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Fourth Quarterly Report

Biological control agents for spotted wing drosophila in Virginia

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This project addresses a relatively new invasive pest, spotted wing drosophila (SWD), an insect that is having a dramatic impact on berry and vineyard crops in much of the U.S. The current project is expanded to include an further invasive species we found in Virginia for the first time, African fig fly (AFF).

Spotted wing drosophila, *Drosophila suzukii* (Matsumura), is a congeneric relative of other vinegar or pomace flies (popularly called fruit flies). This species is native to eastern Asia. It was introduced into California in 2008. During 2009, it spread up the Pacific Coast through British Columbia. Late in 2009, it was found in Florida. Because of the speed with which it moved up the west coast, we established a trapping program in South Carolina, North Carolina and Virginia in 2010. At that time, SWD was detected in both Carolinas but not Virginia; however, it was found in all five trapping locations in Virginia in 2011 (Pfeiffer et al. 2011, Pfeiffer et al. 2012). In the first year of this project (2012), we found SWD wherever we trapped (Pfeiffer 2012); it should now be considered generally distributed in the state (Fig. 1).

Unlike other *Drosophila* species, SWD attacks ripening fruit on the plant, not limited to overripe fruit material. SWD has a large, toothed ovipositor with which it cuts through healthy, intact fruit skin. Each female can lay 7-16 eggs per day, with an adult life span of up to 9 weeks, averaging 350 eggs per female. There are about 13 generations per season. Larvae develop and feed in the fruit tissue, causing a premature softening with tissue breakdown. Infested clusters may become infected with sour rot organisms.

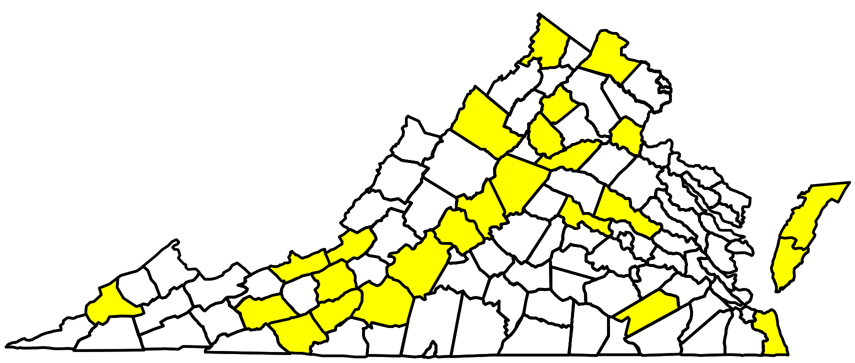

Fig. 1. Collection counties for spotted wing drosophila in Virginia, as of October 2013.

Fruit are mainly attacked during the ripening process. It is therefore critical to provide control of sensitive crops in the period shortly preceding harvest. It is important not merely to provide efficacy, but material must also be labeled with a short Preharvest Interval (PHI). With the introduction of SWD being very recent (mid-late summer 2011), we have not had the opportunity to perform control studies of this pest yet. Several likely materials are listed in the 2012 Virginia Tech Pest Management Guide (Pfeiffer et al. 2016). However, research needed to determine actually control provided in the field. Some likely pesticides for SWD were listed by Walsh et al. (2011). With the high number of generations and high reproductive capacity of SWD, there is high risk of insecticide resistance. Such resistance already appears to have developed in California after repeated applications of pyrethrins, even when SWD adults were exposed to twice the label rate (Bolda 2011).

In the course of our first year work, we found a new invasive drosophilid infesting grapes in commercial vineyards, the African fig fly (AFF), *Zaprionus indianus* Gupta (Pfeiffer 2012). In some cluster samples retrieved to the lab for rearing, 90% of the flies were AFF. The role of AFF in grape quality needs to be addressed.

Control strategies for SWD now center almost exclusively on chemical control. This threatens to upset biological control systems for other pests. There is also a great risk of pesticide resistance because of the high reproductive rates of SWD. Sole reliance on insecticides is not sustainable; we must develop biological and cultural methods to supplement chemical control. There are currently exploration efforts in Asia to find natural enemies of SWD. But there is almost no information on natural enemies that are already here. It will be years before a suitable natural enemy can be found in Asia and approved for release.

We need to compare infestation in varying settings and fruit crops that are hosts to SWD. In other systems, there are differences in parasitization by a given parasitoid species depending on the crop (Vinson 1976, Price et al. 1980, Eben et al. 2000).

Results under the specific objectives are as follows:

1. **Determine presence of biological control agents for SWD in Virginia vineyards**

Leptopilina spp. (Figitidae) (Fig. 2a) is a larval parasitoid, and was the most abundant parasitoid reared from the traps. In the cherry orchard, more parasitoids of *Leptopilina* spp. were reared from traps baited with banana than those baited with cherry, and *P. vindemiae* was only reared from traps baited with banana. Interestingly, in the caneberry field, we only reared out *Leptopilina* from sentinel traps, and only from traps baited with caneberry; no parasitoids were reared from the traps baited with banana (Figure 3).

Pachycrepoideus vindemiae (Pteromalidae) (Fig. 2b), a pupal parasitoid, was reared in lower numbers, and was only reared from traps placed in the cherry site. One individual of *P. vindemiae* was reared from SWD, the rest were reared from *D. melanogaster* or other wild drosophilids. It is surprising we did not see more *P. vindemiae* reared from SWD, because similar studies (e.g. Stacconi et al. 2013) reared considerably more of this species from sentinel traps infested with SWD. It is possible that we reared fewer numbers of *P. vindemiae* because there were not as many pupae present as larvae, and pupae would have been present in the traps for a shorter amount of time than the larvae.

Fig. 2. Parasitic wasps reared from *Drosophila melanogaster* in Virginia fruit systems: (a) *Leptopilina*, a larval parasitoid, and (b) *Pachycrepoideus*, a pupal parasitoid.

Fly counts from traps were completed, most data have been analyzed. Sentinel traps served as traps for flies as well as parasitoids, so flies reared out of traps were counted in hopes that the numbers might tell us something about drosophilid populations and/or behavior in the different fruit crops. The fruit baits differed in their ability to attract parasitoids to the contained fly hosts. In cherry, banana bait was superior to cherry baits; in caneberry, only caneberry bait attracted parasitoids (Fig. 3).

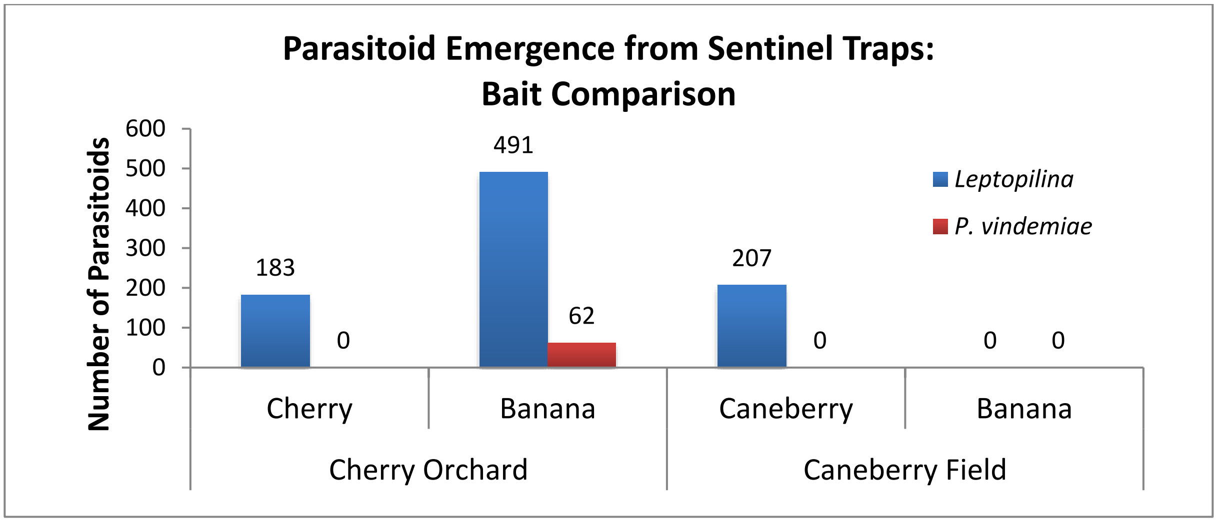

Figure 3: Number of parasitoids reared from sentinel traps with respect to bait type. Three *Leptopilina* were also reared from a blueberry-baited trap in the blueberry site. No parasitoids were reared from traps placed in vineyards.

2. **Determine significance of crop environment to parasitization of SWD**

Parasitoid captures are greatest in traps near vineyard edges, reflecting the immigration from drosophilid host plants along edges. In both the cherry and caneberry sites, we reared considerably more parasitoids from traps placed on the edge than those placed on the interior (Figure 4). There could be several explanations for why we saw this: 1) each site had wooded habitat at the edge of the crop planting, so maybe the parasitoids were moving into the crops from the woods, and naturally went to the first traps they encountered; 2) the edges of the sites, being wooded, were shadier and traps were in direct sunlight for a shorter amount of time, so temperature would have been cooler; maybe the parasitoids prefer the shady, cooler locations and/or the larvae perform better under such conditions; 3) there may also be an edge effect with their wild hosts, so it could be that there are more parasitoids because there are more hosts at the edge of the site.

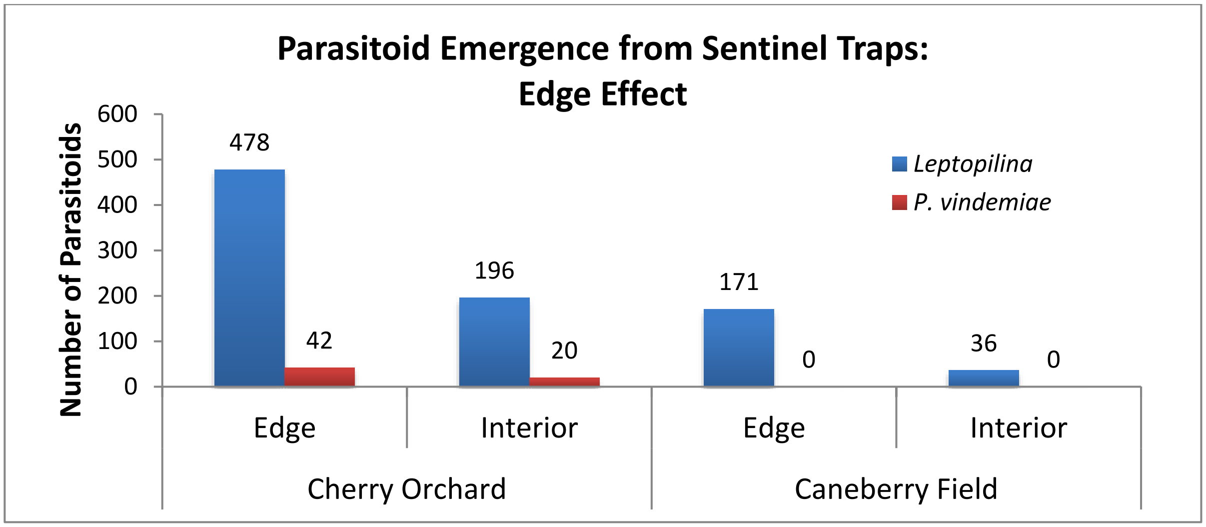

Figure 4: Number of parasitoids reared from sentinel traps with respect to trap placement.

3. Compare parasitization of SWD and AFF

One individual of *P. vindemiae* and 3 individuals of *Leptopilina* were reared from *Drosophila suzukii*; all other parasitoids reared from *D. melanogaster* or other ambient drosophilids that had infested traps.

Parasitization bioassays in the laboratory with the *Leptopilina* species have been completed. Results show that this *Leptopilina* species cannot successfully attack *D. suzukii* or *Zaprionus indianus* in the laboratory. This is likely due to a high hemocyte content of their hemolymph (blood), allowing a high encapsulation rate of parasitoid eggs (Kaksoh and Shlenke 2012). Conservation biological control of these flies will be difficult, supporting the need for classical biological control efforts (searching in a pest's home range for natural enemies).

Results summary:

The two most common parasitoids of Drosophilidae collected were *Leptopilina* (a larval parasitoid) and *Pachycrepoideus*, a pupal parasitoid. Very few parasitoids were reared from either *Drosophila suzuk*ii or *Zaprionus indianus*. Most parasitoids were reared from *D. melanogaster*. . Unless large numbers of parasitoids are available to compensate for low success rate, the best hope for biological control lies in classical biological control (exploration in the pest's home range for successful parasitoids, rearing in quarantine in the US, and subsequent release). Fruit baits varied in their ability to collect parasitoids to contained fly eggs or larvae. There was a strong edge effect in degree of parasitization, with higher rates toward plot edges.

Technology Transfer:

a. Information has been shared with industry through numbered extension publications, grower conferences, in-season vineyard meetings, and through the Virginia Fruit web set, maintained by the PI. This is a heavily visited site; there were 70,308 visits to pages within this web site in 2015.

b. Information was shared with the scientific community through presentations at the Cumberland-Shenandoah Fruit Workers Conference, the Entomological Society of America national and regional meetings, and will be incorporated into refereed journal articles.

Extension Presentations:

Wahls, J. C. E. and D. G. Pfeiffer. 2016. Are there natural enemies of spotted wing drosophila in Virginia? North American Raspberry and Blackberry Conference. Williamsburg, VA. March 2-4.

Pfeiffer, D. G., M. E. Shrader, J. C. E. Wahls, A. Balayara and C. A. Laub. 2016. Research and development in fruit invasive insect pests: Those here and those coming? Orchard Fruit Schools. Feb 8-12. Patrick-Carroll, Roanoke-Botetourt, Southside (Blackstone), Nelson-Albemarle, Madison-Rappahannock, Winchester.

Scientific Presentations:

Wahls, J. C. E. and D. G. Pfeiffer. 2016. Investigating the parasitization of two invasive drosophilids in Virginia small fruit cropping systems. Entomol. Soc. Am.: East. Brnch. Annu. Mtng. Philadelphia, PA. Jan 3-7.

Pfeiffer, D. G., M. E. Shrader, J. C. E. Wahls, C. A. Laub & B. Hussain. 2015. Invasive drosophilids *Drosophila suzukii* and *Zaprionus indianus* in Virginia: 2015 progress. WERA Spotted Wing Drosophila Working Group. Entomol. Soc. Am. Annu. Mtng., Minneapolis MN. Nov 15-18.

Wahls, J. C. E., D. G. Pfeiffer, and S. Salom. 2015. Parasitization of drosophilids in Virginia fruit crop environments. Entomol. Soc. Am. Annu. Mtng., Minneapolis, MN. Nov 15-18.

Technical Publications:

Wahls, J. C. E. and D. G. Pfeiffer. 2015. Parasitization of drosophilids in Virginia small fruit cropping systems. *In* Proceedings of the 91st Annual Cumberland-Shenandoah Fruit Workers Conference. Winchester, VA. December 3-4.

Wahls, J. C. E., and D. G. Pfeiffer. 2014. Sentinel trapping for parasitoids of spotted wing drosophila (*Drosophila suzukii*) in Virginia fruit crops. *In* Proceedings of the 90th Annual Cumberland-Shenandoah Fruit Workers Conference. Winchester, VA. December 4-5.

Student/Project Recognition
2016 J. M. Grayson Award, 3rd Place
2016 Alwood Extension Award
2016 ESA Eastern Branch Linnaean Games Champion

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Pfeiffer, D. G., A. B. Baudoin, J. C. Bergh, and M. Nita. 2016. Grapes: Diseases and insects in vineyards, pp. 3-1 – 3-20, 2016 Pest Management Guide for Horticultural and Forest Crops. Va. Coop. Ext. Pub. 456-017. Virginia Tech, Blacksburg.

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