *suzukii* subgroup. They all showed substantial polymorphism as well as revealing strong genetic differentiation between the two genotyped populations. These markers represent a promising molecular tool for population genetic studies on *D. suzukii*, more especially in order to reconstruct the pathways and demographic processes of the world-wide invasion in this major insect pest.

Gabarra, R., J. Riudavets, G. A. Rodriguez, J. Pujade-Villar and J. Arno (2015). "Prospects for the biological control of *Drosophila suzukii*." *Biocontrol* 60(3): 331-339.

The invasive pest *Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae) causes serious economic damage in several soft fruit crops. This study aimed (1) to identify naturally occurring parasitoids and predators of this pest in North East Spain and (2) to get preliminary data on their potential as pest biological control agents. Two parasitoid species were found spontaneously parasitizing *D. suzukii*: *Pachycrepoideus vindemmiae* (Rondani) (Hymenoptera: Pteromalidae) and *Trichopria cf. drosophilae* Perkins (Hymenoptera: Diapriidae). Both species were found repeatedly through the survey

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period and successfully reproduced in the laboratory on *D. suzukii* pupae. In addition, both species strongly reduced adult emergence of *D. suzukii* from infested fruits. Regarding predators, *Orius laevigatus* (Fieber) (Hemiptera: Anthochoridae) were able to feed on *D. suzukii* eggs but not on larvae whereas the soil predator *Labidura riparia* Pallas (Dermaptera: Labiduridae) consumed *D. suzukii* larvae and pupae and was effective in reducing pest populations in laboratory tests.

Goffin, J., & Beliën, T. (2015). Overleeft *Drosophila suzukii* de winter 2014-2015. *Fruiteeltnieuws*, 6-20 maart.

Guzzon, R., Anfora, G., Grassi, A., & Ioriatti, C. (2015). Un nuovo ed efficace attrattivo per la cattura di *Drosophila Suzukii* basato su ceppi di *Oenococcus oeni*. In 38th World Congress of Vine and Wine (Part 2) (Vol. 5, p. 05003). EDP Sciences.

*Drosophila suzukii* (SWD) è un insetto parassita di grande rilevanza per la vite. Tra le strategie di contrasto le esche attrattive sono uno strumento fondamentale per un controllo efficiente e sostenibile di questo parassita. Recentemente gli autori hanno sviluppato un'esca alimentare, chiamata Droskidrink, in grado di garantire buone catture di SWD. Tuttavia nuovi e più efficienti strumenti sono necessari per il controllo di questo parassita. Questo lavoro prende avvio dallo studio delle caratteristiche chimiche e microbiologiche del Droskidrink, in relazione ai meccanismi di attrazione verso SWD. È stato così dimostrato che metaboliti caratteristici di fermentazioni batteriche rivestono un fondamentale ruolo nell'attrazione verso SWD. È stata quindi sperimentata l'aggiunta di ceppi batterici all'esca per incrementarne l'attrattività. Trappole innescate con Droskidrink e inoculate con batteri lattici sono state testate nel 2014 in provincia di Trento. Le esche fermentate sono state caratterizzate mediante GC-MS per identificare il profilo dei composti volatili emessi dai batteri. Gli estratti ottenuti dallo spazio di testa di ogni esca sono stati utilizzati per un'analisi elettroantennografica, registrando la risposta delle antenne di SWD. Tutti i risultati concordano nell'individuare in 3 ceppi di *Oenococcus oeni* i batteri più attrattivi verso SWD. Questo lavoro fornisce nuove conoscenze nella biologia di SWD e informazioni utili per la produzione efficaci esche per la cattura di questo insetto.

Hardin, J. A., D. A. Kraus and H. J. Burrack (2015). "Diet quality mitigates intraspecific larval competition in *Drosophila suzukii*." *Entomologia Experimentalis Et Applicata* 156(1): 59-65.

The invasive frugivore *Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae) utilizes a wide range of host plants and damages important fruit crops, including blueberries, cherries, blackberries, raspberries, and strawberries. Field infestations of *D. suzukii* often exceed one larva per berry, suggesting that intraspecific competition may frequently occur. Because dietary resources are also likely to vary across the host range of *D. suzukii*, we designed a laboratory assay to measure larval performance across diets of varying quality: a standard artificial diet, a fruit-based medium, a low-protein, and a low-carbohydrate diet. We manipulated egg density across these diets to provide increasing levels of competition and measured larval performance by observing survival to pupation and adulthood, and development times for both life stages. Although increasing density generally negatively impacted *D. suzukii* performance across diets, the magnitude of these impacts varied by diet type. *Drosophila suzukii* performance was generally similar in fruit and standard diets, although larval development was more rapid in fruit diets at lower densities. Even at low densities (5 or 10 eggs per arena), survival was reduced and development time increased in low-protein diets relative to standard and fruit diets. At the two highest larval densities (20 or 40 eggs per arena), survivorship was reduced in low-carbohydrate diets as compared to standard and fruit diets. There is evidence that larvae compensated in both low-quality diets by extending development time, which could have consequences for population dynamics. Population models for use in *D. suzukii* management may need to account for both host nutritional quality and relative competition to accurately predict turnover and geographic expansion.

Herrel, A., B. Villaroel, R. Cornette, T. Decamps and V. Debat (2015). "Phenotypic plasticity and flight performance in relation to developmental temperature in the invasive species *Drosophila suzukii*." *Integrative and Comparative Biology* 55: E78-E78.

Hottel, B. A., J. L. Spencer and S. T. Ratcliffe (2015). "Trapping *Drosophila repleta* (Diptera: Drosophilidae) using color and volatiles." *Florida Entomologist* 98(1): 272-275.

Iacovone, A., Girod, P., Ris, N., Weydert, C., Gibert, P., Poirié, M., & Gatti, J. L. (2015). Worldwide invasion by *Drosophila suzukii*: does being the "cousin" of a model organism really help setting up biological control? Hopes, disenchantments and new perspectives.

L'invasion récente et rapide de *Drosophila suzukii* en Europe et en Amérique du Nord a suscité de nombreuses études sur le terrain comme en laboratoire. Cette drosophile est en effet à la fois un ravageur important, du fait de son développement dans des fruits à maturité, et une « cousine » de l'espèce modèle *Drosophila melanogaster* dont la biologie et la génétique sont bien connues. Cet article s'appuie sur les données publiées par différentes équipes et sur des résultats préliminaires pour discuter de l'avancée des recherches et notamment des questions suivantes: en quoi nos connaissances sur *D. melanogaster* peuvent-elles ou non aider à comprendre et gérer l'invasion de *D. suzukii* ? Les résultats obtenus en condition de laboratoire avec cette espèce sont-ils représentatifs de sa biologie ? Comment mesurer l'impact écologique d'une espèce invasive si la niche qu'elle vient occuper est peu décrite localement en termes d'espèces présentes et de réseaux trophiques ? Cet article discute aussi des pistes et contraintes en termes de lutte biologique et de biocontrôle.

Ioriatti, C., Boselli, M., Caruso, S., Galassi, T., Gottardello, A., Grassi, A., ... & Mori, N. (2015). Approccio integrato per la difesa dalla *Drosophila suzukii*. *Frutticoltura*, 4, 32-36.

Ioriatti, C., V. Walton, D. Dalton, G. Anfora, A. Grassi, S. Maistri and V. Mazzoni (2015). "*Drosophila suzukii* (Diptera: Drosophilidae) and its Potential Impact to Wine Grapes During Harvest in Two Cool Climate Wine Grape Production Regions." *Journal of Economic Entomology* 108(3): 1148-1155.

*Drosophila suzukii* (Matsumura) is a global pest attacking various berry crops. *Drosophila suzukii* lays eggs in damaged and in intact wine grape berries of the most soft-skinned varieties. Here, we describe the relative host utilization of different wine grape cultivars grown in Northern Italy and Oregon. Assessments of host berry utilization were performed in both field and laboratory settings. Results were correlated to physiological changes occurring during grape berry development starting at veraison and concluding during harvest. We found that oviposition increased with an increase in sugar content and a decrease of acidity levels. Oviposition increased with a decrease of penetration force. Penetration force, as a measure of skin hardness, is a critical component of host selection among the *Drosophila suzukii*-exposed cultivars. We demonstrated that incised berries are more favorable for *Drosophila suzukii* oviposition and as a nutrient substrate. Increased presence on wine grapes, as indicated by egg laying and increased longevity, was observed for flies that were exposed to incised berries as opposed to fully intact berries. *Drosophila suzukii* flies can be found feeding on damaged wine grapes during the harvest period, especially when the skins of berries are negatively impacted due to cracking, disease, hail injury, and bird damage. Such an increase of feeding and oviposition may increase the likelihood of spoilage bacteria vectoring due to *Drosophila suzukii*.

Iwasaki, S., Sasaki, H. M., Sakaguchi, Y., Suzuki, T., Tadakuma, H., & Tomari, Y. (2015). Defining fundamental steps in the assembly of the *Drosophila* RNAi enzyme complex. *Nature*, 521(7553), 533-536.

Small RNAs such as small interfering RNAs (siRNAs) and microRNAs (miRNAs) silence the expression of their complementary target messenger RNAs<sup>1, 2</sup> via the formation of effector RNA-induced silencing complexes (RISCs), which contain Argonaute (Ago) family proteins at their core. Although loading of siRNA duplexes into *Drosophila* Ago2 requires the Dicer-2-R2D2 heterodimer<sup>3, 4, 5</sup> and the Hsc70/Hsp90 (Hsp90 also known as Hsp83) chaperone machinery<sup>6, 7, 8</sup>, the details of RISC assembly remain unclear. Here we reconstitute RISC assembly using only Ago2, Dicer-2, R2D2, Hsc70, Hsp90, Hop, Droj2 (an Hsp40 homologue) and p23. By following the assembly of single RISC molecules, we find that, in the absence of the chaperone machinery, an siRNA bound to Dicer-2-R2D2 associates with Ago2 only transiently. The chaperone machinery extends the dwell time of the Dicer-2-R2D2-siRNA complex on Ago2, in a manner dependent on recognition of the 5'-phosphate on the siRNA guide strand. We propose that the chaperone machinery supports a productive state of Ago2, allowing it to load siRNA duplexes from Dicer-2-R2D2 and thereby assemble RISC.

Jakobs, R., T. D. Garipey and B. J. Sinclair (2015). "Adult plasticity of cold tolerance in a continental-temperate population of *Drosophila suzukii*." *Journal of Insect Physiology* 79: 1-9.

*Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae) is a worldwide emerging pest of soft fruits, but its cold tolerance has not been thoroughly explored. We determined the cold tolerance strategy, low temperature thermal limits, and plasticity of cold tolerance in both male and female adult *D. suzukii*. We reared flies under common conditions (long days, 21 degrees C; control) and induced plasticity by rapid cold-hardening (RCH, 1 h at 0 degrees C followed by 1 h recovery), cold acclimation (CA, 5 days at 6 degrees C) or acclimation under fluctuating temperatures (FA). *D. suzukii* had supercooling points (SCPs) between -16 and -23 degrees C, and were chill-susceptible. 80% of control flies were killed after 1 h at -7.2 degrees C (males) or -7.5 degrees C (females); CA and FA improved survival of this temperature in both sexes, but RCH did not. 80% of control flies were killed after 70 h (male) or 92 h (female) at 0 degrees C, and FA shifted this to 112 h (males) and 165 h (females). FA flies entered chill coma (CTmin) at approximately -1.7 degrees C, which was ca. 0.5 degrees C colder than control flies; RCH and CA increased the CTmin compared to controls. Control and RCH flies exposed to 0 degrees C for 8 h took 30-40 min to recover movement, but this was reduced to <10 min in CA and FA. Flies placed outside in a field cage in London, Ontario, were all killed by a transient cold snap in December. We conclude that adult phenotypic plasticity is not sufficient to allow *D. suzukii* to overwinter in temperate habitats, and suggest that flies could overwinter in association with built structures, or that there may be additional cold tolerance imparted by developmental plasticity. (C) 2015 Elsevier Ltd. All rights reserved.

Jaramillo, S. L., E. Mehlferber and P. J. Moore (2015). "Life-history trade-offs under different larval diets in *Drosophila suzukii* (Diptera: Drosophilidae)." *Physiological Entomology* 40(1): 2-9.

Most larval drosophilids eat the microorganisms that develop in rotting fruit, a relatively protein-rich resource. By contrast, the spotted-wing *Drosophila suzukii* Matsumura (Diptera: Drosophilidae) uniquely develops in ripening fruit, a protein-poor, carbohydrate-rich resource. This shift in larval nutritional niche has led to *D. suzukii* being a significant agricultural pest in the U.S.A. and Europe. Although occupying a new niche may benefit a species by reducing competition, adaptation in host use may generate trade-offs affecting fitness. To test the hypothesis that fitness trade-offs will change with adaptation to novel larval diets, *D. suzukii* larval development on either a diet of a fresh, ripe blueberry (a natural host) or standard artificial *Drosophila media* (protein-rich) is compared and the effect of diet on development time from egg to adult, adult body size and male wing spot area, and female fecundity is assessed. Larval development time differs, with larvae on the blueberry emerging as adults earlier than those on the artificial medium, although other fitness measures do not vary between the two diets. In addition, the faster development time on a blueberry does not trade off with body size as expected, although early fecundity is delayed in females that develop on blueberries. Thus, adaptation to a novel larval diet environment does not come at a cost to the ability to develop in protein-rich resources.

Kaçar, G., Wang, X. G., Stewart, T. J., & Daane, K. M. (2015). Overwintering survival of *Drosophila suzukii* (Diptera: Drosophilidae) and the effect of food on adult survival in California's San Joaquin Valley. *Environmental entomology*, nvv182.

The overwintering survival and development of *Drosophila suzukii* Matsumura were investigated in California's San Joaquin Valley. *Drosophila suzukii* were exposed to overwintering conditions in cages hung in a citrus orchard, and the pupae were buried in the soil. Eggs exposed from late November to January did not survive; a low percentage (<3%) of larvae and pupae developed into adults. Survival of pupae was significantly higher when buried in the soil than on the citrus tree. From late January to March, all life stages developed into adults and overwintered adult female *D. suzukii* produced eggs when provided with 10% honey-water and sliced oranges. Adult survival varied among fruit juice provision treatments and overwintering exposure periods, ranging from 3.4 ± 0.9 d (water) to 44.1 ± 3.0 d (10% honey-water). Fruit juices of apple, cherry, grape, orange, and pomegranate were tested as adult food sources; results showed that adult female and male *D. suzukii* lived only 2 d with water only, whereas adults survived from 14.2 to 34.8 d with fruit juice treatments and the 10% honey-water control. An unexpected event was the oviposition and immature development of *D. suzukii* with the fruit juice. In a follow-up laboratory trial, when 10% honey-water or orange juice were provided along with an artificial diet for oviposition and immature development, female *D. suzukii* survived for 21.6 ± 2.4 or 21.6 ± 1.5 d, and produced 106.8 ± 14.1 or 98.5 ± 13.1 offspring, respectively. We discuss factors potentially influencing overwintering survival of *D. suzukii*.

Keesey, I. W., M. Knaden and B. S. Hansson (2015). "Olfactory Specialization in *Drosophila suzukii* Supports an Ecological Shift in Host Preference from Rotten to Fresh Fruit." *Journal of Chemical Ecology* 41(2): 121-128.

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It has been demonstrated that *Drosophila suzukii* is capable of attacking ripening fruit, making it a unique species within a fly family named for their attraction towards the fermentation products associated with rotten fruits, vinegar, and yeast. It also has been hypothesized that *D. suzukii* is more attracted to the volatiles associated with the earlier ripening stages of fruit development, and in turn, that *D. suzukii* is less attracted to fermented food resources, especially when compared with *D. melanogaster*. Here, we demonstrate that *D. suzukii* and its close relative *D. biarmipes* are in fact more sensitive to volatiles associated with the fruit-ripening process; however, in choice-assays, both spotted-wing species are more attracted to fermented fruit than to earlier stages of fruit development, which is similar to the behavioral preferences of *D. melanogaster*, and thus, fruit developmental stage alone does not explain the ecological niche observed for *D. suzukii*. In contrast, we show that both *D. suzukii* and *D. biarmipes* are more attracted to leaf odors than *D. melanogaster* in behavioral trials. For *D. suzukii*, this differential behavioral preference towards leaves appears to be linked to beta-cyclocitral, a volatile isoprenoid that we show is most likely a novel ligand for the "ab3A" neuron. In addition, this compound is not detected by either of the other two tested fly species.

Kim, M. J., Kim, J. S., Park, J. S., Choi, D. S., Park, J., & Kim, I. (2015). Oviposition and development potential of the spotted-wing drosophila, *Drosophila suzukii* (Diptera: Drosophilidae), on uninjured Campbell Early grape. *Entomological Research*, 45(6), 354-359.

The spotted-wing drosophila (SWD), *Drosophila suzukii* (Diptera: Drosophilidae), originally distributed across a few Asian countries including South Korea, has invaded North America and Europe but is absent from Australia. In order to export the South Korean grape cultivar Campbell Early to Australia, its potential to serve as an oviposition and development medium for SWD must first be determined. In this study, we determined the oviposition and development potential of SWD on Campbell Early, after elucidating the SWD life cycle and establishing an artificial diet-based mass-culturing system. An investigation of the life cycle under five temperature regimes (16, 19, 22, 25 and 28°C) showed that the durations of the egg, larval and adult stages were shortened when temperature was increased from 16, 19, 22, 25 and 28°C, but pupal duration was shortest at 25°C and extended again at 28°C. A test of oviposition and development potential of SWD on Campbell Early grape clusters showed oviposition of  $30.8 \pm 6.8$  eggs per cluster of injured grapes and  $157.7 \pm 16.2$  eggs on a culture dish of artificial diet. However, in a similar experiment using uninjured grape clusters, only a single egg was deposited on the grape skin, which soon dried. In light of these results, newly harvested grapes left at vineyards during daily harvests are unlikely to serve as an oviposition and development medium for SWD, as long as the grapes remain uninjured.

Kirkpatrick, D. M., McGhee, P. S., Hermann, S. L., Gut, L. J., & Miller, J. R. (2015). Alightment of spotted wing drosophila (diptera: Drosophilidae) on odorless disks varying in color. *Environmental entomology*, nvv155.

Methods for trapping spotted wing drosophila, *Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae), have not yet been optimized for detecting this devastating pest of soft-skinned fruits. Here, we report outcomes of choice and no-choice laboratory bioassays quantifying the rates of spotted wing drosophila alightment on 5-cm-diameter sticky disks of various colors, but no fruit odors. Red, purple, and black disks captured the most spotted wing drosophila when presented against a white background. Male and female spotted wing drosophila responded identically in these tests. Significantly more *D. suzukii* were captured on the red and yellow disks than those presenting the corresponding grayscale for that color, proving that *D. suzukii* perceives colors and not just the level of target brightness. Fluorescent red is the best candidate for trap color, while clear and white are the least desirable. However, when the background was switched to black, all nonfluorescent colors were equally acceptable to spotted wing drosophila, suggesting that background must be specified when reporting spotted wing drosophila color preference. Additional spotted wing drosophila research is justified on the effects of target color against natural backgrounds.

Klick, J., W. Q. Yang and D. J. Bruck (2015). "Marking *Drosophila suzukii* (Diptera: Drosophilidae) With Rubidium or N-15." *Journal of Economic Entomology* 108(3): 1447-1451.

*Drosophila suzukii* Matsumura (Diptera: Drosophilidae) has caused significant economic damage to berry and stone fruit production regions. Markers that are systemic in plants and easily transferred to target organisms are needed to track *D. suzukii* exploitation of host resources and trophic interactions. High and low concentrations of the trace element, rubidium (Rb), and the stable isotope, N-15, were tested to mark *D. suzukii* larvae feeding on fruits of enriched strawberry plants grown in containers under greenhouse conditions. Fly marker content and proportion of flies marked

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1, 7, and 14 d after emergence from enriched fruits and fly dry mass were analyzed. Nearly 100% of the flies analyzed 14 d after emerging from N-15-enriched plants were marked, whereas only 30-75% and 0-3% were marked 14 d after emerging from high and low Rb concentration plants, respectively. Rapid Rb decay, strong N-15 persistence, and the economics of using these markers in the field to elucidate *D. suzukii* pest ecology are discussed.

Knight, A. L., Basoalto, E., Yee, W., Hilton, R., & Kurtzman, C. P. (2015). Adding yeasts with sugar to increase the number of effective insecticide classes to manage *Drosophila suzukii* (Matsumura)(Diptera: Drosophilidae) in cherry. *Pest management science*.

**BACKGROUND:** *Drosophila suzukii* is a major pest of cherry in the western United States. We evaluated whether the addition of sugary baits could improve the efficacy of two classes of insecticides not considered to be sufficiently effective for this pest, diamides and spinosyns, in laboratory and field trials in cherry. **RESULTS:** Adding cane sugar alone or in combination with the yeasts *Saccharomyces cerevisiae* or *Aureobasidium pullulans* significantly improved insecticide efficacy. However, the significance of adding yeasts to the sugar plus insecticide on fly mortality varied with respect to both the insecticide and yeast species. The addition of *S. cerevisiae* to sugar also did not significantly reduce egg densities in fruit compared with sugar alone. The addition of a yeast plus sugar significantly reduced egg densities in three field trials with cyantraniliprole and in two out of three trials with spinosad. **CONCLUSION:** The addition of cane sugar with or without yeast can improve the effectiveness of diamide and spinosyn insecticides for *D. suzukii* in cherry. Inclusion of these two insecticides in *D. suzukii* management programs may alleviate the strong selection pressure currently being imposed on a few mode-of-action insecticide classes used by growers to maintain fly suppression over long continuous harvest periods of mixed cultivars. Published 2015. This article is a U.S. Government work and is in the public domain in the USA.

Krause Pham, C. and A. Ray (2015). "Conservation of Olfactory Avoidance in *Drosophila* Species and Identification of Repellents for *Drosophila suzukii*." *Scientific Reports* 5: 11527-11527.

Flying insects use olfaction to navigate towards fruits in complex odor environments with remarkable accuracy. Some fruits change odor profiles substantially during ripening and related species can prefer different stages. In *Drosophila* species attractive odorants have been studied extensively, but little is understood about the role of avoidance pathways. In order to examine the role of the avoidance cue CO<sub>2</sub> emitted from fruit on behavior of two species with different ripening stage preferences, we investigated the CO<sub>2</sub>-detection pathway in *Drosophila melanogaster* and *Drosophila suzukii*, a harmful pest of fruits. Avoidance to CO<sub>2</sub> is not conserved in *D. suzukii* suggesting a behavioral adaptation that could facilitate attraction to younger fruit with higher CO<sub>2</sub> emission levels. We investigated known innate avoidance pathways from five species at different evolutionary distances: *D. melanogaster*, *D. yakuba*, *D. suzukii*, *D. pseudoobscura* and *D. virilis*. Surprisingly, only DEET shows strong repellency across all species, whereas CO<sub>2</sub>, citronellal and ethyl 3-hydroxybutyrate show only limited conservation. These findings guide us to test recently discovered safe DEET substitutes, and we identify one that protects fruits from *D. suzukii* thus providing a new behavioral strategy for controlling agricultural pests.

Łabanowska, B. H., & Piotrowski, W. (2015). The spotted wing drosophila *Drosophila suzukii* (Matsumura, 1931)—monitoring and first records in Poland. *Journal of Horticultural Research*, 23(2), 49-57.

The spotted wing drosophila (*Drosophila suzukii*) (SWD) monitoring was carried out between 2012-2014 in eight locations. In order to determine the presence of *Drosophila suzukii*, several types of traps and baits were used. In 2014, Polish (prototype of Drosinal) and Spanish (Cera Trap) traps and baits were used in our study. In each year, traps were placed on the plantations of blueberry, strawberry, raspberry and at a wholesale market at the beginning of July, and monitored once or twice a week until mid-December. During 2012 and 2013 there were no flies of the spotted wing drosophila in traps. First flies of this species were captured in 2014 in two locations: Września (3rd week of October) and Brzezna (1st week of December) – western and southern Poland respectively, in both types of the traps. However, Polish traps were more effective in trapping *D. suzukii*. In addition, the Polish product has small holes and therefore captures less no target and beneficial insects than Spanish traps. Despite detection of SWD in Poland, damaged fruits were not found.

Lafargue, P. (2015). Évaluation d'un parasitoïde exotique, *Asobara japonica* (Ichneumonoidea, Braconidae), contre le diptère ravageur *Drosophila suzukii* (Diptera, Drosophilidae).

<https://hal-agrocampus-ouest.archives-ouvertes.fr/dumas-01205530/document>

Lam, S. S., & Howell, K. S. (2015). *Drosophila*-associated yeast species in vineyard ecosystems. *FEMS microbiology letters*, 362(20), fnv170.

Yeast activity during wine fermentation directly contributes to wine quality, but the source and movement of yeasts in vineyards and winery environments have not been resolved. Here, we investigate the yeast species associated with the *Drosophila* insect vector to help understand yeast dispersal and persistence. *Drosophila* are commonly found in vineyards and are known to have a mutualistic relationship with yeasts in other ecosystems. *Drosophilids* were collected from vineyards, grape waste (marc) piles and wineries during grape harvest. Captured flies were identified morphologically, and their associated yeasts were identified. *Drosophila melanogaster*/*D. simulans*, *D. hydei* and *Scaptodrosophila lativittata* were identified in 296 captured *Drosophila* flies. These flies were associated with *Metschnikowia pulcherrima*, *Hanseniasspora uvarum*, *Torulaspora delbrueckii* and *H. valbyensis* yeasts. Yeast and *Drosophila* species diversity differed between collection locations (vineyard and marc:  $R = 0.588$  for *Drosophila* and  $R = 0.644$  for yeasts). Surprisingly, the primary wine fermentation yeast, *Saccharomyces cerevisiae*, was not isolated. *Drosophila* flies are preferentially associated with different yeast species in the vineyard and winery environments, and this association may help the movement and dispersal of yeast species in the vineyard and winery ecosystem.

Landi, S., E. Gargani, F. Paoli, S. Simoni and P. F. Roversi (2015). "Morphological Markers for Cryopreservation in the Embryonic Development of *Drosophila suzukii* (Diptera: Drosophilidae)." *Journal of Economic Entomology* 108(4): 1875-1883.

*Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae) is an invasive pest recently reported in Europe whose spread into new areas has caused severe economic damage to many agricultural crops. There are serious concerns about the currently available chemical insecticides because of their low efficacy in controlling the species and their environmental impact; so, several studies have focused on environmentally safe strategies. The sterile insect technique (SIT), which requires colony maintenance in laboratory and production of large numbers of live animals, can be utilized in pest management programs and could be integrated with other control strategies if the potential risks associated with the rearing and maintenance of the insect line under laboratory conditions are given sufficient attention. In this regard, the ability to cryobiologically preserve such stocks would be of substantial value. Important prerequisites for long-term cryopreservation are determination of the embryonic stages, identification of specific embryonic stages, and knowledge of development time. This paper describes the main visible markers for the different stages of embryonic development and determines the timing of development at 25 degrees C. *D. suzukii* embryogenesis lasts 23-25 h at 25 degrees C and can be divided into 17 stages defined by specific morphological markers. The point at which 50% of embryos are at Stage 14 and 50% are at Stage 15, the most tolerant stages for cryopreservation treatment, as ascertained for *Drosophila melanogaster* Meigen in prior studies, is reached in 14-15 h. The efficiency of this procedure might be impaired by the retention of eggs in the oviducts, making it impossible to determine the stage of embryonic development for similar to 25% of laid eggs.

Lasa, R. and E. Tadeo (2015). "Invasive drosophilid pests *Drosophila suzukii* and *Zaprionus indianus* (Diptera: Drosophilidae) in Veracruz, Mexico." *Florida Entomologist* 98(3): NIL\_173-NIL\_174.

The invasive drosophilid pests *Drosophila suzukii* (Matsumura) and *Zaprionus indianus* Gupta (Diptera: Drosophilidae) were captured in traps baited with hydrolyzed protein lures during a trial aimed at monitoring *Anastrepha* flies infesting guava, *Psidium guajava* L. (Myrtales: Myrtaceae) in Xico, Veracruz, Mexico, during Sep 2014. This is the first record of these species in Veracruz State. These exotic species represented over 80% of the total drosophilid flies captured. Studies on the commercial impact of these pests in guava and in the production of other fruit species in the region should be considered a priority.

Lee, J. C., A. J. Dreves, A. M. Cave, S. Kawai, R. Isaacs, J. C. Miller, S. Van Timmeren and D. J. Bruck (2015). "Infestation of Wild and Ornamental Noncrop Fruits by *Drosophila suzukii* (Diptera: Drosophilidae)." *Annals of the Entomological Society of America* 108(2): 117-129.

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*Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae) is a pest of small fruits and cherries, and has also been noted to infest a variety of wild, ornamental, and uncultivated hosts. Identifying alternative hosts is critical for pest management. Research objectives were to: 1) survey fruits in the field for natural infestation of *D. suzukii*, 2) determine the susceptibility of fruits in laboratory no-choice studies, and 3) evaluate short-range preference between simultaneously ripe alternative hosts and cultivated fruits in laboratory choice studies. Field surveys identified new hosts or confirmed previously reported hosts including: *Berberis aquifolium* Pursh, Oregon grape; *Cornus* spp., dogwood; *Cotoneaster lacteus* W.W. Smith, milkflower cotoneaster; *Elaeagnus umbellata* Thunberg, Autumn olive; *Frangula purshiana* (de Candolle) A. Gray, cascara buckthorn; *Lindera benzoin* (L.) Blume, spicebush; *Lonicera caerulea* L., blue honeysuckle; *Morus* sp., mulberry; *Phytolacca americana* L., pokeweed; *Prunus avium* (L.) L., wild cherry; *Prunus laurocerasus* L., cherry laurel; *Prunus lusitanica* L., Portuguese laurel; *Rubus armeniacus* Focke, Himalaya blackberry; *Rubus spectabilis* Pursh, salmonberry; *Sambucus nigra* L., black elderberry; *Sarcococca confusa* Sealy, sweet box; *Solanum dulcamara* L., bitter-sweet nightshade; and *Symphoricarpos albus* (L.) S.F. Blake, snowberry. High fruit infestations were observed in *S. confusa* during April-May and *Lonicera* spp. in June before most commercial fruits ripen. From both field and laboratory studies, there was no evidence of susceptibility during the estimated ripe period *Crataegus* L. 'Autumn Glory,' hawthorn; *Ilex crenata* Thunberg, Japanese holly; *Nandina domestica* Thunberg, sacred bamboo; *Rhaphiolepis umbellata* (Thunberg) Makino, yeddo hawthorne; *Rosa acicularis* Lindley, prickly rose; *Skimmia japonica* Thunberg, Japanese skimmia; and *Viburnum davidii* Franchet, David's viburnum. Lastly, laboratory choice tests identified that several fall-ripening alternative hosts were more susceptible than 'Pinot noir' or 'Pinot gris' wine grapes. By understanding host use, growers can identify high-risk areas where coordinated action may reduce infestation of *D. suzukii* in crops.

Lengyel, G. D., S. Orosz, B. Kiss, R. Luptak and Z. Karpati (2015). "NEW RECORDS AND PRESENT STATUS OF THE INVASIVE SPOTTED WING DROSOPHILA, DROSOPHILA SUZUKII (MATSUMURA, 1931) (DIPTERA) IN HUNGARY." *Acta Zoologica Academiae Scientiarum Hungaricae* 61(1): 73-80.

The spotted wing drosophila (*Drosophila suzukii* (Matsumura, 1931) - SWD) is one of the most recently introduced invasive pests of economical importance in Europe. It has invaded many countries in Europe and North America causing significant losses in fruit production. In 2012, the species has been detected for the first time in Hungary at a highway rest area. The following year a countrywide trapping program was conducted to monitor the spreading of the species. In 2013, thirty-three highway rest areas and furthermore cherry, strawberries, raspberries, peach, grape orchards were monitored using apple vinegar bait traps. Altogether 33 individuals of SWD have been captured in 5 localities along highways in western Hungary, including the collecting site of the first detection. On the other hand the species was not found in countryside orchards. The location of the collecting sites indicates that international transport along highways plays an important role in spreading of SWD. Highway infrastructures, like selective trash bins, or buildings may serve as refugee spots for SWD. The role of vehicle transport in the spreading of SWD is also supported by the relatively high spreading rate of SWD, which was estimated around 320-390 km year<sup>-1</sup>.

Linder, C., Kehrl, P., Kuske, S., & Viret, O. (2015). *Drosophila suzukii* en viticulture Recommandations 2015. *Revue suisse de viticulture, arboriculture et horticulture*, 47(3), 161-162.

[http://www.rouvinez.com/multimedia/docs/2015/07/Drosophila\\_suzukii\\_en\\_viticulture-Recommandations\\_2015\\_agroscope.pdf](http://www.rouvinez.com/multimedia/docs/2015/07/Drosophila_suzukii_en_viticulture-Recommandations_2015_agroscope.pdf)

Masson, C. (2015). Amélioration des connaissances sur le ravageur *Drosophila suzukii* afin d'affiner les méthodes de lutte en verger de cerisiers (Doctoral dissertation, Centre technique interprofessionnel des fruits et légumes (Ctifl), 751 chemin de Balandran, 30127 Bellegarde).

<https://hal-agrocampus-ouest.archives-ouvertes.fr/dumas-01203432/document>

Mazzetto, F., E. Gonella and A. Alma (2015). "Wolbachia infection affects female fecundity in *Drosophila suzukii*." *Bulletin of Insectology* 68(1): 153-157.

Bacteria in the genus *Wolbachia* are intracellular symbionts widespread in several arthropod species that majorly cause reproductive alterations in their hosts, but may also display a variety of other beneficial or negative interactions. In this study, an antibiotic-treated *Wolbachia*-free line of *Drosophila suzukii* Matsumura (Diptera Drosophilidae) was created in

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the laboratory for mating with the naturally Wolbachia-infected flies. Crossing experiments on two consecutive fly generations between antibiotic-treated and untreated individuals were carried out to evaluate the effect of Wolbachia on *D. sukuzii*. The results obtained showed no difference in the vitality of parental individuals; nevertheless a reduction of 30-50% in emerging progeny abundance was recorded in all crosses when females were cured of Wolbachia. These results suggest a mutualistic association between Wolbachia and *D. sukuzii*, resulting in increased female fecundity. Further research on this symbiotic interaction could have promising implications for developing symbiotic strategies for the containment of *D. sukuzii*.

Mazzetto, F., M. G. Pansa, B. L. Ingegno, L. Tavella and A. Alma (2015). "Monitoring of the exotic fly *Drosophila sukuzii* in stone, pome and soft fruit orchards in NW Italy." *Journal of Asia-Pacific Entomology* 18(2): 321-329.

After its introduction in Europe, *Drosophila sukuzii* Matsumura (Diptera: Drosophilidae), an invasive pest native to South-East Asia, has rapidly spread into many European countries, including Italy, causing several economic losses on stone fruits and berries. Therefore, monitoring of fly adults and fruit damage was carried out in stone, pome and soft fruit orchards in two areas in NW Italy in 2011-2012. In 2012, different types of vinegars and traps [apple cider vinegar (ACV), mixture of wine vinegar and ACV, rice vinegar in transparent traps; ACV in red traps] were also used in the field; moreover, the responses of females to these vinegars were evaluated in the laboratory through a two-choice olfactometer. In the two-year field surveys, adults of *D. sukuzii* were trapped in all orchards. In both years, after few specimens were caught in early spring, adults were no longer found until June. The captures increased in late summer, reaching higher peaks in October and November. In winter, the population decreased severely, but a few adults were still caught. At harvest, no damage was found on stone and pome fruits. Instead, severe yield losses occurred on berries, especially on later cultivars. In the field, the numbers of adults sampled by the tested vinegars fluctuated highly during the season, but significant differences were found only between red traps and the other ones. In the laboratory, ACV was the most attractive substance for fly females in the two-choice olfactometer. (C) 2015 Korean Society of Applied Entomology, Taiwan Entomological Society and Malaysian Plant Protection Society. Published by Elsevier B.V. All rights reserved.

Miller, B., Anfora, G., Buffington, M., Dalton, D. T., Miller, J. C., Wiman, N. G., & Walton, V. M. (2015). Seasonal occurrence of resident parasitoids associated with *Drosophila sukuzii* in two small fruit production regions of Italy and the USA.

For the first time we report the results of a survey to determine the presence, seasonal phenology and biological control status of indigenous parasitoid populations utilizing *Drosophila sukuzii* (Matsumura) and *Drosophila melanogaster* Meigen (Diptera Drosophilidae) as hosts in Trento Province, Northern Italy, and the Willamette Valley, Oregon, USA. Larval and pupal parasitoids were sampled using sentinel traps baited with larvae of *D. sukuzii* or *D. melanogaster*, or traps baited with fruit or yeast-based host substrates. Two generalist parasitoids, *Pachycrepoideus vindemiae* (Rondani) (Hymenoptera Pteromalidae) and *Leptopilina heterotoma* (Thomson) (Hymenoptera Figitidae) emerged from the sentinel traps in both regions, and a third generalist parasitoid, *Trichopria drosophilae* Perkins (Hymenoptera Diapriidae), was found in Italy. *L. heterotoma* was present during the early portion of the season in Italy while *P. vindemiae* was found throughout the growing season in both production regions. Low numbers of parasitoids relative to initial larval load in baits suggest a limited effect of indigenous parasitoids on *D. sukuzii* in these two important fruit production regions. These findings highlight the need for improved biological control of *D. sukuzii* through introduction or augmentation of specialist parasitoids from the native range of *D. sukuzii*. This report provides baseline data on the current status of biological control of *D. sukuzii* in Italy and Oregon.

Moreno Carrillo, G., B. Rodriguez Velez, J. A. Sanchez Gonzalez and H. C. Arredondo Bernal (2015). "Trapping and Recording of the Parasitoid *Pachycrepoideus vindemiae* (Rondani) (Hymenoptera: Pteromalidae) of *Drosophila sukuzii* (Matsumura) (Diptera: Drosophilidae) in Mexico." *Southwestern Entomologist* 40(1): 199-203.

*Drosophila sukuzii* (Matsumura) is an invasive and polyphagous species native to Southeast Asia, capable of causing severe economic damage to the fruits of its hosts. The first record in Mexico of this Diptera was for the state of Michoacan, subsequently was reported for the states of Colima, Jalisco and Baja California. Sentinel traps with pupae of *D. sukuzii* were placed in areas of blackberry crops to attract its parasitoids. From those traps, specimens of *Pachycrepoideus vindemiae* (Rondani) were obtained; this association was already registered in the United States and Europe in cherries and blackberries, but this is the first record for Mexico.

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Murphy, K. A., T. R. Unruh, L. M. Zhou, F. G. Zalom, P. W. Shearer, E. H. Beers, V. M. Walton, B. Miller and J. C. Chiu (2015). "Using comparative genomics to develop a molecular diagnostic for the identification of an emerging pest *Drosophila suzukii*." *Bulletin of Entomological Research* 105(3): 364-372.

*Drosophila suzukii* (Spotted Wing *Drosophila*) has recently become a serious invasive pest of fruit crops in the USA, Canada, and Europe, leading to substantial economic losses. *D. suzukii* is a direct pest, ovipositing directly into ripe or ripening fruits; in contrast, other *Drosophilids* utilize decaying or blemished fruits and are nuisance pests at worst. Immature stages of *D. suzukii* are difficult to differentiate from other *Drosophilids*, posing problems for research and for meeting quarantine restrictions designed to prevent the spread of this pest in fruit exports. Here we used a combined phylogenetic and bioinformatic approach to discover genetic markers suitable for a species diagnostic protocol of this agricultural pest. We describe a molecular diagnostic for rapid identification of single *D. suzukii* larva using multiplex polymerase chain reaction. Our molecular diagnostic was validated using nine different species of *Drosophila* for specificity and 19 populations of *D. suzukii* from different geographical regions to ensure utility within species.

Nomano, F. Y., H. Mitsui and M. T. Kimura (2015). "Capacity of Japanese *Asobara* species (Hymenoptera; Braconidae) to parasitize a fruit pest *Drosophila suzukii* (Diptera; Drosophilidae)." *Journal of Applied Entomology* 139(1-2): 105-113.

*Drosophila suzukii* is a pest of soft fruit such as cherry, strawberry or blueberry and recently colonized North America and Europe from Asia. In this study, we assessed the utility of Japanese *Asobara* species as agents for the biological control of this pest species by examining their host use in nature and their capacity to parasitize this pest species. From Japan, eight *Asobara* species including putative three undescribed species were found; *Asobara japonica* was recorded from all over Japan, *Asobaratabida* from high altitude areas in central and northern Japan, *Asobararossica* and *Asobara rufescens* from central to northern Japan, three undescribed species from central to western or southern Japan and *Asobarapleuralis* from a subtropical island of Japan. Among them, an undescribed species *Asobara* sp. TK1 may be useful as an agent for the biological control because it was recorded only from *D. suzukii*. All of the remaining seven species were generalists mainly using *drosophilid* species associated with fermenting fruits, and four of them had no or very low abilities to parasitize *D. suzukii*, indicating that these seven species are not or less appropriate as agents for biological control.

Núñez, L. M. G., & Sánchez-Ramos, I. I. (2015). Desarrollo de estrategias para el manejo sostenible de *Drosophila suzukii*. *Phytoma España: La revista profesional de sanidad vegetal*, (269), 29.

Pham, C. K. and A. Ray (2015). "Conservation of Olfactory Avoidance in *Drosophila* Species and Identification of Repellents for *Drosophila suzukii*." *Scientific Reports* 5.

Flying insects use olfaction to navigate towards fruits in complex odor environments with remarkable accuracy. Some fruits change odor profiles substantially during ripening and related species can prefer different stages. In *Drosophila* species attractive odorants have been studied extensively, but little is understood about the role of avoidance pathways. In order to examine the role of the avoidance cue CO<sub>2</sub> emitted from fruit on behavior of two species with different ripening stage preferences, we investigated the CO<sub>2</sub>-detection pathway in *Drosophila melanogaster* and *Drosophila suzukii*, a harmful pest of fruits. Avoidance to CO<sub>2</sub> is not conserved in *D. suzukii* suggesting a behavioral adaptation that could facilitate attraction to younger fruit with higher CO<sub>2</sub> emission levels. We investigated known innate avoidance pathways from five species at different evolutionary distances: *D. melanogaster*, *D. yakuba*, *D. suzukii*, *D. pseudoobscura* and *D. virilis*. Surprisingly, only DEET shows strong repellency across all species, whereas CO<sub>2</sub>, citronellal and ethyl 3-hydroxybutyrate show only limited conservation. These findings guide us to test recently discovered safe DEET substitutes, and we identify one that protects fruits from *D. suzukii* thus providing a new behavioral strategy for controlling agricultural pests.

Poyet, M., Le Roux, V., Gibert, P., Meirland, A., Prévost, G., Eslin, P., & Chabrerie, O. (2015). The wide potential trophic niche of the Asiatic fruit fly *Drosophila suzukii*: the key of its invasion success in temperate Europe?. *PloS one*, 10(11), e0142785.

The Asiatic fruit fly *Drosophila suzukii* has recently invaded Europe and North and South America, causing severe damage to fruit production systems. Although agronomic host plants of that fly are now well documented, little is

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known about the suitability of wild and ornamental hosts in its exotic area. In order to study the potential trophic niche of *D. suzukii* with relation to fruit characteristics, fleshy fruits from 67 plant species were sampled in natural and anthropic ecosystems (forests, hedgerows, grasslands, coastal areas, gardens and urban areas) of the north of France and submitted to experimental infestations. A set of fruit traits (structure, colour, shape, skin texture, diameter and weight, phenology) potentially interacting with oviposition choices and development success of *D. suzukii* was measured. Almost half of the tested plant species belonging to 17 plant families allowed the full development of *D. suzukii*. This suggests that the extreme polyphagy of the fly and the very large reservoir of hosts producing fruits all year round ensure temporal continuity in resource availability and contribute to the persistence and the exceptional invasion success of *D. suzukii* in natural habitats and neighbouring cultivated systems. Nevertheless, this very plastic trophic niche is not systematically beneficial to the fly. Some of the tested plants attractive to *D. suzukii* gravid females stimulate oviposition but do not allow full larval development. Planted near sensitive crops, these "trap plants" may attract and lure *D. suzukii*, therefore contributing to the control of the invasive fly.

Profaizer, D., Grassi, A., Zadra, E., & Maistri, S. (2015). Efficacy of insecticide treatment strategies against *Drosophila suzukii* in combination with mass trapping. *IOBC-WPRS Bulletin*, 109, 215-218.

Quarles, W. (2015). IPM for Spotted Wing *Drosophila*. In *The IPM Practitioner* (Vol. 35, pp. 1-7).

<http://www.birc.org/FinalOctober2015.pdf>

Radonjic, S., & Hrnčić, S. (2015). First record of spotted wing drosophila *Drosophila suzukii* (Diptera: Drosophilidae) in Montenegro.

The spotted wing drosophila *Drosophila suzukii* Matsumura (Diptera: Drosophilidae) is an invasive pest originating from Southeast Asia. It was detected for the first time in Europe in 2008 (Spain and Italy) and subsequently in other European countries. It is a highly polyphagous pest that infests healthy, ripening fruit and presents a serious threat to fruit production, particularly of soft skinned fruit. In the first half of October 2013, a new fruit fly species was unexpectedly detected in Tephri traps baited with the three-component female-biased attractant BioLure that is regularly used for monitoring the Mediterranean fruit fly *Ceratitis capitata* Wiedem. (Diptera: Tephritidae) in Montenegro. Brief visual inspection identified the new species as the spotted wing drosophila *D. suzukii*. The pest was first recorded in several localities on the Montenegrin seacoast around Boka Kotor Bay. After the finding, all *Drosophila* specimens were collected from traps for further laboratory observation. A quick follow-up monitoring of other Tephri traps was carried out within the next few days on the rest of the seacoast (localities from Tivat to Ulcinj). Additionally, Tephri traps were set up around Lake Skadar and in the city of Podgorica, as well as on fresh fruit markets in Podgorica. The results of this preliminary study showed that *D. suzukii* was present in all surveyed locations and adults were captured until late December. Both sexes were found in traps with BioLure. Our data show that *D. suzukii* is present in southern parts of Montenegro and there is a serious threat of its further spreading, particularly towards northern parts of the country where the main raspberry and blueberry production is placed. The results also show that Tephri traps baited with BioLure can be used for detection and monitoring of spotted wing drosophila.

Renkema, J. M., Z. Telfer, T. Garipey and R. H. Hallett (2015). "Dalotia coriaria as a predator of *Drosophila suzukii*: Functional responses, reduced fruit infestation and molecular diagnostics." *Biological Control* 89: 1-10.

*Drosophila suzukii* Matsumura is a recent invasive fruit pest in North and South America and Europe, causing pre-harvest damage and significant economic losses to crops. Little is known about biological control of *D. suzukii*; here we report the predatory capability of *Dalotia (Atheta) coriaria* Kraatz, a commercially available control agent against small dipteran pests, and develop molecular tools to assess predation. *Da. coriaria* showed a Type II functional response to all *D. suzukii* instars, with maximal consumption of 26 first, 15 second, and 6 third instars per beetle per day. No pupae were consumed. When raspberries with 11-21 larvae (2nd-3rd instar) per berry were exposed to six *Da. coriaria* for 4.5 d, a 50% reduction in infestation occurred. A primer pair for *D. suzukii* was designed that produced a 112 bp amplicon from the mtDNA CO1 gene. Of 19 *Drosophila* species tested, DNA from one species in the invaded range of *D. suzukii* was amplified, but it was distinguishable from *D. suzukii* due to different amplicon melting temperatures. A standard curve was created, relating amount of second instar *D. suzukii* DNA to Cq values (amount of fluorescence) generated by

qPCR. In a feeding trial, the half-life of *D. suzukii* DNA was 2.3 h in *Da. coriaria*, but the estimated median detection time was 25.9 h. *D. suzukii* DNA was detected in *Da. coriaria* exposed to infested raspberries, but DNA quantity in beetles was only weakly related to predation rates. The control potential of *Da. coriaria* against *D. suzukii* should be further assessed, and molecular tools used to identify other *D. suzukii* predators. (C) 2015 Elsevier Inc. All rights reserved.

Revadi, S., S. Lebreton, P. Witzgall, G. Anfora, T. Dekker and P. G. Becher (2015). "Sexual Behavior of *Drosophila suzukii*." *Insects* 6(1): 183-196.

A high reproductive potential is one reason for the rapid spread of *Drosophila suzukii* in Europe and in the United States. In order to identify mechanisms that mediate mating and reproduction in *D. suzukii* we studied the fly's reproductive behavior, diurnal mating activity and sexual maturation. Furthermore, we studied the change of female cuticular hydrocarbons (CHCs) with age and conducted a preliminary investigation on the role of female-derived chemical signals in male mating behavior. Sexual behavior in *D. suzukii* is characterized by distinct elements of male courtship leading to female acceptance for mating. Time of day and age modulate *D. suzukii* mating activity. As with other drosophilids, female sexual maturity is paralleled by a quantitative increase in CHCs. Neither female CHCs nor other olfactory signals were required to induce male courtship, however, presence of those signals significantly increased male sexual behavior. With this pilot study we hope to stimulate research on the reproductive biology of *D. suzukii*, which is relevant for the development of pest management tools.

Revadi, S., S. Vitagliano, M. V. R. Stacconi, S. Ramasamy, S. Mansourian, S. Carlin, U. Vrhovsek, P. G. Becher, V. Mazzoni, O. Rota-Stabelli, S. Angeli, T. Dekker and G. Anfora (2015). "Olfactory responses of *Drosophila suzukii* females to host plant volatiles." *Physiological Entomology* 40(1): 54-64.

*Drosophila suzukii* Matsumura, an endemic pest in southeast Asia, has invaded Europe and the U.S.A. Unlike most of its closely related sibling species, the serrated ovipositor of *D. suzukii* permits ovipositing in undamaged fresh fruits. In the present study, volatiles are identified from host plants that are potentially involved in *D. suzukii* host recognition and oviposition behaviour. It is shown that mated females are attracted to volatiles emitted from intact fruits. The antennally-active suite of compounds released from the fresh fruits is identified by gas chromatography coupled with electroantennographic detection, as well as gas chromatography-mass spectrometry. In olfactometer bioassays, mated females are significantly attracted to an electroantennographically active volatile, isoamyl acetate, when tested at 10 µg of synthetic compound in a rubber septa, which has a release rate comparable to that of fresh fruits. In addition, a genomic survey shows that *D. suzukii* not only possesses the full repertoire of genes encoding odorant receptors activated by isoamyl acetate in *D. melanogaster*, but also that one of the genes, OR67a, is represented by five duplicated copies. These results indicate that *D. suzukii* uses olfactory cues to select oviposition sites. The identification of volatiles emitted by host fruits that attract *D. suzukii* may aid in the development of a selective and efficient synthetic lure for monitoring this pest. As a close relative of *Drosophila melanogaster*, *D. suzukii* provides a unique opportunity for understanding the physiological mechanisms involved in the shift of this species from use of rotten to ripe fruits for oviposition.

Rosensteel, D. O., & Sial, A. A. (2015). Season-long Management of *Drosophila suzukii* in Southern Highbush Blueberry, 2014. *Arthropod Management Tests*, 40(1), C12.

Sampson, B. J., Stafne, E. T., Marshall-Shaw, D. A., Stringer, S. J., Mallette, T., Werle, C. T., & Larson, D. (2015, June). Environmental ethanol as a reproductive constraint on spotted wing drosophila and implications for control in *Rubus* and other fruits. In XI International *Rubus* and *Ribes* Symposium 1133 (pp. 411-418).

Spotted wing drosophila (SWD), *Drosophila suzukii* Mat. (Diptera: Drosophilidae), is a recent fruit pest of the Americas whose destructiveness stems from its subcutaneous insertion of eggs into cultivated berries via the female's prominent double bladed and serrated ovipositor. Atypical of most other *Drosophila*, *D. suzukii* adults and larvae are non-saprophagous and therefore do not have to contend with fermented substrates containing toxic levels of ethanol. Here, we test whether *D. suzukii* can safely ingest environmental ethanol, which could have important implications for host selection, reproductive potential, chemical control, and the need for crop sanitation. We designed a series of laboratory

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experiments to measure critical life history traits of *D. suzukii* feeding on *Rubus* and *Vaccinium* in an ethanolic environment. These life history traits included adult survivorship, sex ratio, and optimal reproductive output. *D. suzukii* were quite sensitive to ethanol when compared with *D. melanogaster*. Ethanol concentrations >2.5% reduced both pupal and adult production of SWD and increased adult mortality. Male SWD were 2 to 3 times more sensitive to ethanol than were females with sex ratios increasingly favoring females at higher concentrations. These results suggest that little if any overlap between the niches of SWD and native *D. melanogaster* will enable these species to coexist. In fact, SWD may create more habitat for wild *Drosophila* at the expense of both wild and cultivated fruit species.

Scheidler, N. H., C. Liu, K. A. Hamby, F. G. Zalom and Z. Syed (2015). "Volatile codes: Correlation of olfactory signals and reception in *Drosophila*-yeast chemical communication." *Scientific Reports* 5.

*Drosophila* have evolved strong mutualistic associations with yeast communities that best support their growth and survival, resulting in the development of novel niches. It has been suggested that flies recognize their cognate yeasts primarily based on the rich repertoire of volatile organic compounds (VOCs) derived from the yeasts. Thus, it remained an exciting avenue to study whether fly spp. detect and discriminate yeast strains based on odor alone, and if so, how such resolution is achieved by the olfactory system in flies. We used two fly species known to exploit different niches and harboring different yeasts, *D. suzukii* (a pest of fresh fruit) and *D. melanogaster* (a saprophytic fly and a neurogenetic model organism). We initially established the behavioral preference of both fly species to six *Drosophila*-associated yeasts; then chemically analyzed the VOC profile of each yeast which revealed quantitative and qualitative differences; and finally isolated and identified the physiologically active constituents from yeast VOCs for each *drosophilid* that potentially define attraction. By employing chemical, behavioral, and electrophysiological analyses, we provide a comprehensive portrait of the olfactory neuroethological correlates underlying fly-yeast coadaptation in two *drosophilids* with distinct habitats.

Stacconi, M. V. R., M. Buffington, K. M. Daane, D. T. Dalton, A. Grassi, G. Kacar, B. Miller, J. C. Miller, N. Baser, C. Ioriatti, V. M. Walton, N. G. Wiman, X. Wang and G. Anfora (2015). "Host stage preference, efficacy and fecundity of parasitoids attacking *Drosophila suzukii* in newly invaded areas." *Biological Control* 84: 28-35.

*Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae) causes severe damage to certain fruit crops in both North America and Europe. This may be due, in part, to the absence of specialized natural enemies that suppress population outbreaks. We performed a series of experiments under controlled laboratory conditions in tandem with a field study to evaluate the presence and efficacy of natural enemies associated with this pest in Italian and western United States fruit production regions. Our study involved one larval parasitoid, *Leptopilina heterotoma* (Thomson) (Hymenoptera: Figitidae), and two pupal parasitoids, *Pachycrepoideus vindemiae* (Rondani) (Hymenoptera: Pteromalidae) and *Trichopria drosophilae* (Perkins) (Hymenoptera: Diapriidae). Three indices were used to describe host-parasitoid interactions: degree of infestation (DI), success rate of parasitism (SP) and total encapsulation rate (TER). Results confirmed that each of these parasitoid species can develop on certain populations of the pest. In addition, host stage preferences of the tested parasitoid populations, developmental parameters and lifetime fecundity of North American *P. vindemiae* are provided. Results are discussed with respect to differences in potential utilization of *D. suzukii* among the tested parasitoid species and regional populations. (C) 2015 Elsevier Inc. All rights reserved.

Stephens, A. R. (2015). Cold tolerance of *Drosophila suzukii* (Diptera: Drosophilidae) (Doctoral dissertation, UNIVERSITY OF MINNESOTA).

*Drosophila suzukii* Matsumura, or spotted wing drosophila (Diptera: Drosophilidae), is a fly that is believed to be native to Japan. Spotted wing drosophila females lay eggs into ripe and ripening soft skinned fruits, where larvae develop. The species was first found in the continental United States in 2008, where it was reported to cause extensive economic damage in many fruit crops, including raspberry, blackberry, blueberry and cherry. Spotted wing drosophila is believed to overwinter as a seasonally acclimated winter morph adult. While spotted wing drosophila is found in northern states with colder climates, the ability of it to establish and overwinter in these regions is unknown. Likelihood of spotted wing drosophila overwintering survival was hypothesized by reviewing literature on other *Drosophila* species cold tolerance. Cold tolerance of spotted wing drosophila was then measured by comparing the supercooling points and lower lethal temperatures of seasonally acclimated (winter-morphs) and non-acclimated adults (summer-morphs). The ability of

winter-morphs and summer-morphs to rapidly cold-harden was also studied to determine if the fly can quickly acclimate to new cold temperatures.

Stephens, A. R., Asplen, M. K., Hutchison, W. D., & Venette, R. C. (2015). Cold hardiness of winter-acclimated *Drosophila suzukii* (Diptera: Drosophilidae) adults. *Environmental entomology*, 44(6), 1619-1626.

*Drosophila suzukii* Matsumura, often called spotted wing drosophila, is an exotic vinegar fly that is native to Southeast Asia and was first detected in the continental United States in 2008. Previous modeling studies have suggested that *D. suzukii* might not survive in portions of the northern United States or southern Canada due to the effects of cold. As a result, we measured two aspects of insect cold tolerance, the supercooling point and lower lethal temperature, for *D. suzukii* summer-morph pupae and adults and winter-morph adults. Supercooling points were compared to adults of *Drosophila melanogaster* Meigen. The lower lethal temperature of *D. suzukii* winter-morph adults was significantly colder than that for *D. suzukii* summer-morph adults, while supercooling points of *D. suzukii* winter-morph adults were actually warmer than that for *D. suzukii* summer-morph adults and pupae. *D. suzukii* summer-morph adult supercooling points were not significantly different than those for *D. melanogaster* adults. These measures indicate that *D. suzukii* is a chill intolerant insect, and winter-morph adults are the most cold-tolerant life stage. These results can be used to improve predictions of where *D. suzukii* might be able to establish overwintering populations and cause extensive damage to spring fruit crops.

Sugie, A., Hakeda-Suzuki, S., Suzuki, E., Silies, M., Shimozono, M., Möhl, C., ... & Tavosanis, G. (2015). Molecular remodeling of the presynaptic active zone of *Drosophila* photoreceptors via activity-dependent feedback. *Neuron*, 86(3), 711-725.

Neural activity contributes to the regulation of the properties of synapses in sensory systems, allowing for adjustment to a changing environment. Little is known about how synaptic molecular components are regulated to achieve activity-dependent plasticity at central synapses. Here, we found that after prolonged exposure to natural ambient light the presynaptic active zone in *Drosophila* photoreceptors undergoes reversible remodeling, including loss of Bruchpilot, DLiprin- $\alpha$ , and DRBP, but not of DSyd-1 or Cacophony. The level of depolarization of the postsynaptic neurons is critical for the light-induced changes in active zone composition in the photoreceptors, indicating the existence of a feedback signal. In search of this signal, we have identified a crucial role of microtubule meshwork organization downstream of the divergent canonical Wnt pathway, potentially via Kinesin-3 Imac. These data reveal that active zone composition can be regulated in vivo and identify the underlying molecular machinery.

Swoboda-Bhattarai, K. A., & Burrack, H. J. (2015, June). *Drosophila suzukii* infestation in ripe and ripening caneberries. In XI International Rubus and Ribes Symposium 1133 (pp. 419-430).

*Drosophila suzukii* (Matsumura) is a highly invasive vinegar fly that was first detected in the continental United States in 2008. Females use their saw-like ovipositor to lay eggs in soft-skinned fruits and severely threaten the viability of raspberry, blackberry, blueberry, cherry, and strawberry production. In a recent study, females in no-choice laboratory bioassays laid eggs in ripening blueberries and blackberries. However, most of the eggs failed to develop, perhaps because the ripening process was interrupted in the prematurely-harvested fruit. We hypothesized that eggs laid in ripening fruit in a field may be able to complete development as the fruit continues to ripen. To test this hypothesis, we used fine mesh cages to prevent later egg laying by *D. suzukii* in fruit at several ripeness stages: green-pink, pink, and ripe raspberries and in green-pink, red, purple, and ripe blackberries. We collected the fruit once they were ripe, and reared out and counted all *D. suzukii* present. This experiment was conducted at two locations during 2013 and 2014, one with very high fly populations and one with low populations. Very few flies emerged from blackberry clusters that were bagged at the green-pink stage, and in general, more flies emerged from clusters bagged at later stages of ripening (purple and red blackberries and pink raspberries) than from green-pink fruit. Knowing what ripeness stages are susceptible to *D. suzukii* infestation will help growers to better pinpoint when to begin applying management tools.

Vaccari, G., Caruso, S., Nouhaud, C., & Maistrello, L. (2015). Comparison between different trap types for *Drosophila suzukii* in cherry orchards. In *Proceedings of the 8th workshop on Integrated Soft Fruit Production, May 2014 at Vigalzano di Pergine Valsugana (Italy)* (Vol. 109, pp. 211-214).

In 2013 an experiment was carried out to compare six types of similar size traps baited with the same food attractant ("DroskiDrink"), differing for their shape and the number of entry holes. Four of the traps are already/will be soon

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available on the market, two of them being marketed specifically for SWD ("Drosotrap new®" and "Drosotrap®" by BIOBEST), and two being marketed for other pests ("Taptrap®" and "Vasotrap®" by Roberto Carello). The other two traps were specifically designed and hand-made on purpose (Kartell red and Bot). The trial was performed in a cherry orchard in Vignola (Modena Province, Northern Italy), area of IGP cherries; traps were placed according to a completely randomized block design and their position was changed weekly. The number of captured *Drosophila suzukii* (SWD) and that of other insect taxa was recorded weekly. After the first year, results show that the traps with the best performance in terms of early season captures and total number of SWD catches were "Drosotrap new" and "Bot". However, the low selectivity towards other insect types and the uneasiness of use suggest the need of further research to improve the efficacy of these traps.

Vonlanthen, O., & Kehrl, P. (2015). Caractérisation et apparition des formes hivernale et estivale de *Drosophila suzukii*. *Revue suisse de viticulture, arboriculture et horticulture*, 47(5), 318-323.

En Suisse, l'installation de la drosophile du cerisier (*Drosophila suzukii*) suscite une grande inquiétude chez les producteurs de fruits. A la différence des femelles, les mâles possèdent une tache noirâtre à l'extrémité de chaque aile. En plus de ce dimorphisme sexuel, des observations effectuées aux Etats-Unis signalent deux phénotypes distincts. Agroscope a mené un essai pour vérifier si ce phénomène existait également en Suisse et, le cas échéant, comment il se manifestait au cours de l'année. Des échantillonnages réalisés à Gland (VD) ont révélé que, par rapport au phénotype estival, la forme hivernale se caractérise par une taille plus importante et une coloration plus foncée du thorax et des tergites. Les premiers imagos du phénotype hivernal apparaissent en août et dominant durant l'hiver. Les individus estivaux sont majoritaires en été mais également présents en hiver. Les observations indiquent que *D. suzukii* se reproduit dès avril sur des fruits hôtes encore indéterminés et que le phénotype hivernal continue à se propager en automne.

Wallingford, A. K., Hesler, S. P., Cha, D. H., & Loeb, G. M. (2015). Behavioral response of spotted-wing drosophila, *Drosophila suzukii* Matsumura, to aversive odors and a potential oviposition deterrent in the field. *Pest management science*.

BACKGROUND: *Drosophila suzukii* Matsumura is an invasive pest insect that lays its eggs in the fruit of several commercially grown crops. An effective oviposition deterrent could contribute to its management. Repellent odors were evaluated in the laboratory and in the field. RESULTS: Geosmin and 1-octen-3-ol were found to be aversive to seven-day-old female *D. suzukii* at concentrations of 10<sup>-1</sup> and 10<sup>-2</sup> in laboratory choice tests. Field experiments found that fewer eggs were observed in fruit on the day of harvest and fewer adult *D. suzukii* were reared from fruit associated with 1-octen-3-ol odors than control fruit in cultivated red raspberry. CONCLUSION: Geosmin and 1-octen-3-ol induce aversive behaviors in *Drosophila suzukii* and are potential oviposition deterrents for its management in fruit crops.

Wise, J. C., R. Vanderpoppen, C. Vandervoort, C. O'Donnell and R. Isaacs (2015). "Curative activity contributes to control of spotted-wing drosophila (Diptera: Drosophilidae) and blueberry maggot (Diptera: Tephritidae) in highbush blueberry." *Canadian Entomologist* 147(1): 109-117.

Semi-field experiments were used to compare the curative activity of insecticides on spotted-wing drosophila (*Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae)) and blueberry maggot (*Rhagoletis mendax* Curran (Diptera: Tephritidae)) in blueberry fruit. The organophosphate phosmet, the spinosyn spinetoram, and neonicotinoids imidacloprid, acetamiprid, and thiamethoxam showed significant lethality on spotted-wing drosophila and blueberry maggot larvae and eggs, when applied topically to blueberry fruit post-infestation. The pyrethroids fenpropathrin and zeta-cypermethrin showed high levels of post-infestation activity on spotted-wing drosophila larvae or eggs, and indoxacarb showed statistically weaker activity. Curative activity is a previously unrecognised contributor to the overall means by which blueberry growers may achieve control of spotted-wing drosophila and blueberry maggot with the use of insecticides in blueberries.

Wise, J. C., VanWoerkom, A. H., & Isaacs, R. (2015). Control of Spotted Wing *Drosophila* in Blueberries, 2014. *Arthropod Management Tests*, 40(1), C17.

Woltz, J. M., Donahue, K. M., Bruck, D. J., & Lee, J. C. (2015). Efficacy of commercially available predators, nematodes and fungal entomopathogens for augmentative control of *Drosophila suzukii*. *Journal of Applied Entomology*, 139(10), 759-770.

The recent arrival of *Drosophila suzukii*, an invasive pest of soft-skinned fruit with a wide host range, has resulted in increased production costs for growers and the need for additional insecticide applications each growing season. There are few effective organic insecticides for *D. suzukii*, and insecticide use in conventional farms may be disruptive to natural enemies, suggesting a need for effective biological control to combat *D. suzukii*. Commercially available natural enemies were evaluated for their potential use in augmentative releases, including: the predators *Orius insidiosus* and *Dalotia coriaria*; the entomopathogenic fungi *Metarhizium anisopliae*, *Beauveria bassiana* and *Paecilomyces fumosoroseus*; and the entomopathogenic nematodes *Heterorhabditis bacteriophora*, *Steinernema feltiae* and *S. carpocapsae*. This suite of natural enemies was chosen to target *D. suzukii* adults as well as larvae in hanging or dropped fruit. Of the cultured fungal strains tested, only *M. anisopliae* significantly decreased *D. suzukii* survival, but it had low residual activity and no effect on *D. suzukii* fecundity. *O. insidiosus* decreased *D. suzukii* survival in simple laboratory arenas but not on potted blueberries or bagged blueberry branches outdoors. *D. coriaria* did not decrease *D. suzukii* survival in infested blueberries in simple laboratory arenas. The nematodes tested showed low infection rates and were not able to affect *D. suzukii* survival. Although this suite of natural enemies showed limited ability to suppress *D. suzukii* under the tested conditions, these and related natural enemies are present as part of the endemic natural enemy community in agricultural fields, where they may contribute to *D. suzukii* suppression.

WU, J., LUO, Y., LIAO, T., ZENG, H., SHI, Z., CHEN, J., ... & Jiangsu, E. E. I. (2015). The orthogonal optimization of artificial diet for larvae of *Drosophila suzukii* Matsumura. *Journal of Nanjing Forestry University (Natural Sciences Edition)*, 4, 031.

In order to provide the basis for large-scale artificial breeding of *Drosophila suzukii* Matsumura, the composition of artificial diet for larvae was optimized by orthogonal design with 3 factors and 3 levels. Corn particle, sucrose and yeast extract were selected as the three key factors to determine their effects on the survival rate of larvae, larval developmental duration, mean pupal weight and emergence rate. Corn particle had significant effect on the survival rate of larvae. Sucrose had significant effect on mean pupal weight, and yeast extract had significant effect on larval developmental duration. As the results, the optimized weight ratio of corn particle to sucrose and yeast extract was 9:16:3.

Zerulla, F. N., Schmidt, S., Streitberger, M., Zebitz, C. P., & Zelger, R. (2015). On the overwintering ability of *Drosophila suzukii* in South Tyrol. *Journal of Berry Research*, 5(1), 41-48.

**BACKGROUND:** *Drosophila suzukii* became one of the most dangerous pests in fruit crops and vineyards in Europe since 2009. Lacking knowledge of the overwintering biology under European environmental conditions makes an environmentally friendly control of this invasive pest difficult. **OBJECTIVE:** The objective of this study was to investigate its hibernation capability under the climatic conditions of South Tyrol, Italy. **METHODS:** Monitoring flight activity by baited traps revealed an overwintering location in the Adige valley. We determined the reproductive status of females trapped weekly at "Schlossleiten" from August 2012 until September 2013 by dissecting their abdomens. For further potential correlation between overwintering locations, reproductive status, and climatic conditions were assessed. **RESULTS:** The microclimatic conditions of single locations affected overwintering success and suggest the aggregation of adults in most favourable hibernation sites where a high proportion of females is able to survive. However, in spring some of the females showed degenerated reproductive organs. Dissection of abdomens evinced a reproductive diapause, which appears to be affected by winter climatic conditions, the nutritional status, and food availability. **CONCLUSIONS:** *D. suzukii* is able to overwinter in the South Tyrolean area. Control and management of the potential hibernation sites may delay the population dynamics in the following season.

## Articles parus en 2014

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Adrion, J. R., A. Kousathanas, M. Pascual, H. J. Burrack, N. M. Haddad, A. O. Bergland, H. Machado, T. B. Sackton, T. A. Schlenke, M. Watada, D. Wegmann and N. D. Singh (2014). "Drosophila suzukii: The Genetic Footprint of a Recent, Worldwide Invasion." *Molecular Biology and Evolution* 31(12): 3148-3163.

Native to Asia, the soft-skinned fruit pest *Drosophila suzukii* has recently invaded the United States and Europe. The eastern United States represents the most recent expansion of their range, and presents an opportunity to test alternative models of colonization history. Here, we investigate the genetic population structure of this invasive fruit fly, with a focus on the eastern United States. We sequenced six X-linked gene fragments from 246 individuals collected from a total of 12 populations. We examine patterns of genetic diversity within and between populations and explore alternative colonization scenarios using approximate Bayesian computation. Our results indicate high levels of nucleotide diversity in this species and suggest that the recent invasions of Europe and the continental United States are independent demographic events. More broadly speaking, our results highlight the importance of integrating population structure into demographic models, particularly when attempting to reconstruct invasion histories. Finally, our simulation results illustrate the general challenge in reconstructing invasion histories using genetic data and suggest that genome-level data are often required to distinguish among alternative demographic scenarios.

Atallah, J., L. Teixeira, R. Salazar, G. Zaragoza and A. Kopp (2014). "The making of a pest: the evolution of a fruit-penetrating ovipositor in *Drosophila suzukii* and related species." *Proceedings of the Royal Society B-Biological Sciences* 281(1781).

Evolutionary innovation can allow a species access to a new ecological niche, potentially reducing competition with closely related species. While the vast majority of *Drosophila* flies feed on rotting fruit and other decaying matter, and are harmless to human activity, *Drosophila suzukii*, which has a morphologically modified ovipositor, is capable of colonizing live fruit that is still in the process of ripening, causing massive agricultural damage. Here, we conducted the first comparative analysis of this species and its close relatives, analysing both ovipositor structure and fruit susceptibility. We found that the ovipositor of the species most closely related to *D. suzukii*, *Drosophila subpulchrella*, has a similar number of enlarged, evolutionarily derived bristles, but a notably different overall shape. Like *D. suzukii*, *D. subpulchrella* flies are capable of puncturing the skin of raspberries and cherries, but we found no evidence that they could penetrate the thicker skin of two varieties of grapes. More distantly related species, one of which has previously been mistaken for *D. suzukii*, have blunt ovipositors with small bristles. While they did not penetrate fruit skin in any of the assays, they readily colonized fruit interiors where the skin was broken. Our results suggest that considering evolutionary context may be beneficial to the management of invasive species.

Cha, D. H., T. Adams, C. T. Werle, B. J. Sampson, J. J. Adamczyk, H. Rogg and P. J. Landolt (2014). "A four-component synthetic attractant for *Drosophila suzukii* (Diptera: Drosophilidae) isolated from fermented bait headspace." *Pest Management Science* 70(2): 324-331.

Background : A mixture of wine and vinegar is more attractive than wine or vinegar to spotted wing drosophila, *Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae), and ethanol and acetic acid are considered key to that attractiveness. In addition to ethanol and acetic acid, thirteen other wine and vinegar volatiles are antennally active to *D. suzukii* and might be involved in food-finding.

Results : Out of the 13 antennally active chemicals, acetoin, ethyl lactate and methionol increased fly response to the mixture of acetic acid and ethanol in field trapping experiments. A 5-component blend of acetic acid, ethanol, acetoin, ethyl lactate and methionol was as attractive as the starting mixture of wine and vinegar in field tests conducted in the states of Oregon and Mississippi. Subtracting ethyl lactate from the 5-component blend did not reduce the captures of flies in the trap. However, subtracting any other compound from the blend significantly reduced the numbers of flies captured.

Conclusion : These results indicate that acetic acid, ethanol, acetoin and methionol are key olfactory cues for *D. suzukii* when attracted to wine and vinegar, which may be food-finding behavior leading flies to fermenting fruit in nature. We anticipate that this 4-component blend can be used as a highly attractive chemical lure for detection and management of *D. suzukii*.

Chandler, J. A., P. M. James, G. Jospin and J. M. Lang (2014). "The bacterial communities of *Drosophila suzukii* collected from undamaged cherries." *PeerJ* 2.

Choi, J. Y. and C. F. Aquadro (2014). "The Coevolutionary Period of *Wolbachia pipientis* Infecting *Drosophila ananassae* and Its Impact on the Evolution of the Host Germline Stem Cell Regulating Genes." *Molecular Biology and Evolution* 31(9): 2457-2471.

The endosymbiotic bacteria *Wolbachia pipientis* is known to infect a wide range of arthropod species yet less is known about the coevolutionary history it has with its hosts. Evidence of highly identical *W. pipientis* strains in evolutionary divergent hosts suggests horizontal transfer between hosts. For example, *Drosophila ananassae* is infected with a *W. pipientis* strain that is nearly identical in sequence to a strain that infects both *D. simulans* and *D. suzukii*, suggesting recent horizontal transfer among these three species. However, it is unknown whether the *W. pipientis* strain had recently invaded all three species or a more complex infectious dynamic underlies the horizontal transfers. Here, we have examined the coevolutionary history of *D. ananassae* and its resident *W. pipientis* to infer its period of infection. Phylogenetic analysis of *D. ananassae* mitochondrial DNA and *W. pipientis* DNA sequence diversity revealed the current *W. pipientis* infection is not recent. In addition, we examined the population genetics and molecular evolution of several germline stem cell (GSC) regulating genes of *D. ananassae*. These studies reveal significant evidence of recent and long-term positive selection at stonewall in *D. ananassae*, whereas *pumilio* showed patterns of variation consistent with only recent positive selection. Previous studies had found evidence for adaptive evolution of two key germline differentiation genes, *bag of marbles (bam)* and *benign gonial cell neoplasm (bgcn)*, in *D. melanogaster* and *D. simulans* and proposed that the adaptive evolution at these two genes was driven by arms race between the host GSC and *W. pipientis*. However, we did not find any statistical departures from a neutral model of evolution for *bam* and *bgcn* in *D. ananassae* despite our new evidence that this species has been infected with *W. pipientis* for a period longer than the most recent infection in *D. melanogaster*. In the end, analyzing the GSC regulating genes individually showed two of the seven genes to have evidence of selection. However, combining the data set and fitting a specific population genetic model significant proportion of the nonsynonymous sites across the GSC regulating genes were driven to fixation by positive selection. Clearly the GSC system is under rapid evolution and potentially multiple drivers are causing the rapid evolution.

Cini, A., G. Anfora, L. A. Escudero-Colomar, A. Grassi, U. Santosuosso, G. Seljak and A. Papini (2014). "Tracking the invasion of the alien fruit pest *Drosophila suzukii* in Europe." *Journal of Pest Science* 87(4): 559-566.

Biological invasions are a leading threat to native wildlife, human health and food production worldwide. Understanding the invasion history helps identifying introduction pathways and organizing integrated management strategies especially aimed at avoiding multiple reintroductions. We coupled a recently developed spatial analysis (Geographic profiling) with trade flows quantification to identify the most likely spreading centre of a recent invader of Europe, the spotted wing drosophila, *Drosophila suzukii*. This polyphagous vinegar fly recently colonized western countries, where it is heavily threatening fruit production causing severe economic losses. Characterized by a rapid spread and a huge impact, the invasion of this pest has a few precedents and it is becoming a model in invasion biology and pest management. Thanks to our spatial approach based on data presence of *D. suzukii* in European countries in the very first years of its spread, we update the current knowledge of a first spread in Spain and Italy, suggesting on the contrary that the South of France may be the most likely spreading centre of *D. suzukii* in Europe. Estimates of propagule pressure (fresh host fruits importation) support this finding as imports from contaminated South East Asian countries are higher in France than in Spain or Italy. Our study provides a first step in the comprehension of invasion history of this pest species and emphasizes geographic profiling as an efficient technique to track down invaders colonization patterns.

Cuthbertson, A. G. S., L. F. Blackburn and N. Audsley (2014). "Efficacy of commercially available invertebrate predators against *Drosophila suzukii*." *Insects* 5: 952-960.

Depra, M., J. L. Poppe, H. J. Schmitz, D. C. De Toni and V. L. S. Valente (2014). "The first records of the invasive pest *Drosophila suzukii* in the South American continent." *Journal of Pest Science* 87(3): 379-383.

This paper presents the first report of the occurrence of *Drosophila suzukii* (Diptera: Drosophilidae) in South America. Several samples were collected during various seasons in 2012 and 2013, and a significant number of individuals were obtained and identified. Based on the data recorded during each sampling campaign, including the locality, temperature, time of year, and number of individuals collected, several conclusions were drawn about the development of this invasion in southern Brazil.

Cette veille bibliographique est réalisée par Nathalie Roullé et Nicolas Chatel-Launay, Pôle d'excellence en lutte intégrée (PELI).

Être informé des activités du PELI : <http://www.lutteintegree.com/fr/Nous-joindre/>

Dhami, M. K. and L. Kumarasinghe (2014). "A HRM Real-Time PCR Assay for Rapid and Specific Identification of the Emerging Pest Spotted-Wing *Drosophila* (*Drosophila suzukii*)." *Plos One* 9(6).

Spotted wing drosophila (*Drosophila suzukii*) is an emerging pest that began spreading in 2008 and its distribution now includes 13 countries across two continents. Countries where it is established have reported significant economic losses of fresh produce, such as cherries due to this species of fly. At larval stages, it is impossible to identify due to its striking similarities with other cosmopolitan and harmless drosophilids. Molecular methods allow identification but the current technique of DNA barcoding is time consuming. We developed and validated a rapid, highly sensitive and specific assay based on real-time PCR and high resolution melt (HRM) analysis using EvaGreen DNA intercalating dye chemistry. Performance characteristics of this qualitative assay, validation and applicability in a New Zealand quarantine framework are discussed. Application of this robust and independently validated assay across the spectrum of key food production and border protection industries will allow us to reduce the further spread of this damaging species worldwide.

Emiljanowicz, L. M., G. D. Ryan, A. Langille and J. Newman (2014). "Development, Reproductive Output and Population Growth of the Fruit Fly Pest *Drosophila suzukii* (Diptera: Drosophilidae) on Artificial Diet." *Journal of Economic Entomology* 107(4): 1392-1398.

*Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae) is a fruit pest of Asian origin that invaded North America in 2008. Despite the widespread economic impact of this species, much of the biology and general life history of this pest remains largely unknown. Under optimal laboratory conditions (22 degrees C, approximate to 25% relative humidity), we measured development, survival, fecundity, hatch rate, and sex ratio of a North American ecotype of *D. suzukii*. Life history traits were used to construct a life table and reproductive schedule, and to calculate the intrinsic rate of population increase. The mean (+/- SE) total lifespan (egg to adult mortality) was 86.1 +/- 4.25 d, with a maximum value of 153.7 d. On average, females produced 5.7 +/- 0.24 eggs per day, with a mean total lifetime production of 635.6 eggs. The gross reproductive rate was 317.8 daughter eggs per female and the net reproductive rate was 240.4 daughter eggs per female. The intrinsic rate of natural increase was 0.179. The stable age distribution ( $c(x)$ ) was comprised of 51% larvae, 25% eggs, 16% pupae, and 8% adults. The sex ratio over time was approximate to 1:1. We conclude with a comparison of our data with previous work on *D. suzukii* and other *Drosophila*, and discuss the implications for control and monitoring of this pest.

Follett, P. A., A. Swedman and D. K. Price (2014). "Postharvest Irradiation Treatment for Quarantine Control of *Drosophila suzukii* (Diptera: Drosophilidae) in Fresh Commodities." *Journal of Economic Entomology* 107(3): 964-969.

Irradiation is a postharvest quarantine treatment option for exported commodities such as stone fruits and small fruits to prevent movement of the new invasive pest spotted wing drosophila, *Drosophila suzukii* (Walker) (Diptera: Drosophilidae). The effects of irradiation on larval and pupal development and adult reproduction in *D. suzukii* were examined. Larvae (first, second, and third instars) and pupae (1-2-d-old, 3-5-d-old, and 7-8-d-old) on diet were irradiated at target doses of 20, 30, 40, and 50 Gy in replicated factorial experiments and survival to the adult stage was recorded. Tolerance to radiation increased with increasing age and developmental stage. Males and females were equally susceptible. A radiation dose of 40 Gy applied to first- and second-instar larvae prevented adult emergence. The late-stage pupa was the most radiation-tolerant stage that occurs in fruit, and individuals irradiated at this stage readily emerged as adults; therefore, prevention of F-1 adults was the desired treatment response for large-scale validation tests with naturally infested fruit. In large-scale tests, a radiation dose of 80 Gy applied to late-stage pupae in sweet cherries or grapes resulted in no production of F-1 adults in >33,000 treated individuals, which meets the zero tolerance requirement for market access. A minimum absorbed dose of 80 Gy is recommended for quarantine control of *D. suzukii*.

Hamby, K. A., M. P. Bolda, M. E. Sheehan and F. G. Zalom (2014). "Seasonal Monitoring for *Drosophila suzukii* (Diptera: Drosophilidae) in California Commercial Raspberries." *Environmental Entomology* 43(4): 1008-1018.

Native to Southeast Asia, *Drosophila suzukii* (Matsumura) prefer to oviposit on ripe fruit and have become an important pest of California raspberries (*Rubus idaeus* L.) since their detection in Santa Cruz County, CA, in 2008. Preliminary management guidelines included *D. suzukii* monitoring recommendations, though there was little available information

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on seasonal occurrence and potential lures for use in raspberries. To address this issue, we trapped adult *D. suzukii* weekly for 2 yr (including both spring and fall harvests) in multiple raspberry varieties using apple cider vinegar and a yeast-sugar-water mixture as liquid lures, and measured fruit infestation when commercially ripe fruit were available. *D. suzukii* pressure as measured by larval infestation and adult trap captures was higher during the fall raspberry harvest season. The yeast lure captured significantly more *D. suzukii* during the fall harvest than the apple cider vinegar, and while both lures tended to capture more females than males, this varied by month of the year and was more pronounced for the yeast lure. Trap captures from each lure correlated well to one another, and often exhibited significant correlation to larval infestation. However, during all seasons and under both conventional and organic management, worrisome outliers were present (high larval infestation with low trap captures) that call into question the reliability of using the systems presented here as a basis for management decisions at this time.

Hamm, C. A., D. J. Begun, A. Vo, C. C. R. Smith, P. Saelao, A. O. Shaver, J. Jaenike and M. Turelli (2014). "Wolbachia do not live by reproductive manipulation alone: infection polymorphism in *Drosophila suzukii* and *D. subpulchrella*." *Molecular Ecology* 23(19): 4871-4885.

*Drosophila suzukii* recently invaded North America and Europe. Populations in Hawaii, California, New York and Nova Scotia are polymorphic for Wolbachia, typically with <20% infection frequency. The Wolbachia in *D. suzukii*, denoted wSuz, is closely related to wRi, the variant prevalent in continental populations of *D. simulans*. wSuz is also nearly identical to Wolbachia found in *D. subpulchrella*, plausibly *D. suzukii*'s sister species. This suggests vertical Wolbachia transmission through cladogenesis ('cladogenic transmission'). The widespread occurrence of 7-20% infection frequencies indicates a stable polymorphism. wSuz is imperfectly maternally transmitted, with wild infected females producing on average 5-10% uninfected progeny. As expected from its low frequency, wSuz produces no cytoplasmic incompatibility (CI), that is, no increased embryo mortality when infected males mate with uninfected females, and no appreciable sex-ratio distortion. The persistence of wSuz despite imperfect maternal transmission suggests positive fitness effects. Assuming a balance between selection and imperfect transmission, we expect a fitness advantage on the order of 20%. Unexpectedly, Wolbachia-infected females produce fewer progeny than do uninfected females. We do not yet understand the maintenance of wSuz in *D. suzukii*. The absence of detectable CI in *D. suzukii* and *D. subpulchrella* makes it unlikely that CI-based mechanisms could be used to control this species without transinfection using novel Wolbachia. Contrary to their reputation as horizontally transmitted reproductive parasites, many Wolbachia infections are acquired through introgression or cladogenesis and many cause no appreciable reproductive manipulation. Such infections, likely to be mutualistic, may be central to understanding the pervasiveness of Wolbachia among arthropods.

Hampton, E., C. Koski, O. Barsoian, H. Faubert, R. S. Cowles and S. R. Alm (2014). "Use of Early Ripening Cultivars to Avoid Infestation and Mass Trapping to Manage *Drosophila suzukii* (Diptera: Drosophilidae) in *Vaccinium corymbosum* (Ericales: Ericaceae)." *Journal of Economic Entomology* 107(5): 1849-1857.

Use of early ripening highbush blueberry cultivars to avoid infestation and mass trapping were evaluated for managing spotted wing drosophila, *Drosophila suzukii* (Matsumura). Fourteen highbush blueberry cultivars were sampled for spotted wing drosophila infestation. Most 'Earliblue', 'Bluetta', and 'Collins' fruit were harvested before spotted wing drosophila oviposition commenced, and so escaped injury. Most fruit from 'Bluejay', 'Blueray', and 'Bluehaven' were also harvested before the first week of August, after which spotted wing drosophila activity led to high levels of blueberry infestation. In a separate experiment, damage to cultivars was related to the week in which fruit were harvested, with greater damage to fruit observed as the season progressed. Attractant traps placed within blueberry bushes increased nearby berry infestation by 5%, irrespective of cultivar and harvest date. The significant linear reduction in infestation with increasing distance from the attractant trap suggests that traps are influencing fly behavior to at least 5.5 m. Insecticides applied to the exterior of traps, compared with untreated traps, revealed that only 10-30% of flies visiting traps enter the traps and drown. Low trap efficiency may jeopardize surrounding fruits by increasing local spotted wing drosophila activity. To protect crops, traps for mass trapping should be placed in a perimeter outside fruit fields and insecticides need to be applied to the surface of traps or on nearby fruit to function as an attract-and-kill strategy.

Harris, D. W., K. A. Hamby, H. E. Wilson and F. G. Zalom (2014). "Seasonal monitoring of *Drosophila suzukii* (Diptera: Drosophilidae) in a mixed fruit production system." *Journal of Asia-Pacific Entomology* 17(4): 857-864.

*Drosophila suzukii* Matsumura (Diptera: Drosophilidae), an invasive pest native to Southeast Asia, is now reported throughout North America and Europe. We used traps baited with apple cider vinegar to monitor *D. suzukii* adult presence in multiple crops and associated fruiting plants at the Wolfskill USDA Germplasm Repository in Winters, CA, USA from 2011 to 2013. Traps were placed in small (similar to 160 m x 40 m on average) almond, apricot, cherry, fig, grape, mulberry, peach, persimmon, plum, and pomegranate deciduous fruit orchard blocks as well as a citrus block and evergreen trees located near a house at the repository. *D. suzukii* was present in all blocks with the greatest monthly deciduous fruit captures in the cherry and fig blocks. Few *D. suzukii* were captured in almond, apricot, pomegranate and grape blocks. Deciduous fruit blocks had two distinct periods of trap capture: spring through midsummer and again in fall. Most deciduous fruit blocks had low trap captures during the hottest summer months (August to September) and the coldest winter months (December to April). However, from late December through mid-January, high trap captures were associated with the citrus and house sites. This study provides seasonal trapping data of *D. suzukii* adults in an unsprayed multi-crop mosaic, and may serve as a model of adult capture patterns across smaller mixed-crop commercial orchards and associated urban landscapes. (C) 2014 Korean Society of Applied Entomology, Taiwan Entomological Society and Malaysian Plant Protection Society. Published by Elsevier BM. All rights reserved.

Iglesias, L. E., T. W. Nyoike and O. E. Liburd (2014). "Effect of Trap Design, Bait Type, and Age on Captures of *Drosophila suzukii* (Diptera: Drosophilidae) in Berry Crops." *Journal of Economic Entomology* 107(4): 1508-1518.

Field experiments were conducted in commercial southern highbush blueberries and wild blackberries to evaluate the attractiveness of different trap designs, bait types, and bait age on captures of the spotted wing drosophila, *Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae). During the 2012 trap design study, the five treatments evaluated were four 1-liter clear plastic cup traps (with and without a yellow visual stimulus or odorless dish detergent) and the fifth treatment was a Pherocon AM yellow sticky card trap. Cup traps were baited with 150 ml of apple cider vinegar (ACV) and the Pherocon AM trap had a 7.4-ml glass vial containing ACV. In 2013, the Pherocon AM yellow sticky card was omitted because of low spotted wing drosophila captures in 2012. The four treatments evaluated were four 1-liter cup traps with and without a yellow visual stimulus. One cup trap (with a yellow stimulus) was baited with yeast + sugar in place of ACV and the other cup traps were baited with ACV. In both years, there were no differences in spotted wing drosophila captures among cup traps baited with ACV with and without yellow visual stimulus. However, the cup trap baited with yeast + sugar and yellow visual stimulus captured more spotted wing drosophila than the ACV-baited cup traps irrespective of visual stimulus or detergent. In another study, four baits including 1) ACV, 2) yeast + sugar mixture, 3) yeast + flour mixture (yeast, sugar, water, whole wheat flour, and ACV), and 4) wine + vinegar mixture (rice vinegar and merlot wine) were evaluated in a commercial blueberry planting using 1-liter clear plastic cup traps (as described above). The experiment was repeated in wild blackberries but the yeast + flour bait was replaced with ACV + merlot wine + sugar. Results indicated that the two yeast baits captured significantly more spotted wing drosophila and more nontarget organisms than the vinegar baits. In the final study, although we found that the attraction of ACV and yeast + sugar to spotted wing drosophila did not change with bait age, the attraction to other Drosophilidae flies decreased with age. The ease of implementing a trap-and-lure system for spotted wing drosophila is discussed.

Jakobs, R. (2014). Low temperature tolerance of adult *Drosophila suzukii* (Diptera: Drosophilidae). Biology, University of Western Ontario.

Kim, S. S., A. D. Tripodi, D. T. Johnson and A. L. Szalanski (2014). "Molecular Diagnostics of *Drosophila suzukii* (Diptera: Drosophilidae) Using PCR-RFLP." *Journal of Economic Entomology* 107(3): 1292-1294.

The invasive spotted wing drosophila, *Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae), has become a serious pest in the United States. Identification of immature and poorly preserved specimens can be difficult. A molecular diagnostic method for distinguishing *D. suzukii* from other *Drosophila* spp. associated with fruit in the United States was developed. A 709-bp region of the mitochondrial DNA cytochrome oxidase I gene was amplified from *D. suzukii* collections in the United States and compared with sequences of other *Drosophila* taxa from GenBank. Based on DNA sequence polymorphisms, a polymerase chain reaction-restriction fragment length polymorphism analysis using the

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restriction enzyme Msp-I was found to differentiate *D. suzukii* from other *Drosophila* spp. in the United States. This technique can identify field-collected specimens from various sources and specimens regardless of life stage. This molecular diagnostic method will be useful for monitoring the spread of this economically important invasive insect.

Kinjo, H., Y. Kunimi and M. Nakai (2014). "Effects of temperature on the reproduction and development of *Drosophila suzukii* (Diptera: Drosophilidae)." *Applied Entomology and Zoology* 49(2): 297-304.

The objective of this study was to elucidate how temperature affects the reproduction and development of *Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae), an emerging major pest of blueberry in Japan. Although extensive studies of the biology of this pest have been carried out, the effects of temperature on its reproduction and development remain unknown. We found that when adults mated at 31 A degrees C for 4 days, none of the eggs hatched. Female oviposition and egg hatching rate were also reduced as temperature increased during the oviposition period. When *D. suzukii* larvae developed above 31 A degrees C, pupation and adult eclosion were abolished. According to field observations, adult *D. suzukii* ceased to appear from the end of July 2010, when the average temperature exceeded 28 A degrees C or when the temperature within a day exceeded 33 A degrees C for 8 h or more. Experiments in which the mating temperature fluctuated within a day revealed that both the number of eggs oviposited and their hatch rate were significantly suppressed when the daily temperature regime during mating was either 31 A degrees C for 12 h/25 A degrees C for 12 h or 33 A degrees C for 8 h/25 A degrees C for 16 h, relative to the values at 25 A degrees C for 24 h.

Kleiber, J. R., C. R. Unelius, J. C. Lee, D. M. Suckling, M. C. Qian and D. J. Bruck (2014). "Attractiveness of Fermentation and Related Products to Spotted Wing *Drosophila* (Diptera: Drosophilidae)." *Environmental Entomology* 43(2): 439-447.

Laboratory screening bioassays and field trapping experiments of spotted wing *Drosophila* flies, *Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae), were conducted to determine the attractiveness of 17 compounds as well as to compare attractant efficiency during peak fruit ripeness and postharvest captures late in the season. Compounds structurally related to each of the fermentation products acetic acid, ethanol, ethyl acetate, and 2-phenethyl alcohol were screened for attractiveness compared with a soap water control in greenhouse cage bioassays. The compounds determined to be attractive in the greenhouse bioassay (methanol, ethanol, propanol, formic acid, acetic acid, ethyl acetate, propyl acetate, phenethyl acetate, phenethyl propionate, and phenethyl butyrate) were individually tested in the field added to apple cider vinegar (ACV). The acids were also tested individually in neutralized ACV (NACV; pH approximate to 7). Combinations of the compounds were tested in NACV. The capture numbers in ACV traps were not significantly increased by the addition of any of the compounds tested, although significant deterrent effects of some of the compounds allowed differences between treatments to be observed. Compounds that are most prevalent in wine and vinegar (methanol, ethanol, acetic acid, and ethyl acetate) as well as phenethyl propionate and phenethyl butyrate were less deterrent than the other compounds tested in the field. Captures during peak fruit ripeness were compared with the postharvest period when fruit hosts were not available or were overripe. Although the total number of flies captured late in the season was lower, the trends in treatment performance were similar, indicating a consistent performance of these baits from peak fruit ripeness through postharvest.

Klick, J., J. C. Lee, J. R. Hagler, D. J. Bruck and W. Q. Yang (2014). "Evaluating *Drosophila suzukii* immunomarking for mark-capture research." *Entomologia Experimentalis Et Applicata* 152(1): 31-41.

*Drosophila suzukii* Matsumura (Diptera: Drosophilidae) utilizes Himalaya' blackberry, *Rubus armeniacus* Focke (Rosaceae), as a host and may invade berry and stone fruit crops from field margins containing this invasive weed. Laboratory and semi-field studies were conducted to determine (1) the persistence of protein marks including 10% chicken egg whites (egg albumin protein), 20% bovine milk (milk casein protein), and 20% soy milk (soy trypsin inhibitor protein) on topically sprayed *D. suzukii*, (2) protein retention on blackberry leaves, and (3) *D. suzukii* acquisition of protein after exposure to marked blackberry leaves for up to 14 days after application. All flies and leaves were assayed for the presence of the protein marks using protein-specific enzyme-linked immunosorbent assays. Egg albumin, milk casein, and soy trypsin proteins persisted on 94, 49, and 25% of the topically marked *D. suzukii*, respectively, throughout the 14-day study period. Egg albumin was retained on 100% of treated leaves for 14 days, regardless of environmental conditions. At least 50% of flies exposed residually to egg albumin-treated leaves were marked for 3 days, regardless of exposure time and environmental conditions. However, increasing fly exposure time to

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treated leaves in April and June appeared to improve protein mark acquisition. Acquisition of protein by flies from treated leaves for milk casein was inconsistent, and poor for soy trypsin, despite detectable levels on treated leaves. Egg albumin had the longest and most consistent persistence on flies, leaves, and flies exposed to leaves in laboratory and semi-field studies, under a variety of environmental conditions and exposure times.

Landolt, P. J., D. H. Cha, C. T. Werle, J. J. Adamczyk, R. L. Meagher, R. L. Gilbride, T. S. Clepper, H. C. Reed, P. E. A. Teal and B. J. Sampson (2014). "POLISTES SPP. (HYMENOPTERA: VESPIDAE) ORIENTATION TO WINE AND VINEGAR." *Florida Entomologist* 97(4): 1620-1630.

Attractants are sought for trapping of *Polistes* spp. paper wasps when they are pestiferous. The serendipitous capture of *Polistes metricus* Say and *Polistes bellicosus* Cresson in traps baited with a wine/vinegar mixture for spotted wing drosophila, *Drosophila suzukii* (Matsumura) prompted experiments to determine the nature of the wasp response. Both wasp species were captured in subsequent field tests in traps baited with the same mixture of wine plus vinegar, and not in unbaited traps. *Polistes bellicosus* responses to wine, vinegar, ethanol (as a major volatile of wine), and acetic acid (as a major volatile of vinegar) were evaluated using a Y-tube olfactometer. In the olfactometer, *P. bellicosus* wasps were attracted to wine and not to vinegar. They also preferred wine alone to wine with vinegar, and were attracted to ethanol. Female wasps were deterred by acetic acid. In field tests comparing traps baited with wine, vinegar and a combination of the 2 materials, *P. bellicosus* and *Polistes fuscatus* (Fab.) were captured in traps baited with wine, but were not trapped with vinegar. The inclusion of vinegar with wine did not improve bait attractiveness in the field. We conclude that the paper wasp response to the *D. suzukii* bait of wine plus vinegar was largely the result of the wasp response to wine. This work constitutes the first demonstration of an attractive bait that can be used to trap *P. bellicosus* and *P. metricus* in situations where they are pestiferous, and suggests a potential source of a chemical attractant based on wine volatiles.

Lin, Q. C., Y. F. Zhai, A. S. Zhang, X. Y. Men, X. Y. Zhang, F. G. Zalom, C. G. Zhou and Y. Yu (2014). "COMPARATIVE DEVELOPMENTAL TIMES AND LABORATORY LIFE TABLES FOR *DROSOPHILIA SUZUKII* AND *DROSOPHILA MELANOGASTER* (DIPTERA: DROSOPHILIDAE)." *Florida Entomologist* 97(4): 1434-1442.

*Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae) and *Drosophila melanogaster* Meigen were studied in a laboratory at 25 degrees C, 60% RH and 16:8h L:D. Stage-specific developmental times, reproduction, stage-specific survival rates, and adult sex ratios were recorded and organized in separate life tables for each species. The intrinsic rate of increase ( $r$ ), the finite rate of increase ( $\lambda$ ), the net reproduction rate ( $R_0$ ) and the mean generation time ( $T$ ) were 0.12 day<sup>-1</sup>, 1.13 day<sup>-1</sup>, 27.57 offspring, and 28.04 days, respectively, for *D. suzukii* and 0.17 day<sup>-1</sup>, 1.19 day<sup>-1</sup>, 38.17 offspring, and 21.27 days, respectively, for *D. melanogaster*. The use of the age-stage, two-sex life table method to study *D. suzukii* and *D. melanogaster* yielded considerably more accurate and useful data than would have been obtained by using the female-only age-specific life table. These life tables can be used for population growth projections, designing mass-rearing programs, and for pest management.

Lin, Q. C., Y. F. Zhai, C. G. Zhou, L. L. Li, Q. Y. Zhuang, X. Y. Zhang, F. G. Zalom and Y. Yu (2014). "BEHAVIORAL RHYTHMS OF *DROSOPHILA SUZUKII* AND *DROSOPHILA MELANOGASTER*." *Florida Entomologist* 97(4): 1424-1433.

*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 2432 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 similar to 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.

Lin, Q.-C., Y.-F. Zhai, A.-S. Zhang, X.-Y. Men, X.-Y. Zhang, F. G. Zalom, C.-G. Zhou and Y. Yu (2014). "COMPARATIVE DEVELOPMENTAL TIMES AND LABORATORY LIFE TABLES FOR *DROSOPHILIA SUZUKII* AND *DROSOPHILA MELANOGASTER* (DIPTERA: DROSOPHILIDAE)." *Florida Entomologist* 97(4): 1434-1442.

*Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae) and *Drosophila melanogaster* Meigen were studied in a laboratory at 25 degrees C, 60% RH and 16:8h L:D. Stage-specific developmental times, reproduction, stage-specific survival rates, and adult sex ratios were recorded and organized in separate life tables for each species. The intrinsic rate of increase ( $r$ ), the finite rate of increase ( $\lambda$ ), the net reproduction rate ( $R_0$ ) and the mean generation time ( $T$ ) were 0.12 day<sup>-1</sup>, 1.13 day<sup>-1</sup>, 27.57 offspring, and 28.04 days, respectively, for *D. suzukii* and 0.17 day<sup>-1</sup>, 1.19 day<sup>-1</sup>, 38.17 offspring, and 21.27 days, respectively, for *D. melanogaster*. The use of the age-stage, two-sex life table method to study *D. suzukii* and *D. melanogaster* yielded considerably more accurate and useful data than would have been obtained by using the female-only age-specific life table. These life tables can be used for population growth projections, designing mass-rearing programs, and for pest management.

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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 2432 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 similar to 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.

Naranjo-Lazaro, J. M., M. A. Mellin-Rosas, V. D. Gonzalez-Padilla, J. A. Sanchez-Gonzalez, G. Moreno-Carrillo and H. C. Arredondo-Bernal (2014). "Susceptibility of *Drosophila suzukii* Matsumura (Diptera: Drosophilidae) to Entomopathogenic Fungi." *Southwestern Entomologist* 39(1): 201-203.

The susceptibility of the spotted wing *Drosophila suzukii* Matsumura to four entomopathogenic fungal strains (*Isaria fumosorosea* Pf21, Pf17, Pf15, and *Metarhizium anisopliae* Ma59), was evaluated in vitro bioassays. The results showed that the percentage of mortality of the fly was 85% using the fungal strain Pf21 (85%), followed by Pf17, Pf15, and Ma59, with 60, 57, and 12% mortality, respectively. These results suggest that the application of these entomopathogenic fungal strains could be used as biological control agents of this insect that has recently become a pest of importance in Mexico.

Poyet, M., P. Eslin, M. Heraude, V. Le Roux, G. Prevost, P. Gibert and O. Chabrierie (2014). "Invasive host for invasive pest: when the Asiatic cherry fly (*Drosophila suzukii*) meets the American black cherry (*Prunus serotina*) in Europe." *Agricultural and Forest Entomology* 16(3): 251-259.

1 The vinegar fly *Drosophila suzukii* Matsumura (Diptera: Drosophilidae), native to Asia, recently invaded Europe and North America. By contrast to other frugivorous *Drosophila* species, *D. suzukii* lays eggs on ripening fruits, heavily reducing fruit production. Although cultivated host plants of *D. suzukii* are well documented, very little is known about wild hosts in the invaded areas. 2 The American black cherry *Prunus serotina* Ehrh., a tree species native to North America, became one of the main woody forest invaders in Europe. One cause of its invasion success is the huge

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amount of fruit produced by *P. serotina* trees. 3 A field survey showed that *P. serotina* is a suitable reservoir for the development and persistence of *D. suzukii* populations in European natural systems (on the forest area investigated, up to 70% of all the fruits of *P. serotina* were infested in one of the sampling sites). 4 Laboratory tests demonstrated that *D. suzukii* prefers ripening cherries to ripe ones, therefore increasing the chance of the larvae to fully develop and reach maturity before the mesocarp of the fruit totally decays. 5 Infestation of *P. serotina* cherries could reduce the life span of fruits, as well as their attractiveness to seed consumers and dispersers, yet *P. serotina* could represent a suitable plant reservoir promoting *D. suzukii* invasion in Europe and North America.

Renkema, J. M., R. Buitenhuis and R. H. Hallett (2014). "Optimizing Trap Design and Trapping Protocols for *Drosophila suzukii* (Diptera: Drosophilidae)." *Journal of Economic Entomology* 107(6): 2107-2118.

*Drosophila suzukii* Matsumura (Diptera: Drosophilidae) is a recent invasive pest of fruit crops in North America and Europe. Carnivorous larvae render fruit unmarketable and may promote secondary rot-causing organisms. To monitor spread and develop programs to time application of controls, further work is needed to optimize trap design and trapping protocols for adult *D. suzukii*. We compared commercial traps and developed a new, easy-to-use plastic jar trap that performed well compared with other designs. For some trap types, increasing the entry area led to increased *D. suzukii* captures and improved selectivity for *D. suzukii* when populations were low. However, progressive entry area enlargement had diminishing returns, particularly for commercial traps. Unlike previous studies, we found putting holes in trap lids under a close-fitting cover improved captures compared with holes on sides of traps. Also, red and black traps outperformed yellow and clear traps when traps of all colors were positioned 10-15 cm apart above crop foliage. In smaller traps, attractant surface area and entry area, but not other trap features (e.g., headspace volume), appeared to affect *D. suzukii* captures. In the new, plastic jar trap, tripling attractant volume (360 vs 120 ml) and weekly attractant replacement resulted in the highest *D. suzukii* captures, but in the larger commercial trap these measures only increased by-catch of large-bodied Diptera. Overall, the plastic jar trap with large entry area is affordable, durable, and can hold high attractant volumes to maximize *D. suzukii* capture and selectivity.

Stewart, T. J., X. G. Wang, A. Molinar and K. M. Daane (2014). "Factors Limiting Peach as a Potential Host for *Drosophila suzukii* (Diptera: Drosophilidae)." *Journal of Economic Entomology* 107(5): 1771-1779.

The spotted wing drosophila, *Drosophila suzukii* Matsumura, has widely established in North America and become an economic concern for a variety of fruit crops. To better understand fruit susceptibility, we evaluated peach surface characteristics on the pest's oviposition success. The number of *D. suzukii* eggs laid into the fruit flesh was tested on 1) peaches with or without indumenta (commonly referred to as peach fuzz), 2) peaches physically damaged by harvest operations, 3) peaches damaged by the peach twig borer *Anarsia lineatella* Zeller or the forktailed bush katydid, *Scudderia furcata* Brunner von Wattenwyl, and 4) peaches with punctures that simulated stink bug damage. Female *D. suzukii* did not lay eggs in intact fuzzy sections of the fruit or into small punctures (0.3 or 0.5 mm), but readily laid eggs in sections without fuzz, with insect damage, and with large punctures (1 mm). The number of eggs per treatment was positively related to the area of the damaged section; the overall fruit firmness and sugar content was not related to the number of eggs laid in treated or damaged spots. Direct observations of *D. suzukii* oviposition confirmed that peach fuzz appeared to be an obstacle for the fly's oviposition success, and female flies ceased ovipositional attempts on fuzzy peach sections after a short period of time. Successful oviposition times were associated with substrate firmness, with shorter oviposition time in damaged spots than in cherry fruit or shaved spots of the peach. The results indicate that intact, preharvest peach fruit are unlikely to be infested by the fly, but any surface damage could render the fruit susceptible to the fly.

Swoboda-Bhattarai, K. A. and H. J. Burrack (2014). "Influence of edible fruit coatings on *Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae) oviposition and development." *International Journal of Pest Management* 60(4): 279-286.

*Drosophila suzukii* (Matsumura) is a highly invasive vinegar fly recently detected in the United States that severely threatens the viability of soft skinned fruit production. Insecticides mitigate some of this damage, but alternative methods to manage *D. suzukii* infestation are needed. We tested three edible coatings to determine if they could prevent or reduce oviposition by *D. suzukii* females or affect immature survivorship and development in two important host crops, blueberry and raspberry. None of the coatings prevented oviposition, but some reduced the number of eggs laid. Two carnauba wax-based coatings, PrimaFresh 45 and Raynox, dramatically reduced survivorship of immature

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*D. suzukii* in raspberries, but not in blueberries. Our results suggest that obtaining thorough, even coverage in the field will be essential if edible coatings are to be used as a management strategy for *D. suzukii*.

Tochen, S., D. T. Dalton, N. Wiman, C. Hamm, P. W. Shearer and V. M. Walton (2014). "Temperature-Related Development and Population Parameters for *Drosophila suzukii* (Diptera: Drosophilidae) on Cherry and Blueberry." *Environmental Entomology* 43(2): 501-510.

Temperature-related studies were conducted on *Drosophila suzukii* Matsumura (Diptera: Drosophilidae: Drosophilini). From 10-28 degrees C, temperature had a significant impact on blueberries, *Vaccinium corymbosum* L. (Ericales: Ericaceae), and cherries, *Prunus avium* (L.) L. 1755 (Rosales: Rosaceae), important commercial hosts of *D. suzukii*. Temperature had a significant influence on *D. suzukii* developmental period, survival, and fecundity, with decreasing developmental periods as temperatures increased to 28 degrees C. At 30 degrees C, the highest temperature tested, development periods increased, indicating that above this temperature the developmental extremes for the species were approached. *D. suzukii* reared on blueberries had lower fecundity than reared on cherries at all temperatures where reproduction occurred. The highest net reproductive rate (R-degrees) and intrinsic rate of population increase (r(m)) were recorded on cherries at 22 degrees C and was 195.1 and 0.22, respectively. Estimations using linear and nonlinear fit for the minimum, optimal, and maximum temperatures where development can take place were respectively, 7.2, 28.1, and 42.1 degrees C. The r(m) values were minimal, optimal, and maximal at 13.4, 21.0, and 29.3 degrees C, respectively. Our laboratory cultures of *D. suzukii* displayed high rates of infection for *Wolbachia* spp. (Rickettsiales: Rickettsiaceae), and this infection may have impacted fecundity found in this study. A temperature-dependent matrix population estimation model using fecundity and survival data were run to determine whether these data could predict *D. suzukii* pressure based on environmental conditions. The model was applied to compare the 2011 and 2012 crop seasons in an important cherry production region. Population estimates using the model explained different risk levels during the key cherry harvest period between these seasons.

Van Timmeren, S. and R. Isaacs (2014). "Control of spotted wing drosophila, *Drosophila suzukii*, by specific insecticides and by conventional and organic crop protection programs (vol 54, pg 126, 2013)." *Crop Protection* 59: 81-81.

Van Timmeren, S. and R. Isaacs (2014). "*Drosophila suzukii* in Michigan vineyards, and the first report of *Zaprionus indianus* from this region." *Journal of Applied Entomology* 138(7): 519-527.

*Drosophila suzukii* is a new invasive pest that in recent years has become established in the Great Lakes region of the United States. Understanding the level of infestation in potentially susceptible crops is an important first step for planning appropriate management responses. This study was conducted in 2010-2012 to determine the infestation potential of this pest in native *Vitis labrusca*, French hybrid and *V. vinifera* grape cultivars grown in Michigan vineyards. *Drosophila suzukii* adults were reared out of collected grape samples in all 3 years, comprising a low proportion of all emerged drosophilids in each of the years. This trend was also found in vacuum sampling, conducted in 2011, with the majority of flies collected being non-*D. suzukii* drosophilids. Another recently introduced invasive fly species, *Zaprionus indianus*, was also reared out of grape samples collected in 2012. While the results of this study indicate no immediate threats to commercial grape production from *D. suzukii*, further research is needed to elucidate possible secondary effects that this species may have on vineyards, such as the introduction of diseases to the fruit.

Vilela, C. R. and L. Mori (2014). "The invasive spotted-wing *Drosophila* (Diptera, Drosophilidae) has been found in the city of Sao Paulo (Brazil)." *Revista Brasileira De Entomologia* 58(4): 371-375.

Vogt, H. (2014). A new pest, the Spotted Wing *Drosophila*, *Drosophila suzukii* (MATsumuRA 1931). *Mitteilungen Der Deutschen Gesellschaft Fur Allgemeine Und Angewandte Entomologie*, Bd 19. J. Handel. 19: 211-221.

is threatening fruit-growing and viticulture. *Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae) is an invasive pest that was recently introduced to Europe. Its identification, biology, hosts and distribution, and the damage caused are described with special attention to the actual situation in Germany. Information is provided on possible measures to prevent its further multiplication and spread.

Wiman, N. G., V. M. Walton, D. T. Dalton, G. Anfora, H. J. Burrack, J. C. Chiu, K. M. Daane, A. Grassi, B. Miller, S. Tochen, X. G. Wang and C. Ioriatti (2014). "Integrating Temperature-Dependent Life Table Data into a Matrix Projection Model for *Drosophila suzukii* Population Estimation." *Plos One* 9(9).

Yee, W. L. (2014). "COMPARISON OF THE BROWN SUGAR, HOT WATER, AND SALT METHODS FOR DETECTING WESTERN CHERRY FRUIT FLY (DIPTERA: TEPHRITIDAE) LARVAE IN SWEET CHERRY." *Florida Entomologist* 97(2): 422-430.

Brown sugar and hot water methods have been developed to detect larvae of tephritid fruit flies post-harvest in fruit in order to maintain quarantine security. It would be useful to determine if modifications of these methods can yield better results and if less expensive alternatives exist. This study reports detection rates of *Rhagoletis indifferens* Curran (Diptera: Tephritidae) larvae separated from crushed sweet cherries (*Prunus avium* [L.] L.) by brown sugar flotation versus hot water and sodium chloride (salt) flotation methods. Cherries were crushed and shredded by a standard cherry crusher and submerged either in brown sugar solution, hot water, or salt solution. In sugar and salt solutions, extracted larvae floated, whereas in hot water they sank; and in all 3 visual inspections for larvae were made. The brown sugar flotation method detected more total larvae than the hot water method when using a clear dish or black pan after cherries were shredded through a 2-mm gap in a cherry crusher, resulting in 95, 85, and 85% detections, respectively. Brown sugar and salt flotation methods resulted in similar detection rates of 85-99% after cherries were shredded through either a 2- or 5-mm gap, even though the 2-mm gap resulted in greater shredding. In brown sugar, hot water, and salt solutions, 26-88% of first instars (when there were at least 8 individuals) were detected versus 77-100% of second and third instars. Results demonstrate that salt and brown sugar solutions are equally efficacious for detecting larvae of *R. indifferens* separated from crushed cherries. Salt solution is advantageous over brown sugar solution because it is less expensive. Should salt solution be used for detecting larval spotted wing drosophila (*Drosophila suzukii* [Matsumura]) in cherries, current results show that it would not compromise detection of *R. indifferens*.

Zhai, Y. F., Q. C. Lin, X. H. Zhou, X. Y. Zhang, T. L. Liu and Y. Yu (2014). "Identification and Validation of Reference Genes for Quantitative Real-Time PCR in *Drosophila suzukii* (Diptera: Drosophilidae)." *Plos One* 9(9).

To accurately evaluate gene expression levels and obtain more accurate quantitative real-time RT-PCR (qRT-PCR) data, normalization relative to reliable reference gene(s) is required. *Drosophila suzukii*, is an invasive fruit pest native to East Asia, and recently invaded Europe and North America, the stability of its reference genes have not been previously investigated. In this study, ten candidate reference genes (RPL18, RPS3, AK, EF-1 beta, TBP, NADH, HSP22, GAPDH, Actin, alpha-Tubulin), were evaluated for their suitability as normalization genes under different biotic (developmental stage, tissue and population), and abiotic (photoperiod, temperature) conditions. The three statistical approaches (geNorm, NormFinder and BestKeeper) and one web-based comprehensive tool (RefFinder) were used to normalize analysis of the ten candidate reference genes identified alpha-Tubulin, TBP and AK as the most stable candidates, while HSP22 and Actin showed the lowest expression stability. We used three most stable genes (alpha-Tubulin, TBP and AK) and one unstably expressed gene to analyze the expression of P-glycoprotein in abamectin-resistant and sensitive strains, and the results were similar to reference genes alpha-Tubulin, TBP and AK, which show good stability, while the result of HSP22 has a certain bias. The three validated reference genes can be widely used for quantification of target gene expression with qRT-PCR technology in *D. suzukii*.

## Articles parus avant 2014

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Basoalto, E., R. Hilton and A. Knight (2013). "Factors affecting the efficacy of a vinegar trap for *Drosophila suzukii* (Diptera: Drosophilidae)." *Journal of Applied Entomology* 137(8): 561-570.

*Drosophila suzukii*, Matsumura, is a relatively new pest in the United States attacking a variety of fruit crops. Studies were conducted to develop a standardized, economical trap for monitoring. Laboratory bioassays found that flies were attracted to dark colours ranging from red to black. Similarly, fly catches in 237-ml plastic 'spice' jars with ten 0.48-cm holes and baited with apple cider vinegar were significantly higher in jars with red or black than white caps. The use of

an alternating set of three, horizontal red, black and red bands ('Zorro' trap) significantly increased fly catches compared with the use of all-red or all-black strips. This increase was associated with a significantly higher proportion of flies first landing on the side near the openings of the trap instead of on the cap with the 'Zorro' trap compared with the other traps. Laboratory data were used to develop a predictive model to define total fly capture as a function of trap colour/colour pattern, cumulative area of entry holes and the length of the trapping portion of the trap. Total fly catches by the 'Zorro' trap were compared with other red and clear plastic traps in five field trials conducted in several cultivated and uncultivated sites. Comparisons included a commercial red-capped 200-ml trap with two 0.63-cm holes, an all-red spice jar with ten 0.48-cm holes and clear and red 473-ml and clear 946-ml plastic cups with six or ten 0.48-or 0.63-cm holes. The model was successfully validated, suggesting that performance of cup traps can be predicted based on a few characteristics. The current 'Zorro' trap did not catch most of the flies among trap designs, but showed some advantages, including the durability and potential to recycle the plastic, small size, commercial availability and its greater selectivity for *D. suzukii* than the other traps tested.

Bellamy, D. E., M. S. Sisterson and S. S. Walse (2013). "Quantifying Host Potentials: Indexing Postharvest Fresh Fruits for Spotted Wing *Drosophila*, *Drosophila suzukii*." Plos One 8(4).

Novel methodology is presented for indexing the relative potential of hosts to function as resources. A Host Potential Index (HPI) was developed as a practical framework to express relative host potential based on combining results from one or more independent studies, such as those examining host selection, utilization, and physiological development of the organism resorting to the host. Several aspects of the HPI are addressed including: 1) model derivation; 2) influence of experimental design on establishing host rankings for a study type (no choice, two-choice, and multiple-choice); and, 3) variable selection and weighting associated with combining multiple studies. To demonstrate application of the HPI, results from the interactions of spotted wing drosophila (SWD), *Drosophila suzukii* Matsumura (Diptera: Drosophilidae), with seven "reported" hosts (blackberries, blueberries, sweet cherries, table grapes, peaches, raspberries, and strawberries) in a postharvest scenario were analyzed. Four aspects of SWD-host interaction were examined: attraction to host volatiles; population-level oviposition performance; individual-level oviposition performance; and key developmental factors. Application of HPI methodology indicated that raspberries ((HPIvaried)-H-mean = 301.9 +/- 8.39; rank 1 of 7) have the greatest potential to serve as a postharvest host for SWD relative to the other fruit hosts, with grapes ((HPIvaried)-H-mean = 232.4 +/- 3.21; rank 7 of 7) having the least potential.

Burrack, H. J., G. E. Fernandez, T. Spivey and D. A. Kraus (2013). "Variation in selection and utilization of host crops in the field and laboratory by *Drosophila suzukii* Matsumura (Diptera: Drosophilidae), an invasive frugivore." Pest Management Science Online only.

**BACKGROUND:** *Drosophila suzukii*, a pest of soft-skinned berries and stone fruits, has recently rapidly expanded its global range. The impacts of *D. suzukii* infestation and subsequent fruit damage in North America and Europe have been profound. The aim of the present work was to assess host selection of *D. suzukii* in the field and laboratory, with an emphasis on hosts commonly grown in the southeastern United States, where *D. suzukii* has been established since 2010.

**RESULTS:** Raspberries were infested at a greater rate than blackberries in the field, and varieties within both species were infested at different rates. Primocane-fruited blackberries were often the least heavily infested. Further, blackberries and raspberries grown under high tunnels were infested at lower rates than those grown outside. Fruit and artificial substrates with a lower surface penetration force were more heavily infested than firmer substrates in the laboratory; no eggs were laid in artificial substrates exceeding 52.00 cN surface penetration force.

**CONCLUSION:** Infestation rates differ between species and varieties within species of *Rubus* in the southeastern United States. Fruit penetration force is one potential measure of host susceptibility, but host attractiveness will likely depend upon additional factors, such as soluble sugar content.

Cha, D. H., S. P. Hesler, R. S. Cowles, H. Vogt, G. M. Loeb and P. J. Landolt (2013). "Comparison of a Synthetic Chemical Lure and Standard Fermented Baits for Trapping *Drosophila suzukii* (Diptera: Drosophilidae)." Environmental Entomology 42(5): 1052-1060.

We determined the attractiveness of a new chemical lure compared with fermented food baits in use for trapping *Drosophila suzukii* Matsumura, spotted wing drosophila (Diptera: Drosophilidae), in Connecticut, New York, and

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Washington in the United States and at Dossenheim in Germany. The chemical lure (SWD lure) and food baits were compared in two types of traps: the dome trap and a cup trap. Regardless of trap type, numbers of male and female *D. suzukii* trapped were greater with the SWD lure compared with apple cider vinegar (ACV) baits at the Washington and New York sites, and were comparable with numbers of *D. suzukii* captured with a wine plus vinegar bait (W + V) at Germany site and a combination bait meant to mimic W + V at the Connecticut site. Averaged over both types of attractants, the numbers of *D. suzukii* captured were greater in dome traps than in cup traps in New York and Connecticut for both male and female *D. suzukii* and in Washington for male *D. suzukii*. No such differences were found between trap types at the Washington site for female and Germany for male and female *D. suzukii*. Assessments were also made of the number of large (> 0.5 cm) and small (< 0.5 cm) nontarget flies trapped. The SWD lure captured fewer nontarget small flies and more large flies compared with ACV bait in New York and fewer nontarget small flies compared with W + V in Germany, although no such differences were found in Washington for the SWD lure versus ACV bait and in Connecticut for the SWD lure versus the combination bait, indicating that these effects are likely influenced by the local nontarget insect community active at the time of trapping. In New York, Connecticut, and Germany, dome traps caught more nontarget flies compared with cup traps. Our results suggest that the four-component SWD chemical lure is an effective attractant for *D. suzukii* and could be used in place of fermented food-type baits.

Chiu, J. C., X. T. Jiang, L. Zhao, C. A. Hamm, J. M. Cridland, P. Saelao, K. A. Hamby, E. K. Lee, R. S. Kwok, G. J. Zhang, F. G. Zalom, V. M. Walton and D. J. Begun (2013). "Genome of *Drosophila suzukii*, the Spotted Wing *Drosophila*." *G3-Genes Genomes Genetics* 3(12): 2257-2271.

*Drosophila suzukii* Matsumura (spotted wing drosophila) has recently become a serious pest of a wide variety of fruit crops in the United States as well as in Europe, leading to substantial yearly crop losses. To enable basic and applied research of this important pest, we sequenced the *D. suzukii* genome to obtain a high-quality reference sequence. Here, we discuss the basic properties of the genome and transcriptome and describe patterns of genome evolution in *D. suzukii* and its close relatives. Our analyses and genome annotations are presented in a web portal, SpottedWingFlyBase, to facilitate public access.

Demchak, K. and E. J. Hanson (2013). "Small Fruit Production in High Tunnels in the US." *International Symposium on High Tunnel Horticultural Crop Production* 987: 41-44.

High tunnel production of small fruit crops in the US varies widely as related to extent and objective of tunnel use. On the west coast, large-scale high tunnels are used primarily to protect berry crops from the elements, thus increasing shelf-life and feasibility of shipping berries to distant markets. In the western US, approximately 2100 ha of berry crops are grown under high tunnels, primarily red raspberries and to a lesser extent blackberries, both mainly for wholesale markets. In the midwestern and eastern US, high tunnel production is diverse, with mostly small-scale single-bay tunnels being used by growers who primarily direct market fruit to consumers. In these areas, a main objective is early and late season extension for raspberries and strawberries. Producers of fall berry crops are facing a new challenge, spotted wing drosophila (*Drosophila suzukii*). Populations of this vinegar fly are highest late in the season, thus being problematic for late summer and fall berry crop production.

Freda, P. J. and J. M. Braverman (2013). "DROSOPHILA SUZUKII, OR SPOTTED WING DROSOPHILA, RECORDED IN SOUTHEASTERN PENNSYLVANIA, USA." *Entomological News* 123(1): 71-75.

Collections of *Drosophila* and their relatives were performed using bait traps on the campus of Saint Joseph's University, in Philadelphia and Lower Merion, Pennsylvania, between July and December 2011 and continuing in March of 2012. In the 2011 collection season, more than 200 specimens of *Drosophila suzukii* (Matsumura), or spotted wing *Drosophila*, were collected. In 2012, specimens started to appear in June and were collected until December. The appearance of *D. suzukii* in the Philadelphia and surrounding area has severe, negative implications for local agriculture. *D. suzukii*, unlike most other *Drosophila* species, is an agricultural pest that lays its eggs in soft-skinned, unspoiled fruits like cherries, grapes, and berries (Bolda et al., 2009).

Gargani, E., F. Tarchi, R. Frosinini, G. Mazza and S. Simoni (2013). "NOTES ON DROSOPHILA SUZUKII MATSUMURA (DIPTERA DROSOPHILIDAE): FIELD SURVEY IN TUSCANY AND LABORATORY EVALUATION OF ORGANIC PRODUCTS." *Redia-Giornale Di Zoologia* 96: 85-90.

Reported for the first time in Italy in 2009, the Spotted Wing Drosophila (SWD), *Drosophila suzukii* (Matsumura) (Diptera Drosophilidae), has rapidly spread throughout the country, causing serious damage on many fruit crops. The potential of infestation rate by *D. suzukii* is enormous: the females can complete many generations per year, and are able to attack the fresh, ripe fruit of many hosts by laying eggs under the soft skin; the larvae grow in the fruits and destroy the commercial value of them. The host range of SWD is reportedly wide, including both cultivated (soft fruits, sweet cherry, stone fruits etc...) and wild plants. In 2013, field surveys aimed at monitoring the presence of the insect on Tuscany territory, were regularly carried out: on an important district for the sweet cherry production with differently managed in control, on a biological blueberry orchard and even on other host plants neighboring the samples' areas. *D. suzukii* was present in the monitored areas and its numerically large populations and heavy infestations on sweet cherries have shown that the species has settled in these areas. In laboratory tests, labeled organic products and substances of natural origin - in accordance with the requirements of EU regulations which provides for the reduction of chemicals - were evaluated as concern toxicity and residual effect on the pest. As regards effects of direct toxicity, products based on *Beauveria bassiana* have shown some effectiveness in the control of SWD, other organic products have shown interesting results. The evidences acquired are discussed.

Hamby, K. A., R. S. Kwok, F. G. Zalom and J. C. Chiu (2013). "Integrating Circadian Activity and Gene Expression Profiles to Predict Chronotoxicity of *Drosophila suzukii* Response to Insecticides." *Plos One* 8(7).

Native to Southeast Asia, *Drosophila suzukii* (Matsumura) is a recent invader that infests intact ripe and ripening fruit, leading to significant crop losses in the U.S., Canada, and Europe. Since current *D. suzukii* management strategies rely heavily on insecticide usage and insecticide detoxification gene expression is under circadian regulation in the closely related *Drosophila melanogaster*, we set out to determine if integrative analysis of daily activity patterns and detoxification gene expression can predict chronotoxicity of *D. suzukii* to insecticides. Locomotor assays were performed under conditions that approximate a typical summer or winter day in Watsonville, California, where *D. suzukii* was first detected in North America. As expected, daily activity patterns of *D. suzukii* appeared quite different between 'summer' and 'winter' conditions due to differences in photoperiod and temperature. In the 'summer', *D. suzukii* assumed a more bimodal activity pattern, with maximum activity occurring at dawn and dusk. In the 'winter', activity was unimodal and restricted to the warmest part of the circadian cycle. Expression analysis of six detoxification genes and acute contact bioassays were performed at multiple circadian times, but only in conditions approximating Watsonville summer, the cropping season, when most insecticide applications occur. Five of the genes tested exhibited rhythmic expression, with the majority showing peak expression at dawn (ZT0, 6am). We observed significant differences in the chronotoxicity of *D. suzukii* towards malathion, with highest susceptibility at ZT0 (6am), corresponding to peak expression of cytochrome P450s that may be involved in bioactivation of malathion. High activity levels were not found to correlate with high insecticide susceptibility as initially hypothesized. Chronobiology and chronotoxicity of *D. suzukii* provide valuable insights for monitoring and control efforts, because insect activity as well as insecticide timing and efficacy are crucial considerations for pest management. However, field research is necessary for extrapolation to agricultural settings.

Hanson, E. J., B. I. Gluck and A. Schilder (2013). "High Tunnels for Organic Raspberry Production in the Midwestern US." *International Organic Fruit Symposium* 1001: 73-77.

Demand for organic foods has increased opportunities for sales of fresh organic raspberries (*Rubus idaeus*). Organic berry production in the US Midwest is challenging because arthropod pests and diseases are abundant. High tunnels suppress some diseases and insect pests and may increase opportunities for organic control methods. Raspberry fruit quality and yields are also enhanced in tunnels compared with outdoor production. Since high tunnels hold promise for organic raspberry production in the Midwest, we initiated a long-term project to study organic strategies for managing soil health, available nutrients, and arthropod pests. Raspberries have a consistent nitrogen requirement throughout the growing season which can be difficult to supply organically under dry environmental conditions. Initial observations suggest that compost and solid organic fertilizer are effective if tilled into the row prior to planting, but are less effective if broadcast over established rows. In addition, we observed a number of arthropod pests that pose a

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moderate threat but can likely be controlled with organic materials or beneficial arthropods. Currently, control of spotted wing drosophila (SWD, *Drosophila suzukii*) is the greatest concern.

Kasuya, N., H. Mitsui, S. Ideo, M. Watada and M. T. Kimura (2013). "Ecological, morphological and molecular studies on *Ganaspis* individuals (Hymenoptera: Figitidae) attacking *Drosophila suzukii* (Diptera: Drosophilidae)." *Applied Entomology and Zoology* 48(1): 87-92.

*Ganaspis* individuals parasitizing *Drosophila suzukii* (Matsumura), a pest of fruit crops, were examined for host use and molecular and morphological differences from those attacking *D. lutescens* Okada and some other *Drosophila* species that breed on fermenting fruits. Wild cherry fruits were collected in the suburbs of Tokyo, and drosophilid pupae obtained from these fruits were examined for parasitism. *Drosophila suzukii* was the only drosophilid species infesting fresh wild cherry fruits, and *Ganaspis* individuals were the major parasitoids attacking *D. suzukii* in wild cherry fruits. In parasitism experiments, these *Ganaspis* individuals parasitized *D. suzukii* larvae in fresh cherry fruits, but did not parasitize those in *Drosophila* medium. In addition, they did not parasitize larvae of some other fruit-feeding *Drosophila* species even when these occurred in fresh cherry fruit. These *Ganaspis* individuals parasitizing *D. suzukii* were different from those parasitizing *D. lutescens* and some other drosophilids in nucleotide sequences of the COI gene, as well as in ITS1 and ITS2. They were also different in forewing and antenna morphology, although they showed some overlap in morphological traits. They are tentatively assigned as the *suzukii*- and *lutescens*-associated types of *G. xanthopoda* Ashmead. In the present field survey, *Leptopilina japonica* Novkovič & Kimura and some *Asobara* species were also observed to attack *D. suzukii* larvae in wild cherry fruit.

Kinjo, H., Y. Kunimi, T. Ban and M. Nakai (2013). "Oviposition Efficacy of *Drosophila suzukii* (Diptera: Drosophilidae) on Different Cultivars of Blueberry." *Journal of Economic Entomology* 106(4): 1767-1771.

*Drosophila suzukii* (Matsumura) is an important pest of thin-skinned fruits including blueberry, raspberry, strawberry, and cherry. Blueberry was introduced into Japan in the 1950s, and severe economic losses attributable to *D. suzukii* were first reported in 2002. The objective of this study was to elucidate whether oviposition behavior varies among blueberry cultivars having different firmness of fruit. Fruit firmness in 12 cultivars of highbush blueberry (*Vaccinium corymbosum* L.) and rabbiteye blueberry (*Vaccinium virgatum* Aiton) was determined using a rheometer. More eggs tended to be laid in berries of cultivars possessing softer fruits than in those having firmer fruits. Choice tests, where one female was allowed to oviposit on blueberry fruits with different firmness, showed that softer fruits were more vulnerable to *D. suzukii* females than firmer fruits.

Knight, A., W. Yee and R. Hilton (2013). "Developing a New Bait for Spotted-Wing *Drosophila* in Organic Cherry Production." *II International Organic Fruit Symposium* 1001: 147-152.

Studies conducted at the USDA Laboratory in Wapato, WA and at Oregon State University were initiated in 2011 to improve the efficacy of an organically-certified formulation of the insecticide spinosad (Entrust (R)) for control of the spotted wing drosophila, *Drosophila suzukii*. Our initial approach was to evaluate the possible benefits of adding a bait composed of brown sugar and compressed bread yeast, *Saccharomyces cerevisiae*. A direct comparison of the sugar-yeast bait with the protein-based baits, GF-120 (R) and Nu-Lure (R), in laboratory tests showed that it was more effective than either commercial product. We found that fly mortality at 2 and 6 h significantly increased throughout the season with the addition of the sugar-yeast bait. In particular, the addition of the sugar-yeast bait to Entrust increased fly mortality 4-fold in early-season bioassays with green and yellow cherries. While the mean numbers of eggs laid and larval infestations of cherry was reduced (50%) with the addition of the sugar-yeast bait, these differences were not significant. Studies are continuing in 2012 with a new yeast candidate that is an effective biofungicide combined with a higher concentration of sugar that may be an effective repellent of birds. The potential of this bait to improve control of the western cherry fruit fly, *Rhagoletis indifferens* is also being evaluated.

Lee, J. C., P. W. Shearer, L. D. Barrantes, E. H. Beers, H. J. Burrack, D. T. Dalton, A. J. Dreves, L. J. Gut, K. A. Hamby, D. R. Haviland, R. Isaacs, A. L. Nielsen, T. Richardson, C. R. Rodriguez-Saona, C. A. Stanley, D. B. Walsh, V. M. Walton, W. L. Yee, F. G. Zalom and D. J. Bruck (2013). "Trap Designs for Monitoring *Drosophila suzukii* (Diptera: Drosophilidae)." *Environmental Entomology* 42(6): 1348-1355.

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*Drosophila suzukii* (Matsumura), an invasive pest of small and stone fruits, has been recently detected in 39 states of the United States, Canada, Mexico, and Europe. This pest attacks ripening fruit, causing economic losses including increased management costs and crop rejection. Ongoing research aims to improve the efficacy of monitoring traps. Studies were conducted to evaluate how physical trap features affect captures of *D. suzukii*. We evaluated five colors, two bait surface areas, and a top and side position for the fly entry point. Studies were conducted at 16 sites spanning seven states and provinces of North America and nine crop types. Apple cider vinegar was the standard bait in all trap types. In the overall analysis, yellow-colored traps caught significantly more flies than clear, white, and black traps; and red traps caught more than clear traps. Results by color may be influenced by crop type. Overall, the trap with a greater bait surface area caught slightly more *D. suzukii* than the trap with smaller area (90 vs. 40 cm<sup>2</sup>). Overall, the two traps with a side-mesh entry, with or without a protective rain tent, caught more *D. suzukii* than the trap with a top-mesh entry and tent.

Leskey, T. (2013). Assessment of Attracticidal Spheres as a Tool for Management of Spotted Wing *Drosophila*.  
Lien vers la présentation : <http://www.northeastipm.org/neipm/assets/File/TFWG-Leskey-Attracticidal-Spheres.pdf>

Mazzoni, V., G. Anfora and M. Virant-Doberlet (2013). "Substrate Vibrations during Courtship in Three *Drosophila* species." *Plos One* 8(11).

While a plethora of studies have focused on the role of visual, chemical and near-field airborne signals in courtship of *Drosophila* fruit flies, the existence of substrate-borne vibrational signals has been almost completely overlooked. Here we describe substrate vibrations generated during courtship in three species of the *D. melanogaster* group, from the allegedly mute species *D. suzukii*, its sister species *D. biarmipes*, and from *D. melanogaster*. In all species, we recorded several types of substrate vibrations which were generated by locomotion, abdominal vibrations and most likely through the activity of thoracic wing muscles. In *D. melanogaster* and *D. suzukii*, all substrate vibrations described in intact males were also recorded in males with amputated wings. Evidence suggests that vibrational signalling may be widespread among *Drosophila* species, and fruit flies may provide an ideal model to study various aspects of this widespread form of animal communication.

Ometto, L., A. Cestaro, S. Ramasamy, A. Grassi, S. Revadi, S. Siozios, M. Moretto, P. Fontana, C. Varotto, D. Pisani, T. Dekker, N. Wrobel, R. Viola, I. Pertot, D. Cavalieri, M. Blaxter, G. Anfora and O. Rota-Stabelli (2013). "Linking Genomics and Ecology to Investigate the Complex Evolution of an Invasive *Drosophila* Pest." *Genome Biology and Evolution* 5(4): 745-757.

*Drosophilid* fruit flies have provided science with striking cases of behavioral adaptation and genetic innovation. A recent example is the invasive pest *Drosophila suzukii*, which, unlike most other *Drosophila*, lays eggs and feeds on undamaged, ripening fruits. This not only poses a serious threat for fruit cultivation but also offers an interesting model to study evolution of behavioral innovation. We developed genome and transcriptome resources for *D. suzukii*. Coupling analyses of these data with field observations, we propose a hypothesis of the origin of its peculiar ecology. Using nuclear and mitochondrial phylogenetic analyses, we confirm its Asian origin and reveal a surprising sister relationship between the *eugracilis* and the *melanogaster* subgroups. Although the *D. suzukii* genome is comparable in size and repeat content to other *Drosophila* species, it has the lowest nucleotide substitution rate among the species analyzed in this study. This finding is compatible with the overwintering diapause of *D. suzukii*, which results in a reduced number of generations per year compared with its sister species. Genome-scale relaxed clock analyses support a late Miocene origin of *D. suzukii*, concomitant with paleogeological and climatic conditions that suggest an adaptation to temperate montane forests, a hypothesis confirmed by field trapping. We propose a causal link between the ecological adaptations of *D. suzukii* in its native habitat and its invasive success in Europe and North America.

Poyet, M., S. Havard, G. Prevost, O. Chabrerie, G. Doury, P. Gibert and P. Eslin (2013). "Resistance of *Drosophila suzukii* to the larval parasitoids *Leptopilina heterotoma* and *Asobara japonica* is related to haemocyte load." *Physiological Entomology* 38(1): 45-53.

Unlike other *Drosophila* species, the invasive *Drosophila suzukii* Matsumura (Diptera: *Drosophilidae*) shows a remarkable pest status. Among the physiological traits that may explain the high level of resistance to parasitoids of *Drosophila* larvae, the haemocyte load is shown repeatedly to play an important role. To determine whether haemocyte load can explain immunity resistance of *D. suzukii* to parasitoids, the haemocytes of parasitized and healthy larvae are

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quantified in two Japanese and three French populations of *D. suzukii*. Parasitization tests are conducted with two larval parasitoids: the paleartic *Leptopilina heterotoma* Thomson (Hymenoptera: Figitidae) and the Asian *Asobara japonica* Belokobylskij (Hymenoptera: Braconidae). Based on morphological and functional criteria, *D. suzukii* has classes of haemocytes similar to those described in *Drosophila melanogaster*. However, healthy larvae of the five populations tested possess particularly large numbers of haemocytes compared with *D. melanogaster*. Haemocyte load is also higher in larvae from the French populations than in the Japanese strains. The ability of *D. suzukii* larvae to encapsulate eggs of *L. heterotoma* is associated with a particularly high load of circulating haemocytes. However, it is notable that *A. japonica* induces a strong depression of the haemocyte population in this resistant host associated with an inability to encapsulate parasitoid eggs. The results show that the cellular immune system plays a major role in the failure of larval parasitoids to develop in most instances in larvae of *D. suzukii*, possibly contributing to the success of this species as an invader.

Rota-Stabelli, O., M. Blaxter and G. Anfora (2013). "*Drosophila suzukii*." *Current Biology* 23(1): R8-R9.

Saguez, J., J. Lasnier and C. Vincent (2013). "First record of *Drosophila suzukii* in Quebec vineyards." *Journal International Des Sciences De La Vigne Et Du Vin* 47(1): 69-72.

Objectif : Des études menées entre juillet et septembre 2012, dans des vignobles québécois, ont révélé la présence de la drosophile à ailes tachetées (DAT), *Drosophila suzukii* Matsumura, juste avant la récolte. Méthodes et résultats : Lors d'un échantillonnage de cicadelles sur des cépages rouges et blancs de quatre vignobles, trente DAT adultes ont été collectées de façon inattendue par battage sur des cépages rouges, soit du Maréchal Foch, du Gamay et du Seyval Noir. Un total de 101 DAT ont émergé à partir de grappes sélectionnées en vignobles et placées en conditions de laboratoire. Aucune DAT n'a été détectée sur des cépages blancs. Conclusion: Cela constitue la première mention de la DAT sur des cépages destinés à la production de vin au Québec. Importance et impact de l'étude : La dispersion de la DAT à travers les vignobles québécois pourrait générer d'importantes pertes de rendement. Les traitements insecticides nécessitent donc des adaptations face à ce nouveau défi entomologique.

Schetelig, M. F. and A. M. Handler (2013). "Germline transformation of the spotted wing drosophilid, *Drosophila suzukii*, with a piggyBac transposon vector." *Genetica* 141(4-6): 189-193.

*Drosophila suzukii* is a pest of small fruits in many parts of the world, whose management is limited to cultural practices and the use of insecticides. Here we describe a method to genetically manipulate this species in the first step to create female lethality strains useful for the sterile insect technique method of population suppression. This was achieved by the germ-line transformation of *D. suzukii* with a piggyBac transposon vector having a female-specific lethality effector construct. This can be used in a tetracycline-suppressible conditional gene expression system, when crossed to a suitable tet-transactivator strain. Transformation occurred efficiently, at a frequency of 16 % per fertile G0 embryo injected with vector and helper transposase plasmids. The vector was marked for transformant selection with the polyubiquitin-regulated EGFP fluorescent protein, and contains the attP landing site and heterospecific lox recombination sites for post-integration modification of the transgene vector. The 3xP3-AmCyan fluorescent protein marker was inserted within the lox sites to follow a possible recombinase-mediated cassette exchange, that would allow subsequent improvement of the transgenic strain by immobilization of the vector and introduction of new marker cassettes.

Steffan, S. A., J. C. Lee, M. E. Singleton, A. Vilaire, D. B. Walsh, L. S. Lavine and K. Patten (2013). "Susceptibility of Cranberries to *Drosophila suzukii* (Diptera: Drosophilidae)." *Journal of Economic Entomology* 106(6): 2424-2427.

*Drosophila suzukii* Matsumura (Diptera: Drosophilidae), commonly referred to as the spotted wing drosophila, is an exotic species that has proven a troublesome pest of fruit production in the United States. The fly targets small fruit and thus represents a concern for the U.S. cranberry industry. Two studies were conducted to assess whether cranberries may serve as hosts for *D. suzukii*. In the first study, the suitability of ripe, unripe, and over-ripe cranberries were assayed by examining adult oviposition and larval development in no-choice trials. In the second study, wounded and unwounded fruit were examined as potential hosts in choice and no-choice trials. Our first study showed that ripe, unripe, and over-ripe cranberries were unsuitable hosts (few eggs were laid, with no surviving puparia). In the wounded and unwounded berry study, no larvae survived to adulthood among unwounded berries. Within wounded fruit, *D.*

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suzukii readily fed and developed into adults. Together, these results suggest that unwounded cranberries whether ripe, unripe, or over-ripe are unsuitable as hosts for *D. suzukii*. Wounded rotting cranberries, however, can serve as hosts. Across the landscape, cranberry marshes with rotting fruit may contribute to *D. suzukii* source-sink dynamics.

Van Timmeren, S. and R. Isaacs (2013). "Control of spotted wing drosophila, *Drosophila suzukii*, by specific insecticides and by conventional and organic crop protection programs." *Crop Protection* 54: 126-133.

Spotted wing drosophila, *Drosophila suzukii*, is an invasive insect pest that has spread into many fruit production regions of the world. Strategies to protect fruit from infestation by this insect are currently dominated by insecticide applications, so producers need information on relative efficacy and residual activity of insecticides to be able to select effective treatments. Semi-field bioassays in which highbush blueberry shoots with berries were treated then exposed to adult flies at different times after application revealed that fresh residues of organophosphate, pyrethroid, and spinosyn insecticides have strong initial activity on flies, with varying levels of residual protection against fruit infestation. An organic pyrethrum insecticide was not effective, whereas the neonicotinoid insecticide acetamiprid was found to have activity for up to five days. Rainfall after application greatly reduced the level of control achieved by some insecticides. Field-scale evaluation of conventional and organic spray programs initiated in response to capture of *D. suzukii* flies in monitoring traps indicated that both types of management provide significant fruit protection compared to untreated fields, with less larval detection in the conventionally produced berries.

Walton, V. M., P. W. Shearer, A. J. Dreves, F. Conway, J. Miller, W. Yang, E. H. Beers, L. Tanigoshi, D. Walsh, R. Van Steenwyk, F. Zalom, D. Begun, M. Bolda, R. Goodhue and J. Lee (2013). "Biology and Management of Spotted Wing Drosophila on Small and Stone Fruit - Year 2 reporting cycle". Washington State University Oregon State University, University of California at Berkeley, University of California at Davis, USDA-ARS, USDA-NIFA, and the small and stone fruit industries of Oregon, Washington, and California. A USDA-NIFA Specialty Crop Research Initiative Project: 24.

Lien : <http://spottedwing.org/content/biology-and-management-spotted-wing-drosophila-small-and-stone-fruits-year-3>

Weydert, C. and J. F. Mandrin (2013). "Le ravageur émergent *Drosophila suzukii*. Situation en France et connaissances acquises." *Infos CTIFL* 292: 70-78.

Cet article retrace l'évolution de la situation du ravageur *D. suzukii* en France depuis 2010 en terme de présence et dégâts de l'insecte. Il fait le point sur les dernières connaissances acquises sur sa biologie et son comportement à travers le suivi mené sur le domaine du centre Ctifl de Balandran. Il présente également les derniers résultats obtenus dans les essais du Ctifl visant à l'amélioration du monitoring et au développement des moyens de protection contre *D. suzukii*. Cet article fait suite à deux articles de 2011 et 2012 portant sur la situation de ce ravageur en arboriculture, et à un article paru en avril 2013 présentant les résultats des premières études sur fraise.

Weydert, C. and J. F. Mandrin (2013). "Le ravageur *Drosophila suzukii*. Point sur la situation en arboriculture fruitière et petits fruits." *Infos CTIFL* 279: 45-52.

Officiellement identifiée en 2010, *Drosophila suzukii* fait l'objet de toutes les inquiétudes. En l'espace d'un an on a pu constater une évolution fulgurante de son aire de répartition, de ses niveaux de population et également des dégâts sur les cultures, principalement de cerise, fraise et petits fruits rouges. Il s'agit là d'un ravageur hors normes, polyphage, mobile et très prolifique, contre lequel les moyens de protection testés en 2011 n'ont qu'une efficacité partielle. Cet article dresse un état des lieux de la situation fin 2011 et présente les premiers résultats d'essais sur *D. suzukii*. Il fait suite à un premier article traitant de ce ravageur.

Wilson, H. E., K. A. Hamby and F. G. Zalom (2013). "Host Susceptibility of 'French Prune' *Prunus domestica* to *Drosophila suzukii* (Diptera: Drosophilidae)." *X International Symposium on Plum and Prune Genetics, Breeding and Pomology* 985: 249-254.

Spotted wing drosophila, *Drosophila suzukii* Matsumura, invaded North America in 2008. In contrast to other *Drosophila* species, *D. suzukii* preferentially infests ripe fruits with its serrated ovipositor which can create commercially unmarketable fruit. As *D. suzukii* is reported to infest a variety of hosts, especially stone fruits and berries, growers are encouraged to monitor for *D. suzukii* to help prevent crop damage. We specifically tested the host susceptibility of *Prunus domestica* 'French prune' to *D. suzukii* in a no-choice host experiment and observed its presence in a mixed

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cultivar plum block. Few flies completed development within 'French prune' in a no choice experiment, demonstrating that it may not be a suitable host. *D. suzukii* adult captures were greatest at the beginning and end of plum season, with minimal captures throughout late summer, early fall, and winter. Therefore, while *D. suzukii* trapping may indicate presence of flies within the area, it may not correlate with fruit infestation.

Yu, D., F. G. Zalom and K. A. Hamby (2013). "Host Status and Fruit Odor Response of *Drosophila suzukii* (Diptera: Drosophilidae) to Figs and Mulberries." *Journal of Economic Entomology* 106(4): 1932-1937.

*Drosophila suzukii* Matsumura (Diptera: Drosophilidae) is an agricultural pest with a wide host range. It is known to infest fruit that are still ripening on the plant, as well as rotting and damaged fruit. Our study sought to determine whether *D. suzukii* use mulberries (*Morus* spp.) and figs (*Ficus carica* (L.)) as hosts, as their host status was ambiguous. Accordingly, we collected 25 field-infested fruit and counted the numbers of *D. suzukii* emerging from them. We also sought to determine whether female *D. suzukii* would respond to olfactory cues from ripe figs and mulberries. As the host population has been known to impact host odor response, flies from mulberry, fig, and cherry origins were tested in "one-choice" olfactometry studies. Our results show that mulberries and figs can serve as hosts for *D. suzukii* and that female flies will respond to their odors. The host population did affect response to fruit odors, although further studies are necessary to determine habitat fidelity. This has implications for management of this pest, especially in backyard and mixed fruit orchard situations, which commonly occur in the current range of *D. suzukii*, and fig and mulberry may serve as a pest reservoir for other hosts and cultivated crops.

Calabria, G., J. Maca, G. Bachli, L. Serra and M. Pascual (2012). "First records of the potential pest species *Drosophila suzukii* (Diptera: Drosophilidae) in Europe." *Journal of Applied Entomology* 136(1-2): 139-147.

*Drosophila suzukii* oviposits and feeds on healthy fruits, unlike most other *Drosophila* species. It has been traditionally reported from Asia, but in the last 2 years it has been recorded from North America, where it is causing a lot of agricultural damage. Herein we report the first records of *D. suzukii* in Europe. It has been found in different localities expanding an altitudinal range from 27 to 1550 m above sea level (ab.s.l). Furthermore by comparing collections of drosophilids from different European populations distributed along a latitudinal cline we were able to determine its high dispersal ability since it spread approximately 1400 km in 1 year either actively or passively through infested fruits. The similarities of the introduction dates in North America and Europe and the COI haplotypes suggest that the two invasions could be related. No considerable damage on crops has been reported yet in Europe. However, if this species gets established in more temperate localities it could become a serious pest. Therefore tracking the invasion of this species is recommended. An early detection of this potential pest is decisive for good management of the fields.

Cha, D. H., T. Adams, H. Rogg and P. J. Landolt (2012). "Identification and Field Evaluation of Fermentation Volatiles from Wine and Vinegar that Mediate Attraction of Spotted Wing *Drosophila*, *Drosophila suzukii*." *Journal of Chemical Ecology* 38(11): 1419-1431.

Previous studies suggest that olfactory cues from damaged and fermented fruits play important roles in resource recognition of polyphagous spotted wing *Drosophila* flies (SWD), *Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae). They are attracted to fermented sweet materials, such as decomposing fruits but also wines and vinegars, and to ubiquitous fermentation volatiles, such as acetic acid and ethanol. Gas chromatography coupled with electroantennographic detection (GC-EAD), gas chromatography-mass spectrometry (GC-MS), two-choice laboratory bioassays, and field trapping experiments were used to identify volatile compounds from wine and vinegar that are involved in SWD attraction. In addition to acetic acid and ethanol, consistent EAD responses were obtained for 13 volatile wine compounds and seven volatile vinegar compounds, with all of the vinegar EAD-active compounds also present in wine. In a field trapping experiment, the 9-component vinegar blend and 15-component wine blend were similarly attractive when compared to an acetic acid plus ethanol mixture, but were not as attractive as the wine plus vinegar mixture. In two-choice laboratory bioassays, 7 EAD-active compounds (ethyl acetate, ethyl butyrate, ethyl lactate, 1-hexanol, isoamyl acetate, 2-methylbutyl acetate, and ethyl sorbate), when added singly to the mixture at the same concentrations tested in the field, decreased the attraction of SWD to the mixture of acetic acid and ethanol. The blends composed of the remaining EAD-active chemicals, an 8-component wine blend [acetic acid + ethanol + acetoin + grape butyrate + methionol + isoamyl lactate + 2-phenylethanol + diethyl succinate] and a 5-component vinegar blend [acetic acid + ethanol + acetoin + grape butyrate + 2-phenylethanol] were more attractive than the acetic acid

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plus ethanol mixture, and as attractive as the wine plus vinegar mixture in both laboratory assays and the field trapping experiment. These results indicate that these volatiles in wine and vinegar are crucial for SWD attraction to fermented materials on which they feed as adults.

Chabert, S., R. Allemand, M. Poyet, P. Eslin and P. Gibert (2012). "Ability of European parasitoids (Hymenoptera) to control a new invasive Asiatic pest, *Drosophila suzukii*." *Biological Control* 63(1): 40-47.

Understanding the ecological factors involved in successful invasions is essential for choosing appropriate management measures. One mechanism recognized as often being essential for invasion success is for the invasive species to be less subject to attack by natural enemies. The spotted-wing drosophila, *Drosophila suzukii* (Matsumura, 1931) is an Asian pest of fruit crops that has recently appeared simultaneously in North America and Europe (2008). Here we investigate the effectiveness of European parasitoids of *Drosophila* in parasitizing *D. suzukii*. Of the five main European parasitoid species, only two pupal parasitoids with wide host ranges develop on *D. suzukii*. Two specialized larval parasitoids were unable to develop, presumably because of a strong immune response. The third specialized larval parasitoid rarely oviposited in *D. suzukii*. This confirms that host switching is often difficult for specialist parasitoids. (C) 2012 Elsevier Inc. All rights reserved.

Cini, A., C. Ioriatti and G. Anfora (2012). "A review of the invasion of *Drosophila suzukii* in Europe and a draft research agenda for integrated pest management." *Bulletin of Insectology* 65(1): 149-160.

The vinegar fly *Drosophila suzukii* (Matsumura) (Diptera Drosophilidae), spotted wing drosophila, is a highly polyphagous invasive pest endemic to South East Asia, which has recently invaded western countries. Its serrated ovipositor allows this fly to lay eggs on and damage unwounded ripening fruits, thus heavily threatening fruit production. *D. suzukii* is spreading rapidly and economic losses are severe, thus it is rapidly becoming a pest of great concern. This paper reviews the existing knowledge on the pest life history and updates its current distribution across Europe. *D. suzukii* presence has now been reported in nine European countries. Nonetheless, several knowledge gaps about this pest still exist and no efficient monitoring tools have been developed yet. This review is aimed at highlighting the possible research approach which may hopefully provide management solutions to the expanding challenge that *D. suzukii* poses to European fruit production.

Dalla Via, J. and H. Mantinger (2012). "Agricultural Research in the Field of Fruit Growing in South Tyrol." *Erwerbs-Obstbau* 54(3): 83-115.

South Tyrol (northern Italy) holds the largest contiguous apple growing area in Europe. 1.18 million tons of apples were produced on 18,538 ha in 2011, which contributes to more than half of the total harvest of Italy, while every ninth apple produced in the EU-27 originates from South Tyrol. Apple growing exploits only 7.7 % of the agriculturally-used land but contributes to 53 % of the agricultural added value in South Tyrol. The present study describes the development and advancement of fruit-tree growing research in South Tyrol in the historical context. The needs for professional support, consultancy, education and research became insistent in the 19th century, due to acute questions about cropping practices as well as the emergence of global diseases and pests (powdery mildew, downy mildew, scab, woolly aphid, apple blossom weevil, codling moth, cockchafer) requiring solutions for their control. On the 10th November 1874, the 'Agricultural Institute and Experimental Station' in S. Michele upon Etsch/Adige was inaugurated with the aim of supporting the agricultural sectors of South Tyrol and Trentino. The consequences of the First World War and the Italianization of South Tyrol, have ultimately led to a collapse of agricultural experimentation and education in this area. It took until the end of the Second World War for agricultural education and professional development in German language to be re-established, when the emerging agricultural schools temporarily assumed responsibility for experimentation in fruit-tree growing relevant to the region. With the Second Autonomy Statute of 1972, the competence to establish agricultural experimental stations was transferred to the Autonomous Province of Bozen/Bolzano. On the 1st January 1976 the Research Centre for Agriculture and Forestry Laimburg was founded as an institute covering all aspects of applied and basic agricultural research in South Tyrol. The development of several research areas and their milestones are emphasised in this work including cropping systems, soil maintenance and fertilization, evolution of the pome fruit variety assortment, variety testing and breeding, establishment of the nursery system, irrigation, plant protection (comprising issues such as codling moth, spotted wing drosophila, apple proliferation, fire blight, scab, white haze or the leaf spot diseases), improvement of post-harvest technologies and

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practices, organic fruit growing as well as molecular biology and the development of new diagnostic methods. The Research Centre for Agriculture and Forestry Laimburg started with a two-man team and has since developed into an internationally recognised institution (with 20 outposts) for agricultural research in Europe with almost 200 employees working on 400 projects and activities each year. The building activities planned together with the agricultural schools and the Free University of Bozen/Bolzano will certainly contribute to develop the site 'Laimburg' into a centre of excellence not only for research but also for education and professional development, so as to cope confidently with future challenges in fruit-tree growing in this region.

Hamby, K. A., A. Hernandez, K. Boundy-Mills and F. G. Zalom (2012). "Associations of Yeasts with Spotted-Wing *Drosophila* (*Drosophila suzukii*; Diptera: Drosophilidae) in Cherries and Raspberries." *Applied and Environmental Microbiology* 78(14): 4869-4873.

A rich history of investigation documents various *Drosophila*-yeast mutualisms, suggesting that *Drosophila suzukii* similarly has an association with a specific yeast species or community. To discover candidate yeast species, yeasts were isolated from larval frass, adult midguts, and fruit hosts of *D. suzukii*. Terminal restriction fragment length polymorphism (TRFLP) technology and decimal dilution plating were used to identify and determine the relative abundance of yeast species present in fruit juice samples that were either infested with *D. suzukii* or not infested. Yeasts were less abundant in uninfested than infested samples. A total of 126 independent yeast isolates were cultivated from frass, midguts, and fruit hosts of *D. suzukii*, representing 28 species of yeasts, with *Hanseniaspora uvarum* predominating. This suggests an association between *D. suzukii* and *H. uvarum* that could be utilized for pest management of the highly pestiferous *D. suzukii*.

Kacsoh, B. Z. and T. A. Schlenke (2012). "High Hemocyte Load Is Associated with Increased Resistance against Parasitoids in *Drosophila suzukii*, a Relative of *D. melanogaster*." *Plos One* 7(4).

Among the most common parasites of *Drosophila* in nature are parasitoid wasps, which lay their eggs in fly larvae and pupae. *D. melanogaster* larvae can mount a cellular immune response against wasp eggs, but female wasps inject venom along with their eggs to block this immune response. Genetic variation in flies for immune resistance against wasps and genetic variation in wasps for virulence against flies largely determines the outcome of any fly-wasp interaction. Interestingly, up to 90% of the variation in fly resistance against wasp parasitism has been linked to a very simple mechanism: flies with increased constitutive blood cell (hemocyte) production are more resistant. However, this relationship has not been tested for *Drosophila* hosts outside of the *melanogaster* subgroup, nor has it been tested across a diversity of parasitoid wasp species and strains. We compared hemocyte levels in two fly species from different subgroups, *D. melanogaster* and *D. suzukii*, and found that *D. suzukii* constitutively produces up to five times more hemocytes than *D. melanogaster*. Using a panel of 24 parasitoid wasp strains representing fifteen species, four families, and multiple virulence strategies, we found that *D. suzukii* was significantly more resistant to wasp parasitism than *D. melanogaster*. Thus, our data suggest that the relationship between hemocyte production and wasp resistance is general. However, at least one sympatric wasp species was a highly successful infector of *D. suzukii*, suggesting specialists can overcome the general resistance afforded to hosts by excessive hemocyte production. Given that *D. suzukii* is an emerging agricultural pest, identification of the few parasitoid wasps that successfully infect *D. suzukii* may have value for biocontrol.

Landolt, P. J., T. Adams, T. S. Davis and H. Rogg (2012). "SPOTTED WING DROSOPHILA, DROSOPHILA SUZUKII (DIPTERA: DROSOPHILIDAE), TRAPPED WITH COMBINATIONS OF WINES AND VINEGARS." *Florida Entomologist* 95(2): 326-332.

Field trapping experiments evaluated wine and vinegar baits for spotted wing drosophila flies, *Drosophila suzukii* (Matsumura), and assessed variance in bait attractiveness with wine type, vinegar type, and bait age. A mixture of apple cider vinegar and a Merlot wine attracted more flies than a mixture of acetic acid and ethanol. The vinegar/wine mixture attracted numbers of flies that were similar to numbers of flies trapped with acetic acid with wine or ethanol with vinegar. These results indicate that chemicals in vinegar in addition to acetic acid, and chemicals in wine in addition to ethanol, are attractants for the spotted wing drosophila. Numbers of flies captured with wine/vinegar mixtures varied somewhat with wine type, with a Merlot wine yielding best captures among the wines tested. Numbers of flies captured with wine/vinegar mixes also varied somewhat with vinegar type, with a rice vinegar yielding best captures among vinegars tested. Numbers of flies captured varied little with bait age, from 0 to 7 days old. These

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results will assist efforts to improve baits used to trap spotted wing drosophila, and to provide guidance for the isolation and identification of chemical attractants from wines and vinegars.

Landolt, P. J., T. Adams and H. Rogg (2012). "Trapping spotted wing drosophila, *Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae), with combinations of vinegar and wine, and acetic acid and ethanol." *Journal of Applied Entomology* 136(1-2): 148-154.

Recommendations for monitoring spotted wing drosophila (SWD) *Drosophila suzukii* (Matsumura) are to use either vinegar or wine as a bait for traps. Traps baited with vinegar and traps baited with wine, in field tests in northwest Oregon, captured large numbers of male and female SWD flies. Numbers of SWD trapped were significantly greater with a mixture of vinegar and wine compared with vinegar alone or wine alone. Attraction of SWD to vinegar and wine may be due in part to responses to acetic acid and ethanol evaporated from the two baits, respectively. Numbers of SWD captured in traps baited with 2% acetic acid in water were significantly greater than in unbaited traps, indicating a fly response to acetic acid. Very few flies were captured in traps baited with 10% ethanol in water. Traps baited with a combination of acetic acid and ethanol in water captured more SWD flies than traps baited with acetic acid or ethanol solutions alone. These results indicate a synergy of the two materials, and of the two chemicals, as lures for SWD. A comparison of a mixture of acetic acid with ethanol in water versus a mixture of vinegar with wine showed stronger fly attraction to the vinegar/wine mixture, indicating potential attractiveness of vinegar and wine volatiles in addition to acetic acid and ethanol.

Lee, J. C., H. J. Burrack, L. D. Barrantes, E. H. Beers, A. J. Dreves, K. A. Hamby, D. R. Haviland, R. Isaacs, T. A. Richardson, P. W. Shearer, C. A. Stanley, D. B. Walsh, V. M. Walton, F. G. Zalom and D. J. Bruck (2012). "Evaluation of Monitoring Traps for *Drosophila suzukii* (Diptera: Drosophilidae) in North America." *Journal of Economic Entomology* 105(4): 1350-1357.

*Drosophila suzukii* Matsumura (Diptera: Drosophilidae), a recent invasive pest of small and stone fruits, has been detected in more than half of the U. S. states, and in Canada, Mexico, and Europe. Upon discovery, several different trap designs were recommended for monitoring. This study compared the trap designs across seven states/provinces in North America and nine crop types. Between May and November 2011, we compared a clear cup with 10 side holes (clear); a commercial trap with two side holes (commercial); a Rubbermaid container with mesh lid and rain tent (Haviland), and with 10 side holes and no tent (modified Haviland); a red cup with 10 side holes (red); and a white container with mesh lid and rain tent (Van Steenwyk). Although fly catches among traps varied per site, overall, the Haviland trap caught the most *D. suzukii*, followed by the red, Van Steenwyk, and clear trap. The modified Haviland and commercial trap had low captures. Among five crop types in Oregon, a clear cup with mesh sides (Dreves) also was tested and caught the most flies. Traps with greater entry areas, found in mesh traps, caught more flies than traps with smaller entry areas. In terms of sensitivity and selectivity, traps that caught more flies likewise caught flies earlier, and all traps caught 26-31% *D. suzukii* out of the total *Drosophila* captured. Future trap improvements should incorporate more entry points and focus on selective baits to improve efficiency and selectivity with regard to the seasonal behavior of *D. suzukii*.

Maier, C. T. (2012). "FIRST DETECTION AND WIDESPREAD DISTRIBUTION OF THE SPOTTED WING DROSOPHILA, *DROSOPHILA SUZUKII* (MATSUMURA) (DIPTERA: DROSOPHILIDAE), IN CONNECTICUT IN 2011." *Proceedings of the Entomological Society of Washington* 114(3): 329-337.

The non-native spotted wing drosophila, *Drosophila suzukii* (Matsumura), was first detected in Connecticut in August 2011. In a subsequent survey, conducted between September and December 2011, the eastern Asian *D. suzukii* was found in 86 (50.9%) of 169 municipalities distributed in the eight counties of Connecticut. New distributional records were based primarily on capturing adults in vinegar-baited traps and on rearing them from infested fruit. During the survey, adults were reared from fruit on wild plants of *Elaeagnus umbellata* Thunberg, *Phytolacca americana* L., and *Vitis labrusca* L. and on cultivated plants of *Ampelopsis brevipedunculata* (Maximowicz) Trautvetter, *Cornus kousa* Hance, *Diospyros virginiana* L., *Rubus idaeus* L., and *Vaccinium corymbosum* L. Wild hosts of *D. suzukii* should be considered when management programs are designed and when population growth is modeled.

Mortelmans, J., H. Casteels and T. Belien (2012). "*Drosophila suzukii* (Diptera: Drosophilidae): A pest species new to Belgium." *Belgian Journal of Zoology* 142(2): 143-146.

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Ohrn, A. and A. J. Dreves (2012). Using landscape ecology to inform spotted wing drosophila management practices Portland, OR, USA, Proceedings of the 71st Annual Pacific Northwest Insect Management Conference.

*Drosophila suzukii* (SWD), an invasive vinegar fly native to Japan, made its first appearance in Oregon in the fall of 2009. Since then, SWD has been confirmed in 17 Oregon counties. The pest is known to attack an extensive range of small and stone fruits, resulting in 2009 crop losses as high as 80%. In addition to commercial crops, the host plant range of SWD also includes wild fruits and berries found in many areas of the Pacific Northwest. Development of sound, effective management practices therefore requires a thorough understanding of SWD behavior not only in cultivated crops but in adjacent trees and wildlands, as these areas may act as a refuge and alternative food source for the fly. In the present study, we examine the influence of environmental variables (light, temperature, wind) and habitat characteristics (canopy cover, plant species diversity and abundance) on SWD activity in cultivated crops and adjacent vegetation. To measure SWD abundance in these areas, baited traps were placed along several vertical and horizontal gradients. Ratings were assigned to quantify varying habitat characteristics at each region. SWD abundance in tree traps was positively correlated with trap height. Trap counts in regions adjacent to crops were highest in areas with greatest plant diversity. By taking into account the influence of the overall landscape on the seasonal abundance, behavior, and movement of SWD, studies of this type will open the door to development of more effective management tools for growers and crop consultants.

Rouzes, R., L. Delbac, M. L. Ravidat and D. Thiery (2012). "FIRST OCCURRENCE OF DROSOPHILA SUZUKII IN THE SAUTERNES VINEYARDS." *Journal International Des Sciences De La Vigne Et Du Vin* 46(2): 145-147.

Aim: The present work reports the detection of a new fruit fly species in Sauternes vineyards (Aquitaine region, France): *Drosophila suzukii*. Methods and results: *Drosophila* were collected in two Sauternes vineyards, at the beginning of the harvest time in 2011, using food traps with apple molasses baits. The surveys led to the detection of the invasive species *D. suzukii*. In addition, rotting bunches were randomly taken in each vineyard but no *D. suzukii* emerged from them. The *Drosophila* community found in traps and on bunches was dominated by *D. melanogaster*. Conclusion: *D. suzukii*, although present in the vineyard agroecosystem of Sauternes, did not cause any noticeable damage in 2011. However, population monitoring should be continued. Significance and impact of the study: This first occurrence report of the invasive species *D. suzukii* in the Bordeaux vineyard should motivate further surveys of this potential pest of green berries.

SCRI-SWD (2012). "Biology and Management of Spotted Wing *Drosophila* on Small and Stone Fruit - Year 2 reporting cycle". Washington State University Oregon State University, University of California at Berkeley, University of California at Davis, USDA-ARS, USDA-NIFA, and the small and stone fruit industries of Oregon, Washington, and California. USDA-NIFA Specialty Crop Research Initiative Project 2010-61181-21167: 19.

Lien : <http://spottedwing.org/content/biology-and-management-spotted-wing-drosophila-small-and-stone-fruits-year-2>

Walse, S. S., R. Krugner and J. S. Tebbets (2012). "Postharvest treatment of strawberries with methyl bromide to control spotted wing drosophila, *Drosophila suzukii*." *Journal of Asia-Pacific Entomology* 15(3): 451-456.

Methyl bromide (MB) chamber fumigations were evaluated for postharvest control of spotted wing drosophila (SWD), *Drosophila suzukii*, in strawberry exports from California USA. Strawberries were infested with the most MB-tolerant age of SWD (60- to 108-h old at fumigation, ca. mature larvae), infested fruit were buried amongst uninfested fruit in export packaging, and fumigations were with 48 mg L<sup>-1</sup> (3.0 lbs/1000 ft<sup>3</sup>) for 3 h at 18.0 +/- 0.5 degrees C ((x) over bar +/- s). Complete mortality of 105,173 +/- 3,321 (n +/- s) SWD specimens was achieved with applied doses >= 34.5 mg L<sup>-1</sup> and exposures, expressed as a concentration x time products (CTs), >= 80.3 mg L<sup>-1</sup> h. (C) Korean Society of Applied Entomology, Taiwan Entomological Society and Malaysian Plant Protection Society, 2012. Published by Elsevier B.V. All rights reserved.

Yang, Y., Z. C. Hou, Y. H. Qian, H. Kang and Q. T. Zeng (2012). "Increasing the data size to accurately reconstruct the phylogenetic relationships between nine subgroups of the *Drosophila melanogaster* species group (*Drosophilidae*, *Diptera*)." *Molecular Phylogenetics and Evolution* 62(1): 214-223.

Cette veille bibliographique est réalisée par Nathalie Roullé et Nicolas Chatel-Launay, Pôle d'excellence en lutte intégrée (PELI).

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Previous phylogenetic analyses of the melanogaster species group have led to conflicting hypotheses concerning their relationship; therefore the addition of new sequence data is necessary to discover the phylogeny of this species group. Here we present new data derived from 17 genes and representing 48 species to reconstruct the phylogeny of the melanogaster group. A variety of statistical tests, as well as maximum likelihood mapping analysis, were performed to estimate data quality, suggesting that all genes had a high degree of contribution to resolve the phylogeny. Individual locus was analyzed using maximum likelihood (ML), and the concatenated dataset (12,988 bp) were analyzed using partitioned maximum likelihood (ML) and Bayesian analyses. Separated analysis produced various phylogenetic relationships, however, phylogenetic topologies from ML and Bayesian analysis based on concatenated dataset, at the subgroup level, were completely identical to each other with high levels of support. Our results recovered three major clades: the ananassae subgroup, followed by the montium subgroup, the melanogaster subgroup and the oriental subgroups form the third monophyletic clade, in which melanogaster (*takahashii*, *suzukii*) forms one subclade and *ficuspila* [*eugracilis* (*elegans*, *rhopaloa*)] forms another. However, more data are necessary to determine the phylogenetic position of *Drosophila lucipennis* which proved difficult to place. (C) 2011 Elsevier Inc. All rights reserved.

Yee, W. L. and D. G. Alston (2012). "Behavioral responses, rate of mortality, and oviposition of western cherry fruit fly exposed to malathion, zeta-cypermethrin, and spinetoram." *Journal of Pest Science* 85(1): 141-151.

Western cherry fruit fly, *Rhagoletis indifferens* Curran (Diptera: Tephritidae), is a pest of sweet and tart cherry, *Prunus avium* L. (L.) and *P. cerasus* L., respectively, in western North America. This fly is commonly controlled with spinosad bait sprays. Spotted wing drosophila, *Drosophila suzukii* Matsumura, is potentially a new pest of cherries in this region that could be a threat to orchards at the same time as *R. indifferens*. *Drosophila suzukii* apparently is not controlled using spinosad bait sprays, but may potentially be controlled using malathion, zeta-cypermethrin, and spinetoram. However, how well these last three materials protect fruit against reproductively mature *R. indifferens* is not known. In laboratory observations, *R. indifferens* spent the least amount of time on cherries treated with zeta-cypermethrin, possibly because of its toxicity and irritant effects. In laboratory experiments, zeta-cypermethrin killed flies more quickly than malathion and spinetoram, causing up to 100% mortality 2 h after exposure. Zeta-cypermethrin prevented all oviposition when flies walked on dried residues for 20-25 min or were directly sprayed, and then exposed to cherries with dried residues, simulating exposure of mature female flies in a treated orchard. Malathion and spinetoram reduced oviposition compared with controls, but did not prevent it, when flies contacted residues or were directly sprayed at a high volume. Results suggest zeta-cypermethrin is the most effective of the three materials at protecting cherries against mature *R. indifferens* and could be used in an integrated control program for it and *D. suzukii*.

Beers, E. H., R. A. Van Steenwyk, P. W. Shearer, W. W. Coates and J. A. Grant (2011). "Developing *Drosophila suzukii* management programs for sweet cherry in the western United States." *Pest Management Science* 67(11): 1386-1395.

**BACKGROUND:** The spotted wing drosophila, *Drosophila suzukii* Matsumura (Diptera: Drosophilidae), is a newly introduced pest of sweet cherry on the west coast of North America which produces about 97% of the value of the US sweet cherry crop. *D. suzukii* initially caused considerable economic loss to cherry growers, who were unaware of this new pest. Little control information was available at the time of initial infestation. Pest control studies were initiated to examine the materials, timings and application methods to control *D. suzukii* in three major cherry-producing states (California, Oregon and Washington). **RESULTS:** Three classes of registered insecticides, organophosphates, pyrethroids and spinosyns, have demonstrated good topical or residual activity against *D. suzukii*. Neonicotinoids and the systemic organophosphate dimethoate appear to be able to kill eggs or larvae in fruit. Preliminary timing studies indicate that at least two preharvest insecticide sprays are required to obtain control of *D. suzukii* in California cherry orchards. Aerially applied malathion ULV (ultra-low volume) appears to be a viable control tactic for this pest. **CONCLUSION:** The results presented here form the basis for developing *D. suzukii* management programs in the western United States. Additional studies are needed to refine management practices for the different growing regions and conventional versus organic production requirements. Cherry growers will likely need to apply broad-spectrum insecticides in a prophylactic manner until treatment thresholds and monitoring methods have been developed and validated. (C) 2011 Society of Chemical Industry

Bruck, D. J., M. Bolda, L. Tanigoshi, J. Klick, J. Kleiber, J. DeFrancesco, B. Gerdeman and H. Spittler (2011). "Laboratory and field comparisons of insecticides to reduce infestation of *Drosophila suzukii* in berry crops." *Pest Management Science* 67(11): 1375-1385.

**BACKGROUND:** The spotted wing *Drosophila*, *Drosophila suzukii* (Matsumura, 1931) (Diptera: Drosophilidae), is an invasive pest of small-fruit crops. Unlike most other *Drosophila*, this insect is able to oviposit into and damage ripe and ripening fruit, making it unmarketable. Because this is a new pest in the United States, it is necessary to identify registered insecticides to manage this insect effectively in conventional and organic production systems. **RESULTS:** The present laboratory bioassays and field trials identified a number of insecticides representing various modes of action that are effective in controlling *D. suzukii*. Products that performed well in the laboratory bioassay also performed well in the field, indicating that screening of new chemistries in the laboratory is a worthy exercise. Field application of pyrethroids, organophosphates or spinosyns provided 5-14 days of residual control of *D. suzukii*. The efficacy of the neonicotinoids as adulticides was not satisfactory compared with the other contact-mode-of-action chemistries. Based on the zero tolerance by the small-fruit industry and the individual effects mentioned above, neonicotinoids are not currently recommended for *D. suzukii* management. **CONCLUSIONS:** There are effective insecticides registered for controlling *D. suzukii* infestations in susceptible small-fruit crops. (C) 2011 Society of Chemical Industry

Dalton, D. T., V. M. Walton, P. W. Shearer, D. B. Walsh, J. Caprile and R. Isaacs (2011). "Laboratory survival of *Drosophila suzukii* under simulated winter conditions of the Pacific Northwest and seasonal field trapping in five primary regions of small and stone fruit production in the United States." *Pest Management Science* 67(11): 1368-1374.

**BACKGROUND:** *Drosophila suzukii* was first found in Oregon in August 2009. The threat of this pest to regional small and stone fruit production industries led to investigations on its overwintering capabilities in fruit-growing regions in the Pacific Northwest. Knowledge of its cold tolerance will help in the development of computer models to forecast seasonal population growth and decline. **RESULTS:** Of 1500 adults or pupae, 22 (1.4%) individuals survived the 84 day experimental chilling period. Most (86%) of the survivors were subjected to 10 degrees C temperature treatments. Survival decreased significantly at lower temperature treatments. Freezing temporarily increased the mortality rate but did not significantly affect overall mortality over the trial period. Flies that emerged from pupae are estimated to survive for up to 103-105 days at 10 degrees C and for shorter periods at lower temperatures. Field trapping in five fruit production areas has demonstrated overwintering survival in California and Oregon, but lower survival is predicted in Eastern Washington and Michigan. **CONCLUSION:** The experiments reported here indicate that long-term survival of *D. suzukii* is unlikely at temperatures below 10 degrees C. Field data from five climatic regions indicated extended low initial *D. suzukii* field presence in 2010 in all regions except California, where field presence was recorded earlier. (C) 2011 Society of Chemical Industry

Dreves, A. J. (2011). "IPM program development for an invasive pest: coordination, outreach and evaluation." *Pest Management Science* 67(11): 1403-1410.

**BACKGROUND:** Spotted wing drosophila (SWD), *Drosophila suzukii* Matsumura, was found along the west coast of the United States, beginning in 2008 and 2009, infesting a wide variety of small and stone fruit crops. This pest is a serious economic threat, as noted in its native range (Asia), because it lays eggs within ripening fruit before harvest, leading to crop loss. The aim of this paper is to describe the process in order to create collaboration, communication routes and evaluation methods in response to a new invasive pest. **RESULTS:** Funding was secured and a program (SWD\*IPM) was quickly developed to address social, economic and biological components. Communication routes were outlined, and a stakeholder advisory panel was established to guide program objectives. A central website was created to host up-to-date information. An online monitoring and mapping program for *D. suzukii* in Oregon fruit-growing regions illustrated the range, distribution and seasonal abundance of the pest. In addition, a program for backyard fruit growers was initiated to examine citizen scientists' roles in managing *D. suzukii* infestations in the urban setting. A monitoring kit, laminated educational cards, dry fly mounts and quick-time videos were some of the tools used to educate growers. First-year challenges for dealing with a new pest are discussed. **CONCLUSION:** The discovery and subsequent response to an exotic pest is information intensive and requires a well-planned, coordinated Extension and evaluation effort. (C) 2011 Society of Chemical Industry

Goodhue, R. E., M. Bolda, D. Farnsworth, J. C. Williams and F. G. Zalom (2011). "Spotted wing drosophila infestation of California strawberries and raspberries: economic analysis of potential revenue losses and control costs." *Pest Management Science* 67(11): 1396-1402.

**BACKGROUND:** Economic costs of spotted wing drosophila (SWD) include yield and associated revenue losses, labor and material costs for monitoring and management and revenue losses due to the closure of export markets should fruit from SWD-infested regions be banned by trading partners. This analysis focuses on two types of loss in the California raspberry and strawberry industries: yield losses in the absence of management, and insecticide material costs on a per treatment basis. It computes the cost of a specific management program for raspberries in California's Central Coast region. **RESULTS:** Insecticide material and application costs per treatment and the cost of the management program are small relative to the yield losses in the absence of management that are observed by growers, researchers and others in initial infestations. **CONCLUSION:** It is difficult to evaluate precisely the share of pest management program costs due to SWD because insecticides are sometimes used to manage multiple pests, and because labor-intensive field sanitation efforts to control SWD are recommended practices already. Given these considerations, this analysis finds that the benefits to SWD management well outweigh the costs examined here. Evaluating the efficacy of managing SWD is essential in assessing the risks that SWD poses and the benefits of pest management programs. (C) 2011 Society of Chemical Industry

Hauser, M. (2011). "A historic account of the invasion of *Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae) in the continental United States, with remarks on their identification." *Pest Management Science* 67(11): 1352-1357.

**BACKGROUND:** *Drosophila suzukii* is an oriental species first reported outside Asia from Hawaii in 1980. The first confirmed records for the continental United States were made in 2008 in California. The identification of this pest is difficult because very few published resources exist. **RESULTS:** It has since been recorded in Oregon, Washington, British Columbia, Alberta, Manitoba, Ontario, Quebec, Utah, Michigan, Wisconsin, Louisiana, North Carolina, South Carolina and Florida. Males are relatively easy to identify by the black apical wing spots and the single row of combs on the first and second tarsal segment of the fore leg. The male genitalia are also very characteristic and will aid in identifying general specimens. Females can be identified by the large ovipositor, which is 6-7 times as long as the diameter of the spermatheca. Immature stages can only be identified by molecular techniques. **CONCLUSION:** Although this species has been recorded from many US states and Canadian provinces, it has not been established in all of these places, and the main economic damage is restricted to the western part of North America. With the characters laid out in this paper, it should be possible to identify the pest with high certainty. (C) 2011 Society of Chemical Industry

Lee, J. C., D. J. Bruck, H. Curry, D. Edwards, D. R. Haviland, R. A. Van Steenwyk and B. M. Yorgey (2011). "The susceptibility of small fruits and cherries to the spotted-wing drosophila, *Drosophila suzukii*." *Pest Management Science* 67(11): 1358-1367.

**BACKGROUND:** The spotted-wing drosophila, *Drosophila suzukii* Matsumura, is native to Asia and was first detected in the North American mainland and Europe in 2008-2010. *Drosophila suzukii* is a serious economic pest to stone and small fruits because the female lays eggs within ripening fruit on a plant before harvest, which can lead to crop loss. The aim of this study was to evaluate the susceptibility of blackberries, blueberries, cherries, grapes, raspberries and strawberries to *D. suzukii* among various ripeness stages and cultivars. **RESULTS:** In 26 no-choice and choice replicated laboratory cage tests on ripeness stages, fruits were generally susceptible to *D. suzukii* once fruits started to color. Few *D. suzukii* developed on green fruit, wine grapes or overripe blueberries. In seven cultivar tests, *D. suzukii* preferences ranged from no differences to fourfold differences for specific cultivars of blackberries, blueberries, raspberries and wine grapes. As brix levels increased, more eggs were laid or more *D. suzukii* developed on blackberries, blueberries, cherries, raspberries and strawberries. In a choice test of various fruit types, strawberries, raspberries, blackberries, cherries and blueberries were more susceptible to *D. suzukii* than green table grapes ('Thompson'). **CONCLUSION:** The results suggest that fruits may become susceptible to *D. suzukii* as they start to turn color, and that specific varieties of grapes and overripe blueberries have low susceptibility to *D. suzukii*. (C) 2011 Society of Chemical Industry

Lee, J. C., D. J. Bruck, A. J. Dreves, C. Ioriatti, H. Vogt and P. Baufeld (2011). "In Focus: Spotted wing drosophila, *Drosophila suzukii*, across perspectives." *Pest Management Science* 67(11): 1349-1351.

In August 2008, the first detection of the spotted wing drosophila, *Drosophila suzukii*, to the North America mainland in California caused great concern, as the fly was found infesting a variety of commercial fruits. Subsequent detections

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followed in Oregon, Washington, Florida and British Columbia in 2009; in Utah, North Carolina, South Carolina, Michigan, and Louisiana in 2010; and in Virginia, Montana, Wisconsin, Pennsylvania, New Jersey, Maryland and Mexico in 2011. In Europe, it has been detected in Italy and Spain in 2009 and in France in 2010. Economic costs to the grower from *D. suzukii* include the increased cost of production (increased labor and materials for chemical inputs, monitoring and other management tools) and crop loss. An effective response to the invasion of *D. suzukii* requires proper taxonomic identification at the initial phase, understanding basic biology and phenology, developing management tools, transferring information and technology quickly to user groups, and evaluating the impact of the research and extension program on an economic, social, and environmental level. As *D. suzukii* continues to expand its range, steps must be initiated in each new region to educate and inform the public as well as formulate management tactics suitable for the crops and growing conditions in each. (C) 2011 Society of Chemical Industry

SCRI-SWD (2011). "Biology and Management of Spotted Wing *Drosophila* on Small and Stone Fruit - Year 1 reporting cycle". Washington State University Oregon State University, University of California at Berkeley, University of California at Davis, USDA-ARS, USDA-NIFA, and the small and stone fruit industries of Oregon, Washington, and California. A USDA-NIFA Specialty Crop Research Initiative Project: 24.

Lien : <http://spottedwing.org/content/biology-and-management-spotted-wing-drosophila-small-and-stone-fruits-year-1>

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Walsh, D. B., M. P. Bolda, R. E. Goodhue, A. J. Dreves, J. Lee, D. J. Bruck, V. M. Walton, S. D. O'Neal and F. G. Zalom (2011). "*Drosophila suzukii* (Diptera: Drosophilidae): Invasive Pest of Ripening Soft Fruit Expanding its Geographic Range and Damage Potential." *J. Integ. Pest Mngmt.* 2(1): 1-7.

Spotted wing *drosophila*, *Drosophila suzukii* Matsumura, a native of Eastern and Southeastern Asia, is a pest of small and stone fruits. First detected in California in 2008, the insect is now found across the Pacific Coast states. Its penchant for attacking healthy, ripening fruit (as opposed to overripe and rotting fruit favored by other so-called "vinegar flies") makes it a potential economic threat to a host of soft- and thin-skinned fruit crops including cherry, raspberry, blackberry, blueberry, strawberry, peach, plums, pluots, nectarines, juice grape, table grape, and wine grape. Coordinated research projects to determine host preference, seasonal phenology, biology, and management options are taking place among entomologists in Washington, Oregon, and California. A description of the pest and initial findings on its biology, life history, known and expected geographic range, management and monitoring techniques, and economic considerations are presented and discussed.

Mitsui, H., K. Beppu and M. T. Kimura (2010). "Seasonal life cycles and resource uses of flower- and fruit-feeding drosophilid flies (Diptera: Drosophilidae) in central Japan." *Entomological Science* 13(1): 60-67.

Seasonal life cycles and resource uses of flower- and fruit-feeding drosophilids (Diptera: Drosophilidae) were studied from low to high altitudes in central Japan to understand their adaptation to seasonal changes of environmental conditions. *Drosophila unipectinata* and *D. oshimai* specialized to flowers, *D. suzukii* and *D. subpulchrella* depended almost on fruits, while *D. lutescens*, *D. rufa*, *D. auraria*, *D. biauraria* and *D. sternopleuralis* used both of them. It was assumed that *D. unipectinata* moved from low to high altitudes in June while *D. oshimai*, *D. suzukii* and *D. subpulchrella* in July. Migration of *D. unipectinata* is considered as a means to avoid summer heat or exploit early-summer resources at high altitudes. On the other hand, *D. oshimai*, *D. suzukii* and *D. subpulchrella* have the capacity to pass the summer at low altitudes, and therefore their migration is assumed as a means to escape from resource-poor conditions in summer at low altitudes or exploit resources at high altitudes. The generalist species, *D. lutescens*, *D. rufa*, *D. auraria*, *D. biauraria* and *D. sternopleuralis*, would not perform such extensive movements between low and high altitudes. They may pass the summer at low or mid altitudes depending on accidentally fallen immature fruits and/or some other resources such as decayed leaves.

Mitsui, H. and M. T. Kimura (2010). "Distribution, abundance and host association of two parasitoid species attacking frugivorous drosophilid larvae in central Japan." *Eur. J. Entomol.* 107: 535-540.

In central Japan *Ganaspis xanthopoda* and *Asobara japonica* commonly parasitize the larvae of frugivorous drosophilids, mainly in montane forests, and urban environments and small groves, respectively. These two parasitoids start reproduction about one month later than their host drosophilids, probably to avoid searching for hosts when host

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density is low in early spring. It is likely that the local variation in the abundance of these parasitoids and a temporal refuge for their hosts contribute to the persistence of this parasitoid-host community. The forest species, *G. xanthopoda*, parasitized at least three *Drosophila* species that are abundant in forests, supporting the hypothesis that parasitoids are better adapted to attack frequently-encountered host species. This parasitoid did not parasitize *Drosophilid* species that are phylogenetically distantly-related to the three host species or less frequent in forests. Benefits of using such species as host would not exceed the costs of evolving virulence to them. Another parasitoid, *A. japonica*, parasitized various indigenous and exotic *Drosophilid* species including those that it rarely encountered in the field. It is not clear why this species has such a wide host range.

Vlach, J. (2010). "Identifying *Drosophila* *suzukii*." 2013,  
[http://www.oregon.gov/ODA/PLANT/docs/pdf/ippm\\_d\\_suzukii\\_id\\_guide10.pdf](http://www.oregon.gov/ODA/PLANT/docs/pdf/ippm_d_suzukii_id_guide10.pdf).

Zalom, F., K. Hamby and H. Wilson (2010). "SPOTTED WING DROSOPHILA, A CONCERN FOR DRIED PLUM PRODUCERS?"  
Rapport de recherche.

Da Lage, J. L., G. J. Kergoat, F. Maczkowiak, J. F. Silvain, M. L. Cariou and D. Lachaise (2007). "A phylogeny of *Drosophilidae* using the *Amyrel* gene: questioning the *Drosophila melanogaster* species group boundaries." *Journal of Zoological Systematics and Evolutionary Research* 45(1): 47-63.

In this study, the phylogenetic relationships of 164 species of the family *Drosophilidae* are discussed, using the *Amyrel* gene, a member of the alpha-amylase multigene family. This study focuses on numerous species groups in the subgenera *Sophophora* and *Drosophila* of the genus *Drosophila* but also includes other closely related genera. Nucleotide data were analysed by several methods: maximum parsimony, neighbour joining, maximum likelihood and Bayesian inference. Heterogeneity of base composition (mainly low GC contents in the species groups *willistoni* and *saltans*) has been addressed. In all analyses, the genus *Drosophila* appeared paraphyletic. The subgenus *Sophophora* clearly appeared to be a monophyletic group, showing well-resolved clades, with the Neotropical groups arising in a basal position. Here, it is proposed to raise the species subgroups *anassae* and *montium* to the rank of species group, and to restrict the *melanogaster* species group to the *melanogaster* subgroup plus the 'Oriental' subgroups, among which the *suzukii* subgroup is polyphyletic. Some related genera such as *Zaprionus*, *Liodrosophila*, *Scaptomyza* and *Hirtodrosophila* are clustered with, or inside the subgenus *Drosophila*, which is therefore paraphyletic and should be reviewed.

Mitsui, H., K. H. Takahashi and M. T. Kimura (2006). "Spatial distributions and clutch sizes of *Drosophila* species ovipositing on cherry fruits of different stages." *Population Ecology* 48(3): 233-237.

In the aggregation theory, aggregation of eggs is one of important conditions for the coexistence of species. However, aggregation of eggs by clutch laying does not always promote coexistence, whereas aggregation of eggs by aggregated distributions of ovipositing females always has a significant contribution to the coexistence. In this study, spatial distributions of three *Drosophila* species across naturally occurring cherry fruits were studied with relation to their clutch sizes. *Drosophila* *suzukii* oviposited eggs mainly on fresh fruits on trees, and its eggs were randomly distributed across cherry fruits. The emergence data also indicated random spatial distributions of this species. Random egg distributions of this species are explained by random visits of females to fruits and the production of clutches of mostly single eggs. On the other hand, *D. lutescens* and *D. rufa* oviposited on fallen fruits, showed aggregated distributions in the emergence data, and frequently produced clutches of a few eggs. In these species, the degree of aggregation was usually significantly lower than the expectation based on random visits of females to fruits and their clutch sizes observed in the present experiments, indicating that their aggregation is unlikely to arise from aggregated distributions of ovipositing females. Thus, the spatial aggregation of these species does not necessarily lead to their coexistence.

Takamori, H., H. Watabe, Y. Fuyama, Y. P. Zhang and T. Aotsuka (2006). "*Drosophila* *subpulchrella*, a new species of the *Drosophila* *suzukii* species subgroup from Japan and China (Diptera : *Drosophilidae*)." *Entomological Science* 9(1): 121-128.  
*Drosophila* (*Sophophora*) *subpulchrella* Takamori and Watabe, sp. nov., of the *D. suzukii* subgroup in the *D. melanogaster* species group, is described from Japan and southern China, and compared with its sibling species, *D.*

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pulchrella Tan et al. distributed in the Yun-Gui Highland, south-western China. The results of cross-experiments show a complete pre-mating isolation between *D. subpulchrella* and *D. pulchrella*.

Uchida, G. K., B. E. Mackey, R. I. Vargas, J. W. Beardsley, D. E. Hardy, M. Lee Goff and J. D. Stark (2006). "Response of Nontarget Insects to Methyl Eugenol, Cue-Lure, Trimedlure, and Protein Bait Bucket Traps on Kauai Island, Hawaii, USA." *Proc. Hawaiian Entomology Society* 38: 61-71.

Captures of nontarget insects inside fruit fly (Diptera: Tephritidae) traps placed in native habitats at three localities on Kauai Island, Hawaiian Islands were evaluated. Significantly greater nontarget capture rates were found for traps separately baited with four different attractants, methyl eugenol (five species and two morphospecies), cue-lure (two species), trimedlure (three species and one morphospecies), and protein bait traps (one species and one morphospecies) compared to unbaited control traps. These findings suggest that nontarget insects are attracted to those types of fruit fly traps. However, because of the presence of large numbers of scavenger flies captured in our traps, it appears that attraction may have partially been due to lure and protein bait, and, in part, to decaying insects accumulating inside the traps. Nonetheless, fruit fly traps placed in environmentally sensitive habitats should be used sparingly, so as not to place a strain on populations of rare endemic species.

Lewis, R. L., A. T. Beckenbach and A. O. Mooers (2005). "The phylogeny of the subgroups within the *Drosophila melanogaster* species group: Likelihood tests on COI and COII sequences and a Bayesian estimate of phylogeny." *Molecular Phylogenetics and Evolution* 37(1): 15-24.

The relationships among the majority of the subgroups in the *Drosophila melanogaster* species group remain unresolved. We present a 2223 basepair dataset for mitochondrial cytochrome oxidase I and cytochrome oxidase H for 43 species (including new data from 11 species), sampled to include the major subgroups. After a brief review of competing hypotheses for the *ananassae*, *montium*, *suzukii*, and *takahashii* subgroups, we combine the two genes based on a new use of the SH test and present KH and SH likelihood comparisons (Kishino and Hasegawa, 1989. *J. Mol. Evol.* 29, 170-179; Shimodaira and Hasegawa, 1999) to test the monophyly and placement of these subgroups within the larger species group. Although we find insignificant differences between the two suggested placements for the *ananassae* subgroup, the *ananassae* is sister to the rest of the subgroups in the *melanogaster* species group in every investigation. For the *takahashii* subgroup, although we cannot reject monophyly, the species are so closely related to the *suzukii* subgroup for these data that the two subgroups often form one clade. Finally, we present a Bayesian estimate of the phylogeny for both genes combined, utilizing a recently published method that allows for different models of evolution for different sites. (c) 2005 Elsevier Inc. All rights reserved.

Malik, H. S. and S. Henikoff (2005). "Positive selection of *Iris*, a retroviral envelope-derived host gene in *Drosophila melanogaster*." *Plos Genetics* 1(4): 429-443.

Eukaryotic genomes can usurp enzymatic functions encoded by mobile elements for their own use. A particularly interesting kind of acquisition involves the domestication of retroviral envelope genes, which confer infectious membrane-fusion ability to retroviruses. So far, these examples have been limited to vertebrate genomes, including primates where the domesticated envelope is under purifying selection to assist placental function. Here, we show that in *Drosophila* genomes, a previously unannotated gene (CG4715, renamed *Iris*) was domesticated from a novel, active Kanga lineage of insect retroviruses at least 25 million years ago, and has since been maintained as a host gene that is expressed in all adult tissues. *Iris* and the envelope genes from Kanga retroviruses are homologous to those found in insect baculoviruses and gypsy and roo insect retroviruses. Two separate envelope domestications from the Kanga and roo retroviruses have taken place, in fruit fly and mosquito genomes, respectively. Whereas retroviral envelopes are proteolytically cleaved into the ligand-interaction and membrane-fusion domains, *Iris* appears to lack this cleavage site. In the *takahashii/suzukii* species groups of *Drosophila*, we find that *Iris* has tandemly duplicated to give rise to two genes (*Iris-A* and *Iris-B*). *Iris-B* has significantly diverged from the *Iris-A* lineage, primarily because of the "invention" of an intron de novo in what was previously exonic sequence. Unlike domesticated retroviral envelope genes in mammals, we find that *Iris* has been subject to strong positive selection between *Drosophila* species. The rapid, adaptive evolution of *Iris* is sufficient to unambiguously distinguish the phylogenies of three closely related sibling species of *Drosophila* (*D. simulans*, *D. sechellia*, and *D. mauritiana*), a discriminative power previously described only for a putative "speciation gene." *Iris* represents the first instance of a retroviral envelope-derived host gene outside vertebrates. It is also the first

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example of a retroviral envelope gene that has been found to be subject to positive selection following its domestication. The unusual selective pressures acting on *Iris* suggest that it is an active participant in an ongoing genetic conflict. We propose a model in which *Iris* has "switched sides," having been recruited by host genomes to combat baculoviruses and retroviruses, which employ homologous envelope genes to mediate infection.

Takahashi, K. H. and M. T. Kimura (2005). "Intraspecific and interspecific larval interaction in *Drosophila* assessed by integrated fitness measure." *Oikos* 111(3): 574-581.

Intraspecific density effect was investigated for *D. simulans*, *D. suzukii*, *D. auraria*, *D. rufa* and *D. immigrans*, and interspecific density effect was examined for combinations of *D. simulans*, *D. rufa* and *D. immigrans*. Different numbers of their eggs were introduced to artificial substrates, and intra- and interspecific interaction were evaluated on the basis of per capita egg production of individuals (eggs) introduced. If individuals died before pupation, their per capita egg production was zero; if individuals survived to pupae, their per capita egg production was estimated from their size based on the relation between the pupal size and lifetime egg production. Per capita egg production thus estimated generally decreased with the increase of the density of conspecific larvae, although a slight increase was detected at high densities in some cases. When two species were introduced, per capita egg production of a species was reduced only when the larval density of co-introduced species was very high, suggesting weak interspecific competition. Interspecific interaction was asymmetric; the effect of *D. simulans* on *D. rufa* and *D. immigrans* was often significantly negative, but the effect of *D. rufa* or *D. immigrans* on *D. simulans* was not significant.

Usui-Aoki, K., Y. Mikawa and D. Yamamoto (2005). "Species-specific patterns of sexual dimorphism in the expression of fruitless protein, a neural masculinizing factor in *Drosophila*." *Journal of Neurogenetics* 19(2): 109-121.

In *Drosophila melanogaster*, male-specific forms of the fruitless (*fru*) gene product, mFru protein, function as a neural sex-determination factors that directs the development of at least two male characteristics, namely courtship and mating behavior and the formation of the muscle of Lawrence (MOL). In *D. melanogaster*, the male-specific expression of Fru protein in motoneurons is responsible for the male-limited induction of the MOL by such neurons. Although no *Drosophila* species whose females have the MOL are known, there are many *Drosophila* species whose males lack the MOL. We performed immunohistochemical staining of the central nervous system (CNS) from 9 *Drosophila* species to determine whether the mFru expression profile is different between MOL-present and MOL-absent species. In 8 of the 9 species, Fru protein expression in the CNS is strictly male-specific, regardless of the presence or absence of the MOL. The sole exception is *D. suzukii*, in which females express the Fru protein though less extensively than males do: Fru expression in the CNS of female *D. suzukii* is restricted to the lamina and ventral ganglia. Expression of Fru protein in the lamina is observed in males of *D. virilis* and in both sexes of *D. suzukii*, but not in males and females of the 7 other species. These results indicate that sexually dimorphic expression of the Fru protein has been subjected to species-specific modulation during evolution.

Fleury, F., N. Ris, R. Allemand, P. Fouillet, Y. Carton and M. Bouletreau (2004). "Ecological and genetic interactions in *Drosophila*-parasitoids communities: a case study with *D. melanogaster*, *D. simulans* and their common *Leptopilina* parasitoids in south-eastern France." *Genetica* 120(1-3): 181-194.

*Drosophila* species are attacked by a number of parasitoid wasps, which constitute an important factor of population regulation. Since *Drosophila melanogaster* and *Drosophila simulans* share common parasitoid species, their ecology and evolution can hardly be understood without considering parasitoids. After a short review of data available on *Drosophila*-parasitoid interactions involving *D. melanogaster* and *D. simulans* as hosts, we report field and laboratory experiments investigating the ecological role of *Leptopilina* parasitoids in *Drosophila* communities of southern France. Seasonal survey of species abundance shows that strong interspecific interactions occur at both tropic levels. *D. simulans* progressively replaces *D. melanogaster* in southern areas suggesting competitive displacement. Parasitoids are responsible for very high *Drosophila* mortality (up to 90% in some fruits). Field data emphasize the importance of selective pressure that parasitoids exert on *Drosophila* communities. The two *Leptopilina* parasites (*L. heterotoma* and *L. boulandi*) have different local abundances, which vary in time, and they also compete for hosts. We show that parasitoids can mediate the coexistence of *D. melanogaster* and *D. simulans* in the laboratory, and thus may contribute to their puzzling coexistence in the field. Conversely, hosts exert selective pressures on parasitoids, and development on either *D. melanogaster* or *D. simulans* strongly affects fitness of adult wasps in a temperature-dependent fashion.

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Local variation in host species abundance and diversity could thus account for the genetic differentiation we observed in one parasitoid species. Despite laboratory studies cannot fully explain complex field situations, it is clear that the ecology and evolution of *Drosophila* populations and communities, especially *D. melanogaster* and *D. simulans*, are strongly constrained by parasitoids, which should receive more attention.

Kimura, M. T. (2004). "Cold and heat tolerance of drosophilid flies with reference to their latitudinal distributions." *Oecologia* 140(3): 442-449.

The relation between thermal tolerance and latitudinal distribution was studied with 30 drosophilid species collected from the cool-temperate region (Sapporo), the warm-temperate region (Tokyo and Kyoto) and the subtropical region (Iriomote island) in Japan. In addition, intraspecific variation was examined for five species collected from two localities. The subtropical strains of *Scaptodrosophila coracina*, *Drosophila bizonata* and *D. daruma* were less tolerant to cold than their temperate strains. However, the difference of cold tolerance between these two geographic strains was much smaller than the difference between the species restricted to the subtropical region and those occurring in the temperate region. In *D. auraria* and *D. suzukii*, no difference was observed in thermal tolerance between their cool- and warm-temperate strains. Thus, geographic variation in thermal tolerance within species was low or negligible. Interspecific comparisons by phylogenetic independent contrasts revealed that species which had the northern boundaries of their distributions at higher latitudes were generally more tolerant to cold than those which had their boundaries at lower latitudes. However, the data for some species did not agree with this trend. The use of man-protected warm places for overwintering, competition or predation would also affect their distributions. It also appeared that species which had their southern boundaries at higher latitudes were generally more cold-tolerant. The acquisition of cold tolerance may lower a fly's capacity to compete, survive or reproduce in warmer climates. On the other hand, no relation was observed between heat tolerance and latitudinal distribution. Heat tolerance was higher in species inhabiting openlands or the forest canopy than in those inhabiting the forest understorey.

Yamamoto, D., K. Usui-Aoiki and S. Shima (2004). "Male-specific expression of the Fruitless protein is not common to all *Drosophila* species." *Genetica* 120(1-3): 267-272.

Sex-specific behavioral patterns must be a result of sexual differences in the structure and/or function of the central nervous system (CNS). Male *Drosophila melanogaster* mutants for the fruitless (*fru*) locus exhibit enhanced male-to-male courtship. The *fru* mutant males are accompanied by malformation of the male-specific muscle of Lawrence <LF> (MOL), which, in wild-type males, is induced by male motoneurons innervating it. These two phenotypes are the consequences of impaired sex determination of CNS neurons. In *D. melanogaster*, although the *fru* mRNAs are transcribed in the CNS of both the male and female, the Fru protein is only translated in the male CNS. This male-specific translation of Fru was also observed in *D. simulans*, *D. yakuba*, *D. pseudoobscura* and *D. virilis*; however, in *D. suzukii*, the Fru protein expression was detected even in the female CNS.

Yang, Y., Y. P. Zhang, Y. H. Qian and Q. T. Zeng (2004). "Phylogenetic relationships of *Drosophila melanogaster* species group deduced from spacer regions of histone gene H2A-H2B." *Molecular Phylogenetics and Evolution* 30(2): 336-343.

Nucleotide sequences of the spacer region of the histone gene H2A-H2B from 36 species of *Drosophila melanogaster* species group were determined. The phylogenetic trees were reconstructed with maximum parsimony, maximum likelihood, and Bayesian methods by using *Drosophila pseudoobscura* as the out group. Our results show that the *melanogaster* species group clustered in three main lineages: (1) *montium* subgroup; (2) *ananassae* subgroup; and (3) the seven oriental subgroups, among which the *montium* subgroup diverged first. In the third main lineage, *suzukii* and *takahashii* subgroups formed a clade, while *eugracilis*, *melanogaster*, *elegans*, *ficuspheila*, and *rhopaloea* subgroups formed another clade. The bootstrap values at subgroup levels are high. The phylogenetic relationships of these species subgroups derived from our data are very different from those based on some other DNA data and morphology data. (C) 2003 Elsevier Inc. All rights reserved.

Ko, W. Y., R. M. David and H. Akashi (2003). "Molecular phylogeny of the *Drosophila melanogaster* species subgroup." *Journal of Molecular Evolution* 57(5): 562-573.

Although molecular and phenotypic evolution have been studied extensively in *Drosophila melanogaster* and its close relatives, phylogenetic relationships within the *D. melanogaster* species subgroup remain unresolved. In particular,

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recent molecular studies have not converged on the branching orders of the *D. yakuba*-*D. teissieri* and *D. erecta*-*D. orena* species pairs relative to the *D. melanogaster* *D. simulans*-*D. mauritiana*-*D. sechellia* species complex. Here, we reconstruct the phylogeny of the melanogaster species subgroup using DNA sequence data from four nuclear genes. We have employed "vectorette PCR" to obtain sequence data for orthologous regions of the Alcohol dehydrogenase (*Adh*), Alcohol dehydrogenase related (*Adhr*), Glucose dehydrogenase (*Gld*), and *rosy* genes (totaling 7164 bp) from six melanogaster subgroup species (*D. melanogaster*, *D. simulans*, *D. teissieri*, *D. yakuba*, *D. erecta*, and *D. orena*) and three species from subgroups outside the melanogaster species subgroup [*D. eugracilis* (*eugracilis* subgroup), *D. mimetica* (*suzukii* subgroup), and *D. lutescens* (*takahashii* subgroup)]. Relationships within the *D. simulans* complex are not addressed. Phylogenetic analyses employing maximum parsimony, neighbor-joining, and maximum likelihood methods strongly support a *D. yakuba*-*D. teissieri* and *D. erecta*-*D. orena* clade within the melanogaster species subgroup. *D. eugracilis* is grouped closer to the melanogaster subgroup than a *D. mimetica*-*D. lutescens* clade. This tree topology is supported by reconstructions employing simple (single parameter) and more complex (nonreversible) substitution models.

Schwaroch, V. (2002). "Phylogeny of a paradigm lineage: the *Drosophila melanogaster* species group (Diptera : Drosophilidae)." *Biological Journal of the Linnean Society* 76(1): 21-37.

Although *Drosophila melanogaster* is a paradigm eukaryote for biology, relationships of this species and the other 174 species in the melanogaster species group are poorly explored and ambiguous. Gene regions of Cytochrome oxidase II (*mt:CoII*), Alcohol dehydrogenase (*Adh*) and hunchback (*hb*) were sequenced and analysed phylogenetically to test prior hypotheses of relationships for the group based on chromosomes, morphology, and 28S rRNA gene sequences. A simultaneous cladistic analysis of the three newly sequenced gene regions produced a single well-resolved phylogeny for 49 exemplar species representing eight subgroups. Monophyly of each of the *ananassae*, *melanogaster*, *montium*, and *takahashii* subgroups is supported; the *suzukii* subgroup is polyphyletic. This phylogeny is consistent with variation in significant morphological structures, such as the male sex comb on the fore tarsus. The broad range of morphological variation among these species is interpreted and the applicability to evolution and developmental investigations is discussed. This phylogeny facilitates comparative investigations, such as gene family evolution, transposable element transmission, and evolution of morphological structures. (C) 2002 The Linnean Society of London.

Kido, M. H., A. Asquith and R. I. Vargas (1996). "Nontarget insect attraction to methyl eugenol traps used in male annihilation of the oriental fruit fly (Diptera: Tephritidae) in riparian Hawaiian stream habitat." *Environmental Entomology* 25(6): 1279-1289.

This study set out to identify insect species associated with the riparian habitat of Hawaiian streams that were susceptible to deployment of the plant kairomone, methyl eugenol, used in male annihilation of the oriental fruit fly, *Bactrocera dorsalis* (Hendel). Sixteen nontarget insect species (13 Diptera and 3 Coleoptera) were found to be attracted to methyl eugenol traps deployed in riparian habitat in a variety of stream ecotypes at various elevations. Only 2 Diptera attracted to the lure, *Drosophila perissopoda* Hardy and *D. crucigera* Grimshaw (Drosophilidae), were Hawaiian endemics, whereas the remainder were alien (nonnative) species. Alien drosophilids *Drosophila immigrans* Sturtevant and *D. suzukii* (Matsumura) and alien *Desmometopa tarsalis* Loew (Milichidae) were the most abundant species captured in traps overall. Both plant-associated as well as carrion-associated species were captured in methyl eugenol traps. It is suggested that the fruiting cycle of wild guava, *Psidium guajava* and *P. cattelianum*, in mountainous and lowland areas of Hawaii is an important mechanism driving the population dynamics of insects attracted to methyl eugenol traps. Host plant demographics and species similarities in ecological requirements are important factors influencing the occurrences of susceptible species between sites. Seasonal periods of low oriental fruit fly numbers coupled with low abundances of nontarget insects create windows of opportunity during which male annihilation procedures with methyl eugenol can achieve maximum effect with minimal environmental risk. Environmentally acceptable use patterns for methyl eugenol can be developed through the modification of delivery systems and adaptation of these systems in surgical procedures tailored to specific ecotypes. These procedures can then provide Hawaiian agriculture with badly needed farm-level or area-wide control of destructive oriental fruit flies.

Schmidt, T., Y. Choffat, M. Schneider, P. Hunziker, Y. Fuyama and E. Kubli (1993). "DROSOPHILA-SUZUKII CONTAINS A PEPTIDE HOMOLOGOUS TO THE DROSOPHILA-MELANOGASTER SEX-PEPTIDE AND FUNCTIONAL IN BOTH SPECIES." *Insect Biochemistry and Molecular Biology* 23(5): 571-579.

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A peptide homologous to the *Drosophila melanogaster* sex-peptide (SP) was isolated from *Drosophila suzukii* accessory glands and its amino acid sequence determined. The *D. suzukii* peptide contains 41 amino acids and has a calculated molecular weight of 5100 Da. Comparison of the sequences reveals strong homologies in the N-terminal and C-terminal parts of the peptides. In the *D. suzukii* sex-peptide, however, five additional amino acids are inserted after amino acid 7. Based on the sequence of the peptide, a cDNA coding for the *D. suzukii* peptide was isolated by PCR. Sequence analysis of the cDNA confirmed the SP amino acid sequence determined by peptide sequencing. Furthermore, based on the cDNA sequence, we isolated the *D. suzukii* sex-peptide gene by inverse PCR. The *D. suzukii* sex-peptide gene contains an intron and codes for a 60 amino acid precursor. The *D. melanogaster* and the *D. suzukii* sex-peptides elicit rejection behaviour in the presence of males and an increased egg laying in virgin females of both species.

Ohashi, Y. Y., K. Hainofukushima and Y. Fuyama (1991). "PURIFICATION AND CHARACTERIZATION OF AN OVULATION STIMULATING SUBSTANCE FROM THE MALE ACCESSORY-GLANDS OF DROSOPHILA-SUZUKII." *Insect Biochemistry* 21(4): 413-419.

An ovulation stimulating substance (OSS) was isolated from males of the fruit fly *Drosophila suzukii*, and purified to a homogeneous state by a 5-step purification procedure: extraction with 80% methanol, chloroform wash, heat treatment, ion-exchange chromatography, and reverse phase high performance liquid chromatography. Approximately 100-fold purification was obtained thereby yielding 39-mu-g of OSS from 1000 males for an overall yield of 34%. The OSS is a single peptide consisting of at least 35 amino acid residues and having a molecular weight of 3990. The purified OSS not only initiated ovulation in unmated females but also suppressed their receptivity towards males. The peptide of *D. suzukii* was found to be effective in the females of *D. melanogaster*, a species that belong to a different subgroup, but was less effective in a more closely related species, *D. pulchrella*.

Yoon, J. S., K. Pausic Gagen and D. L. Zhu (1990). "Longevity of 68 Species of *Drosophila*." *OHIO J. SCI.* 90(1): 16-32.  
Adult longevity of *Drosophila* is dependent upon many factors. In this study the differences in longevity caused by species, strain, sex, and mating status were examined for 68 species (89 strains) belonging to the *D. obscura*, *melanogaster*, and *willistoni* species groups. Both inter- and intra-specific differences in adult longevity were observed. In most species studied, females lived longer than males. In general, the longevity of unmated females exceeded that of mated ones, while the longevity of mated males was greater than that of unmated ones.

Yamaguchi, Y., Y. Fuyama, K. Haino and O. Kitagawa (1987). "ETHOLOGICAL ISOLATING MECHANISMS IN THE SUZUKII SPECIES-SUBGROUP OF DROSOPHILA-III - PURIFICATION OF OVULATION STIMULATING SUBSTANCE." *Japanese Journal of Genetics* 62(6): 566-566.

Fuyama, Y. (1984). "ETHOLOGICAL ISOLATING MECHANISMS IN THE SUZUKII SPECIES-SUBGROUP OF DROSOPHILA .4. GEOGRAPHIC-VARIATION IN SEXUAL ISOLATION." *Japanese Journal of Genetics* 59(6): 614-614.

Vet, L. E. M., C. Janse, C. Vanachterberg and J. J. M. Vanalphen (1984). "MICROHABITAT LOCATION AND NICHE SEGREGATION IN 2 SIBLING SPECIES OF DROSOPHILID PARASITOIDS - ASOBARA-TABIDA (NEES) AND A-RUFESCENS (FOERSTER) (BRACONIDAE, ALYSIINAE)." *Oecologia* 61(2): 182-188.

Watabe, H. (1984). "PHOTOPERIODIC RESPONSES IN DROSOPHILA-LUTESCENS AND DROSOPHILA-SUZUKII." *Zoological Science* 1(6): 994-994.

Fuyama, Y. and T. Tanimura (1982). "ETHOLOGICAL ISOLATING MECHANISMS IN THE SUZUKII SPECIES-SUBGROUP OF DROSOPHILA .3. INHERITANCE OF SOME COURTSHIP ELEMENT." *Japanese Journal of Genetics* 57(6): 663-663.

Fuyama, Y. (1981). "ETHOLOGICAL ISOLATING MECHANISMS IN THE SUZUKII SPECIES-SUBGROUP OF DROSOPHILA .2. RELATIONSHIP WITH POST-MATING ISOLATION." *Japanese Journal of Genetics* 56(6): 594-594.

Fuyama, Y. (1980). "ETHOLOGICAL ISOLATING MECHANISMS IN THE SUZUKII SPECIES-SUBGROUP OF DROSOPHILA .1. THE FREQUENCY OF INTERSPECIFIC MATING BETWEEN DROSOPHILA-SUZUKII AND DROSOPHILA-PULCHRELLA." Japanese Journal of Genetics 55(6): 452-452.

Fuyama, Y. (1979). "VISUAL STIMULUS IN THE COURTSHIP OF DROSOPHILA-SUZUKII." Experientia 35(10): 1327-1328.

Lee, T. J. (1965). "SEX-RATIO IN DROSOPHILA SUZUKII AND DROSOPHILA AURARIA." Japanese Journal of Genetics 40(5-6): 402-8.