

Spotted Wing Drosophila: Pest Management Recommendations for Florida Blueberries

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The spotted wing drosophila, *Drosophila suzukii* (Matsumura), is a recently discovered invasive species native to parts of East Asia. It was first detected in the continental United States in California in 2008 and in Hillsborough County, Florida in 2009. Since then the spotted wing drosophila (SWD) has spread to over 28 counties in Florida. SWD is polyphagous, meaning it feeds on many different host plants, including most thin-skinned fruits. The major hosts of concern to the Florida agriculture industry are blueberries, strawberries, blackberries and grapes. Though crop losses have not been quantified in Florida as of current, research in California shows as high as a 40 percent for blueberries (Bolda et al. 2010) and 20 and 50 percent losses in strawberries and raspberries, respectively (Goodhue et al. 2011).

Identification, Life Cycle, and Damage

The spotted wing drosophila is in the family Drosophilidae also known as the vinegar, fruit, or pomace flies. It shares many physical characteristics that are similar to the common vinegar fly, *Drosophila melanogaster* that frequents over-ripe and damaged fruits. SWDs have rounded abdomens that are pale yellow to light brown and have dark brown, unbroken horizontal stripes on the dorsal side. They have large, red eyes and sponging mouthparts with which they sponge up their food.

The male flies can be easily distinguished from other vinegar flies by the single dark spot at the tip of each wing (Figure 1a). These spots can be seen with the naked eye or a hand lens in the field. A close relative to *D. suzukii* is *D. biarmipes*, whose males also have the wingspots. This fly however, does not pose a threat to ripe fruit due to the female's short, weakly developed ovipositor, likely only to attack soft or damaged fruit. The SWD can be distinguished from *D. biarmipes* by the two rows of spines on the forelegs, one on the first tarsal segment and one on the second, whereas *D. biarmipes* has both rows of spines on the first tarsal segment (Hauser 2011). These rows of spines appear as two black horizontal



Figure 1: a. Male SWD. b. Female SWD.



Figure 2: Two rows of spines on male forelegs (Vlach 2010).

stripes on the forelegs when using a hand lens (Fig. 2). Females can be distinguished by comparing the ovipositors.

Female SWD are slightly larger than the males and lack the wing spots (Figure 1b). They can however be identified by their large, dark, and heavily serrated ovipositor with which they use to pierce the skin of their host fruit and lay their eggs (3). The females should be identified using a microscope or at least a strong hand lens.



Figure 3: Female SWD ovipositor is dark with well-developed teeth.

SWD have been shown to have as many as 15 generations per year when observed in captivity (Kanzawa 1935). These flies can complete their lifecycle in 21 to 25 days and can live for up to 66 days (Kanzawa 1939). Female SWD lays 1 to 3 eggs per oviposition site, with an average of 380 eggs throughout her lifetime and multiple female SWD can lay eggs on a single fruit resulting in large numbers of larvae injuring one berry.



Figure 4: SWD larval instars. Clockwise from right, first, second, and third instars.

The eggs of SWD are a milky white and oblong in shape approximately 0.5 mm by 0.2 mm (Kanzawa 1935). They have two long, thread-like appendages used for breathing that protrude from the skin of the blueberry. These can be seen with a microscope or a strong hand lens. Eggs generally hatch between 1 and 3 days inside the berry.



Figure 5: Three pupal instars. From left, first, second, and third instars.

The larvae of SWD are very similar to other *Drosophila* and are extremely difficult to identify even by trained professionals. They are thin, white, and soft-bodied with pointed anterior and posterior ends (4). Their mouthparts appear black on the anterior end. SWD have 3 larval stages that all take place inside of the berry. The full larval stage generally lasts 4 to 5 days (Kanzawa 1935).

SWD pupae are oblong shaped and range from light brown to dark brown as the pupa develops (5). There are spiked protrusions from the anterior end of the pupae that are used as breathing apparatuses. As the pupae get closer to eclosion, the red eyes and wings of the fly can be seen through the pupal case. Pupation can occur in the soil, inside or outside the fruit and generally occurs within 4 to 5 days (Kanzawa 1935).

SWD Management Program for Florida

Our management program is focused on 1) effective monitoring, 2) cultural control and 3) use of selective pesticides

Adult Monitoring

SWD will oviposit on fruit that are still maturing and therefore monitoring should begin as the green berries begin to change to pink. Traps should be hung in the center of the blueberry bush in a shady area at a minimum of 2 traps per 5 acres (Fig. 6). The majority of the traps should be placed along the perimeter of the field but a few traps should be placed towards the center. Since organic growers are unable to use chemicals to induce a more uniform ripening, traps should be placed in varieties where the berries have begun to turn from green to pink. Traps should be serviced at least once per week by collecting the samples and replacing with fresh bait.

The trap recommended for SWD monitoring is a plastic cup trap made from a 32 oz solo cup and lid with 8-10 $\frac{1}{4}$ -inch holes along the upper rim (Fig. 7). A twist tie is used to hang the trap in the bush. Some trap designs include a yellow sticky card inside the trap; we have found that captures do not increase with the addition of the card.

Traps are baited with approximately 1.5 to 2 inches (150 ml) of either apple cider vinegar or a yeast-sugar-water mixture. Two drops of odorless dish soap can be added to the apple cider vinegar to break the surface tension of the vinegar and help prevent fly escape. The yeast-sugar-water mixture is made of 0.25 oz yeast, 4 tsp sugar, and 300 ml water (Bolda 2009). The yeast mixture has shown to be more effective at capturing SWD than the apple cider vinegar when conditions are warm. In cooler conditions, results suggest that the yeast mixture may not react as intensely and the vinegar may perform better. The vinegar is also inexpensive, easy-to-use, and specimens can be identified easily.



Figure 6: Trap hung in shady interior of a blueberry bush.



Figure 7: Plastic cup trap with 8-10 $\frac{1}{4}$ -in holes and a lid. Above trap baited with apple cider vinegar.

Larval Monitoring

Monitoring for larvae is done using the salt test. Randomly collect at least 30 healthy, undamaged berries from your field and place in a resealable plastic bag. SWD prefer to lay eggs in healthy, undamaged fruit rather than over-ripe, damaged fruit, so it is unlikely that larvae found would be another *Drosophila* species. Mix a salt solution of $\frac{1}{4}$ cup salt to 4 cups water. Lightly crush the berries in a bag and add the salt solution. Allow the fruit to sink to the bottom of the bag (approximately 10-15 min). If the fruit is infested, the larvae should float to the top. Larval monitoring should be completed weekly.

Cultural Control

1. Sanitation – Sanitation is one of the most important cultural control methods available to growers for the control of SWD outbreak in blueberries. When possible, fallen berries should be removed from the field and solarized using clear or black plastic bags or mulch. The culls may be harboring SWD larvae or pupae that will emerge to lay eggs in the ripe fruit.
2. Frequent Harvest Intervals – In addition to sanitation practices, frequent harvest intervals will help keep susceptible fruit off of the bushes and help to reduce the SWD population and prevent outbreaks. During peak harvest intervals can be between 2 and 3 days.
3. Exclusion Netting – Mesh netting can help prevent SWD infestation in blueberries when hole size is less than 1 mm and reduce entry into field by 100 percent when the mesh size is less than 0.98 mm (Kawase and Uchino 2005). Netting should be placed over bushes once pollination is complete so that bees still have entry into the field. Netting can be an expensive and labor-intensive option for large blueberry growers but may prove more viable for small or organic growers. Since organic growers cannot use chemicals to induce more uniform ripening, such as Dormex®, netting can be applied in sections, covering only those varieties that have begun to ripen and leaving flowering varieties uncovered for pollination.

Chemical Control

A decision to spray should be based entirely on monitoring data. This data could be obtained from monitoring traps or it could be based on larval counts from berries. The problem with data taken from larval counts is that by the time these data are available it is usually too late for spraying and a large percentage of the field could be infested. Regardless, once SWD is recorded in the planting the grower should embark on a spraying program. Table 1 provides a list of compounds registered for SWD control in Florida. During spraying growers should aim for a 10 to 14 day cycle and the same product should not be used more than two times in a row before rotating to a different class. Rotating among the various classes delays the onset of resistance to the pesticides that are used in the management program. When using pesticides the grower must follow the label and care should be taken to use selective pesticides that do not interfere with pollinating agents. Therefore, pesticides should only be applied late evening or early morning when beneficial insects including bees are less active. Regular monitoring for adults and larvae should continue during the application of pesticides.

Table 1. Insecticides recommended for spotted wing drosophila management in Florida

Active Ingredient	Trade Name	REI ¹	PHI ²	Mode of Action Code ³
Bifenthrin	Brigade	12 hours	0 days	3A

Fenpropathrin	Danitol	24 hours	3 days	3A
Malathion	Malathion	12 hours	1 days	1B
Phosmet	Imidan	1 day	3 days	1B
Spinetoram	Delegate	4 hours	3 days	5
Spinosad	Entrust	4 hours	3 days	5
Zeta-Cypermethrin	Mustang Max	12 hours	1 day	3A

¹REI - Re-entry interval - the period that must pass between application of the selected insecticide and entry of any persons into the treated area.

²PHI - Pre-harvest interval - the period that must pass between the application of a selected insecticide and harvest of the crop. ALWAYS follow label instructions.

³For management of spotted wing drosophila (SWD) resistance to insecticides, growers should use products from one mode of action group during the period of one SWD lifecycle then rotate to another mode of action for a similar period.

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Publication # 2, SWD University of Florida, IFAS Extension publication. February 2013. Oscar Liburd is a professor of fruit and vegetable entomology, Univ. of Florida and Lindsay Iglesias is a graduate research assistant in the Small Fruits and Vegetable IPM laboratory at the University of Florida.