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Final Report

Spotted wing drosophila in Virginia vineyards: Distribution, varietal susceptibility, monitoring and control

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D. Objectives:

This proposed project addresses a new invasive pest, brown marmorated stink bug (BMSB), an insect that is having a dramatic impact on a wide variety of crops in the mid-Atlantic area.

The specific objectives are:

1. Determine abundance and seasonal phenology in vineyards in Virginia
2. Determine varietal differences in severity of infestation,
3. Determine efficacious chemical control tactics,
4. Comparing apple cider vinegar traps with a dry chamber model.

Spotted wing drosophila (SWD), *Drosophila suzukii* Matsumura, has become a severe berry pest, and a late season vineyard pest in Virginia. It was found in Virginia for the first time in 2011 (Pfeiffer et al. 2011, Pfeiffer 2012). This insect is able to oviposit in healthy, ripening fruit (unlike native drosophilids), owing to its hardened and serrate ovipositor. It was first found in Virginia in 2011, where it is expected to cause problems in grape (Pfeiffer et al. 2012). Severe infestations in berry crops occurred, approaching 100% infestation in some caneberry plantings. SWD larvae were found in otherwise intact grapes in winegrape vineyards, with adults reared from retrieved clusters (Fig. 2).

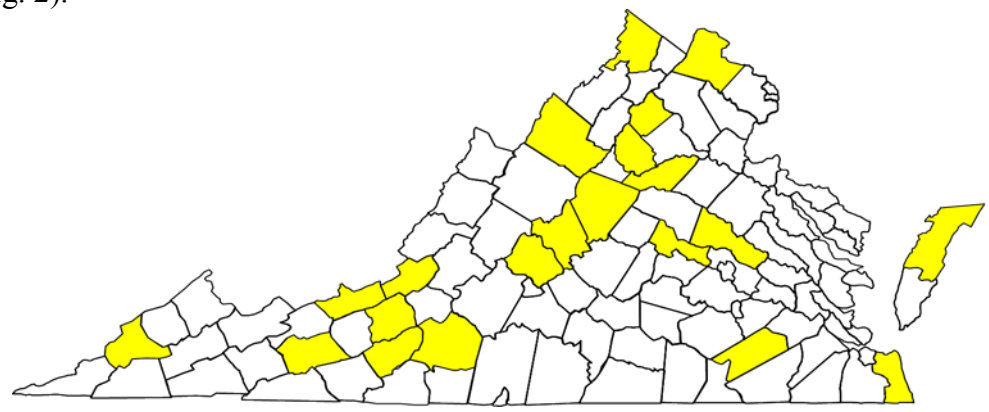

Fig. 1. Collection counties for spotted wing drosophila in Virginia, as of October 2012.

Fig. 2a. Spotted wing drosophila larvae in raspberry, b. Larvae in Pinot Noir grape, c. Adult on Pinot Noir cluster (note oviposition puncture in berry above the fly).

While investigating a suspected infestation of SWD in Albemarle County in September 2012, the grape grower commented that he had an infestation of a different fly, marked by distinctive stripes on the body. Drosophilids were collected and grapes retrieved to the laboratory. In one block of Petit Verdot grapes, many individuals of the striped fly would fly from between grapes in the cluster when disturbed. A few individuals of SWD were also observed. The clusters looked generally intact, except for portions with shriveling berries typically seen in cases of SWD infestation, with a characteristic odor of sour rot. The striped fly was determined to be *Zaprionus indianus* Gupta. This is an invasive drosophilid originally from Africa, having invaded Brazil in 1999, and being found in Florida in 2005 (Steck 2005, van der Linde et al. 2006). It has since colonized Arizona and California (San Diego) (2006), South Carolina and Oklahoma (2007), and is now established in North Carolina (Burrack personal communication) and Mississippi. Populations in the southeastern US are more closely related to those in Africa, and may constitute a second introduction (van der Linde 2010). The *Zaprionus* collected and reared in 2012 from Virginia vineyards were at the time, the northernmost reported populations of this drosophilid. The species has since been collected in Michigan, Wisconsin, Pennsylvania and Connecticut. The US distribution in November 2012 is shown in a map posted by van der Linde (van der Linde 2012). The distribution in Virginia is shown in Fig. 3. While the range is not as extensive as that of SWD, it nevertheless includes some of the most important fruit (including winegrape) counties. While there is no ESA-approved common name, African fig fly (AFF) has been used in the literature and is appropriate.

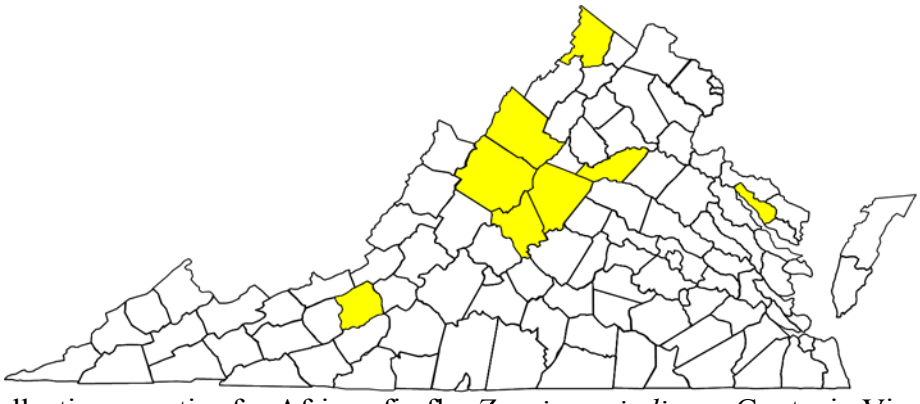

Fig. 3. Collection counties for African fig fly, *Zaprionus indianus* Gupta, in Virginia as of November 2012.

The morphology and appearance of AFF were discussed by van der Linde (2010); the adult is depicted in Fig. 4. This species becomes a human-commensal species (Yassin et al. 2008). *Z. indianus* formerly included two cryptic species: *Zaprionus africanus* Yassin & David and *Z.*

gabonicus Yassin & David (Yassin and David 2010). More sensitive to cold than *Drosophila* species, making it normally a tropical and subtropical species (Araripe et al. 2004). It rises to dominance under warm conditions, causing other drosophilid species to make ecological adjustments (da Silva et al. 2005a).

Fig. 4. Adult African fig fly*, Zaprionus indianus*, collected in a winegrape vineyard in Albemarle County.

Most hosts are fruits that have been injured or have fallen. However in the Valinhos region of Brazil it became a pest in eyed figs, *Ficus carica* L., since they could oviposit into the ostiole of fruits. Entire lots of figs were rejected, with 50% loss estimated (Tidon et al. 2003). In the Brazilian Cerrado, AFF adapted to another plant, *Solanum lycocarpum* St. Hil., attacking fruits throughout the fruit development period (Leão and Tidon 2004). This plant is known locally as fruta do lobo, lobeira or jurubebao, with edible berries, and is the most abundant native fleshy-fruited plant in the region. Leão and Tidon (2004) found that AFF predominated in fresh fruit of that host, but declined markedly in damaged fruit, rising again in severely overripe fruit. African fig fly may be adapting to cooler temperatures (Castro and Valente 2001). It is often associated with human activities; such areas may provide warm areas enabling it to survive in otherwise cold areas (Commar et al. 2012). It has great adaptive flexibility and can develop tolerance to a wide range of environmental conditions (da Mata et al. 2010). It has shown the ability to establish in different ecological niches in new areas of invasion, with different temperature regimes (da Mata et al. 2010); it has become established from southern to northern parts of India.

Other grape growers communicated that they also saw striped flies in Petit Verdot blocks. We collected flies from such blocks in Nelson and Orange Counties. Grapes were retrieved from one of the affected blocks to the lab in Blacksburg in order to rear adults. Both SWD and AFF were reared from grapes. In one sample, AFF comprised about 90% of the emerging adults. AFF is thought to be less able to attack intact fruit because of the less developed ovipositor (Fig. 5b,c). The fact that AFF outnumbered SWD emerging from grapes needs further consideration in order to clarify its potential status as a grape pest. It may be secondary in nature, taking advantage of injury inflicted by SWD or other factors. Secondary in this sense does not mean unimportant, however. AFF is known to inoculate host fruits with the yeast, *Candida tropicalis*, in Brazil (Gomes et al.

2003). Drosophilid-infested grape berries become affected by sour rot, and hence the quality of the crop may be affected. The grower in the Albemarle County vineyard removed the most affected clusters, and estimated a 30% reduction in the crop in the vineyard block.

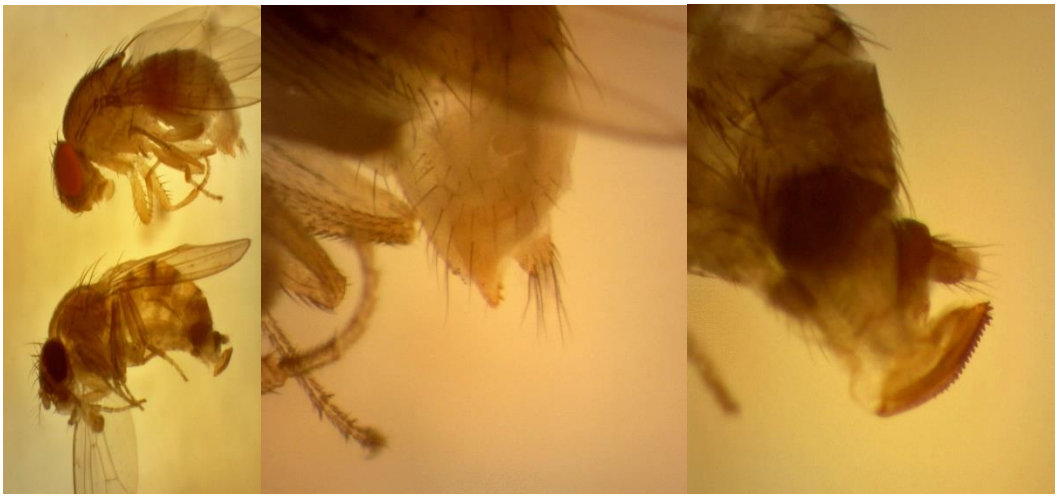

Fig. 5a. African fig fly, *Zaprionus indianus*, above, spotted wing drosophila, *Drosophila suzukii*, female below, b. ovipositor of African fig fly, c. ovipositor of spotted wing drosophila.

Once established in a new area, AFF upset the dominance in the drosophilid community of *Drosophila simulans* and *D. willistoni* (Castro and Valente 2001, da Silva et al. 2005b, da Silva et al. 2005a). Effects on other drosophilid species were studied by Tidon et al. (2003). At the beginning of the wet season, endemic species predominated in their samples; however by the end of the season, AFF predominated. This species feeds on more than 80 host plant species; this relative polyphagy among the Drosophilidae has contributed to is noted ability to invade new areas (Commar et al. 2012). In India, several morphological traits have shown variation with latitude and elevation, indicating genetic adaptation to different environmental conditions (Karan et al. 2000). It has been noted to be able to attack unripe fruit (Commar et al. 2012).
Development was studied by (Nava et al. 2007). At 20°C, the egg stage lasts 1 day, larval development takes 13 days, and the pupal period 6.9 days, resulting in a total of 20.9 days. AFF was reared at several constant temperatures. Development at 18°C 28.8 days, 20°C 20.9 days, 22°C 17.6 days, 25°C 15.4 days, 28°C 12.7 days, 30°C 13.3 days, 32°C 13.0 days. It was projected that AFF may show 13-17 generations in different parts of Brazil.

Gilpin et al. (1986) compared all paired combinations of 28 drosophilid species - all *Drosophila* except for *Zaprionus vittiger* Coquillet, a species closely related to *Z. indianus*, and often confused (Yassin and David 2010). Thick and thin food environments were compared, as well as two temperatures - 19 and 25°C. Some species did better in one medium or another, some at one temperature or another. *Zaprionus* was a medium competitor in most of the comparisons, which were done in thick food at 25°. However, one of the comparisons showed that *Zaprionus* was one of the best competitors in thin diets. In thick food, and at 19°, it was ranked 12 out of 28; in thick medium at 25°, it was ranked 8. But in thin food, it was ranked 5 at 25°, and 3 at 19°. The authors noted, "There is anecdotal evidence for generalized interference under at least some circumstances. The larvae in some cases crowd the entire surface of the food, leaving insufficient space for larvae to breathe or rest. Since larvae do not burrow into the food, only the top layer of food is

immediately accessible. After one week the food becomes liquified, and many larvae and eggs drown and are eaten by other larvae. The species Vir (and also Zap) [*D. virilis* and *Z. vittiger*, respectively] "destroys the habitat" by making the medium soupy and then turning it into a hard, asphaltlike surface. Vir's large and active larval population makes it difficult for larvae of other species to survive. Thus, generalized interference directed at larvae rather than at adults might be important" (Gilpin et al. 1986).

In India, fermenting fruit traps and sweep netting were used to sample AFF (Karan et al. 2000). Populations were sampled by collecting fallen fruit by Castro and Valente (2001). Fermenting banana fruit were used as bait for sampling by Tidon et al. (2003). The species was sampled from fallen *S. lycocarpum* fruit by Leão and Tidon (2004).

In an examination of varietal difference in infestation, we compared Pinot Noir and Chardonnay. We found drosophilid larvae in Pinot Noir, but not Chardonnay (Table 1).

Cultivar	**% Injured Berries**	**Larvae/Berry**
Pinot Noir	8.6	0.03a
Chardonnay	5.7	0.00b

Table 1. Infestation levels in clusters of Pinot Noir and Chardonnay

Table 2 shows infestations in several grape varieties at one Albemarle County vineyard. Most vines had low levels of infestation (0-0.05 larvae per berry – this included a susceptible variety, Petit Verdot. In another block of that variety, very high levels of infestation were seen, 0.24 larvae per berry – about one in four berries infested.

Cultivar	% Injured Berries	Larvae/Berry
Petit Verdot 1	22.0a	0.24a
Petit Verdot 2	7.0b	0.05b
Merlot	5.2b	0.02b
Chardonnay	10.8ab	0.01b
Cabernet Franc	3.4b	0.00b

Table 2. Infestation levels in several grape varieties at one vineyard. Note the variability in infestation in the susceptible variety Petit Verdot.

In a preliminary trapping study, we compared several fruit essence odors with the standard lure, apple cider vinegar (ACV). We obtained fruit essence odors of plum, sweet cherry and sour cherry. Results are shown in Fig. 6. All lures collected more SWD than other drosophilids. However, none of the fruit essence lures collected as many flies as the ACV standard. This is unfortunate, since ACV is generally not as attractive as ripening fruit. It is possible that essence was released too quickly. In this study we replaced lures every 2 weeks. In future work we will change lures weekly.

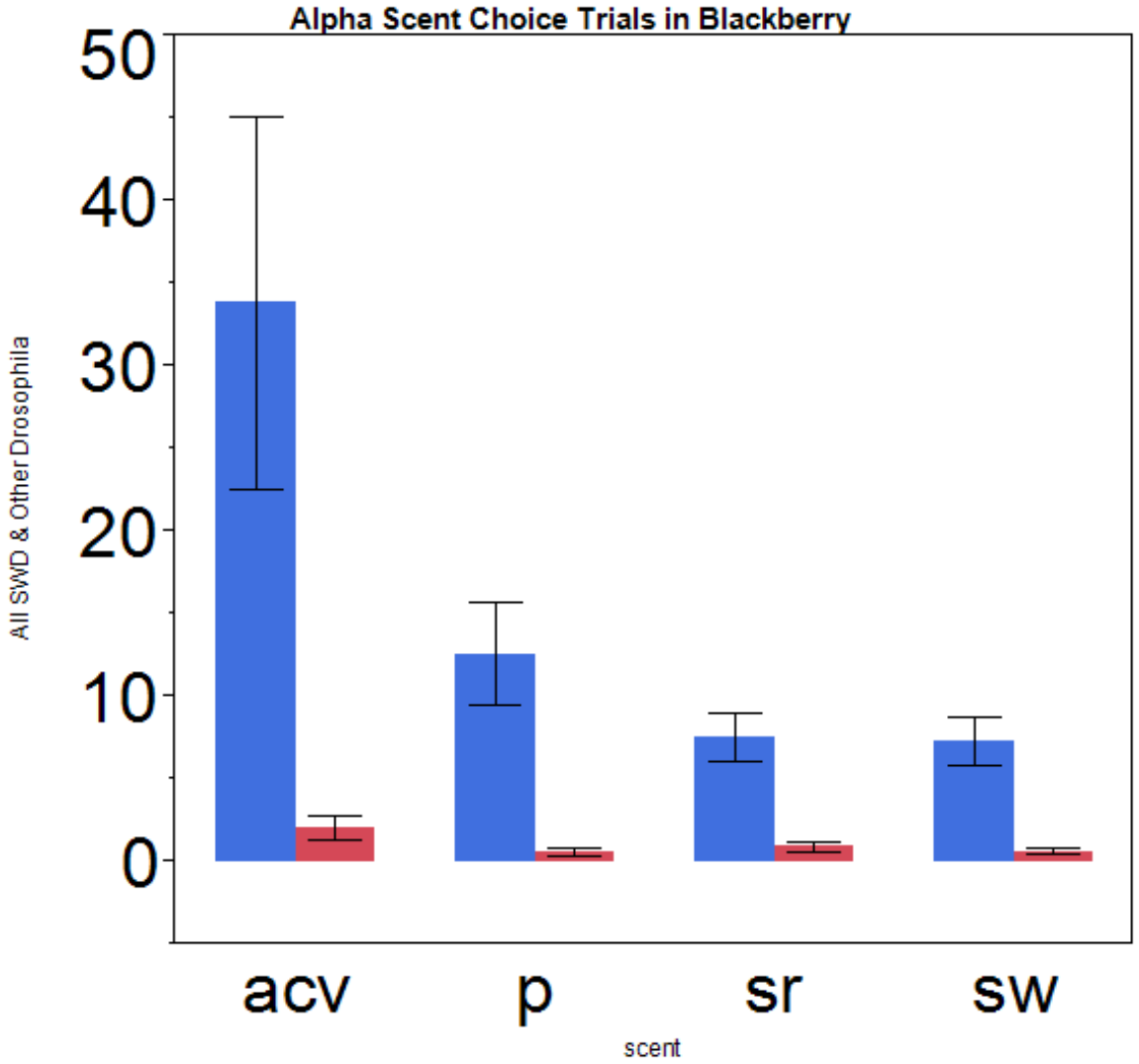

Fig. 6. Captures of spotted wing drosophila (blue bars) and native drosophilids (red bars) in traps baited with apple cider vinegar (ACV), plum essence (P), sour cherry (SR) and sweet cherry (SW).

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