Final Project Report – SRSFC Project # 2014-15

Proposal Category:

Research

Project Title:

Spatio-temporal distribution and overwintering biology of spotted wing drosophila in Georgia

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Objectives:
1) Determine statewide distribution of spotted wing drosophila (SWD) at the County level and develop spatial distribution map for future reference; 2) determine seasonal fluctuation of SWD population in different parts of the state of Georgia and develop temporal distribution charts; and 3) determine overwintering biology of SWD specifically for Georgia condition in order to predict and minimize the likelihood of following spring infestations.

Justification:
Fruit production in the US has recently been challenged with a new invasive insect pest, spotted wing drosophila (SWD), *Drosophila suzukii* Matsumura (Diptera: Drosophilidae). The SWD, a native of Eastern and Southeastern Asia (1), is a devastating pest of small and stone fruits. Since it's first detection in California in 2008 (2, 3), the SWD has spread throughout the United States (Fig. 1) (4) causing significant losses in crop yield and quality, and risk of even more profound damage.

The SWD is highly polyphagous insect (5, 6) and presents a major threat to soft- and thin-skinned fruit crops including blueberries, caneberries (blackberries and raspberries), cherries, strawberries, peaches, and grapes worldwide. SWD larvae have also been observed feeding on other wild and cultivated hosts including pears, persimmons, figs, loquat, currents, mulberry, buckthorn, and dogwood (5).

Based on descriptions of SWD biology, SWD adults mate within 1-2 d of emerging. Females can lay 300-600 eggs in their lifetime, usually 1-3 eggs per fruit. Eggs are inserted just under the skin of fruit, but paired respiratory filaments are left projecting from fruit, which allow the number of eggs to be assessed microscopically. Eggs develop in 1-3 d, larvae in 5-7 d, and pupae in 3-15 d.

Therefore, under optimal conditions of about 20 °C, one generation can complete development in about 8-10 d leading to 15 generations per year (7). Because of this short generation time, SWD populations can increase to potentially devastating levels rather quickly. Estimates of 100-fold population increase every 2 wk are plausible. Actual loss statistics have been more difficult to generate, however, potential losses due to damage caused by SWD in fruit crops in the United States have been estimated at $850-900 million annually (8, 9).

Georgia is among the top three blueberry producing states in the US (NASS 2012). Blueberries are number one fruit crop in Georgia with an annual farm gate value of $250 million (10) and economic impact of $1 billion on the state economy (Sial, Pers. Comm. with Georgia Blueberry Growers Association). Since its first introduction in Georgia in 2010, SWD infestations have led to 15-20% loss of blueberry crop annually (Sial, Pers. Comm. with Georgia Blueberry Growers Association). Blueberries produced in the Southeastern states are primarily marketed as fresh fruit in the US as well as export markets and the fresh fruit marketers have zero tolerance for SWD infestation. Detection of a single larva in fruit samples can result in rejection of the entire shipment.

It can be difficult to determine if fruit are infested by SWD at harvest because they often appear otherwise sound. Unfortunately, currently available traps and baits are useful for determining fly presence only but are not reliable predictors of fly density and fruit infestation risk. While this aspect of SWD monitoring is actively being investigated (11, 12), SWD management is currently achieved primarily through preventative insecticide applications (2, 13-15). The number of insecticides available is limited to those with SWD activity and sufficiently short preharvest intervals (≤3 days) to allow their use on frequently picked crops such as blueberries. The most effective insecticides available for use against SWD are primarily broad-spectrum chemicals including organophosphates, pyrethroids, and spinosyns (13-16), the use of which is further complicated by annual application restrictions, preharvest intervals, and trade related issues with residue tolerances.

In order to meet the zero tolerance policy for SWD mandated by the marketers, growers have to make calendar day weekly insecticide applications, which are reapplied if feasible in the event of rain, resulting in as many as twice weekly applications as a preventive measure. In general, fruit growers are reluctant to apply broad-spectrum pesticides due to residues and associated health and environmental concerns. Additionally, the insecticides are quite expensive and frequent application of insecticides significantly increases the cost of production leading to lower profits for growers. Some growers, especially in the areas where they have not had SWD infestations in the past, don't make preventive applications thinking that they don't have SWD and might not get the problem – why waste money? Drosophilid flies have evolved mechanisms to tolerate wide range of environmental conditions (17-20) and consequently SWD is rapidly expanding its geographical range. Unfortunately, every year some growers lose significant portion of their crop to SWD infestations because they were unaware of SWD distribution and were not prepared to deal with it in a timely manner.

In this situation, a spatial distribution map of SWD in the state of Georgia would be very helpful tool. It will help them clearly understand that SWD has been detected in other orchards in their own County or the neighboring Counties (if that is the case) and could cause serious damage to their crops, even if they have not had it in the past. They would then be willing to take timely measures to avoid significant crop losses. Most of the states have already created distribution maps for SWD at the County level (Fig. 2) and continue to update the maps annually. One of the major objectives of this proposal is to conduct a statewide survey with the help of UGA County Extension Agents and develop

spatial distribution map of SWD at the County level. It will help growers assess the risk of SWD infestation in their crops and allow them to be proactive in taking appropriate measures to avoid significant crop losses.

The SWD are generalists and have a wide range of documented hosts including fruits, vegetables, ornamental flowers, and wild plants (21-24) which means that they can move from one host to another throughout the year depending on availability. The wide variety of native plants naturally occurring around blueberry orchards and other small fruit patches in Georgia and other Southeastern states that may serve as alternate hosts, and that ripen at different times throughout the year, further exacerbates cause for concern about the spread and potential pest status of SWD in the Southeastern US. Currently, we do not have clear understanding of where SWD flies exist after the fruit has been harvested – we simply don't see them around, growers say.

This leads us to another series of questions that I often get from growers, why do we get SWD re-infestations in our orchards every spring; where do they come from; how do they survive through the winter and at what developmental stage (eggs, larvae, pupae, or adults). Actually these are very important questions and not only growers but also researchers are asking the exact same questions. Because SWD is fairly a recent phenomenon, everybody is at earlier stages of understanding its biology and ecology. Very little is known about temporal distribution of SWD and their ability to overwinter in various regions. Although drosophilid flies have evolved mechanisms to tolerate wide range of environmental conditions (17-20), their overwintering success varies from one region to another depending on the degree of cold that they experience during the winter (25). The SWD populations in the Northeastern and Northwestern US experience much lower winter temperatures than those in the Southeastern US. Therefore the likelihood of successful overwintering is much higher in Georgia and other Southeastern states, which in turn means much higher populations in the following spring.

In order for us to improve currently practiced SWD management programs based solely on prophylactic insecticide applications, we need better understanding of various aspects of biology and ecology of this pest. In this project, we propose to conduct survey of SWD populations throughout the year not only in the host crops (small fruits) but also in the native wild plantations as well as soil. We will go a step further to dissect the fly specimens collected during the winter to assess their physiological state with reference to diapause, mating status, reproductive ability, etc. This information would be extremely helpful for us to understand the temporal distribution of SWD throughout the year and especially overwintering biology. These investigations could reveal some week-links in SWD biology that would enable us manage the overwintering populations in order to significantly reduce the risk of re-infestations in the following spring.

Materials and Methods:

A statewide survey was conducted in the state of Georgia to determine spatial distribution of spotted wing drosophila (SWD), an invasive pest of small and stone fruit. A 32 oz. plastic cup trap (Fig. 1) and yeast:sugar:water solution as bait were used to monitor SWD populations. We developed YouTube videos (https://www.youtube.com/watch?v=hVOn5SHqKgI) to educate

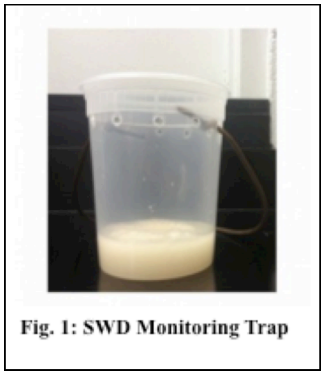

Fig. 1: SWD Monitoring Trap

county agents, growers, and other stakeholders on how to use traps to monitor for SWD. We also organized "Spotted Wing Drosophila Identification, Monitoring and Management Workshops" in each of the four UGA Cooperative Extension Districts in conjunction with their Quarterly Updates (Spring 2014) where pictures, live and preserved specimens, videos, and PowerPoint slides were used to provide hands-on training to all county agents on how to identify, monitor, and manage SWD. The traps were distributed throughout the state in collaboration with county agents, fruit growers, pest management consultants, and other stakeholders. The traps were primarily placed in and around potential host crops such as blueberries, blackberries, raspberries, strawberries, grapes, and peaches to ensure detection of SWD if present. The traps were checked and the bait was changed weekly. The insects collected in the traps were brought back to the laboratory or county extension office and observed under microscope to determine whether or not SWD was present.

In order to determine temporal population dynamics of SWD, we monitored SWD population using yeast-sugar-water solution baited traps at blueberry farms (southern highbush and rabbiteyes) in seven major blueberry producing counties including Appling, Bacon, Brantley, Clinch, Coffee, and Ware County. Traps were placed in the both Southern Highbush and Rabbiteye blueberry orchards as well as in the adjacent wooded areas and checked weekly. This trapping program was conducted in collaboration with County Agents and MBG Scouts.

Results and Discussion:

Through our statewide survey, SWD had been confirmed to be present in 29 counties located in different parts of the state which included most of the major blueberry producing counties in southeastern part of the state. However, we continued our surveys in 2015 and were able to detect SWD in three new counties to bring the total to 32 counties where SWD has been confirmed. Based on the results, we have developed an interactive map (Fig. 2) showing SWD distribution in the state, which is available at our UGA Blueberry Blog (http://blog.caes.uga.edu/blueberry/swd/). In order to facilitate reporting of SWD at new locations in the state, we developed software in collaboration with The University of Georgia Center for Invasive Species and Ecosystem Health, Early Detection & Distribution Mapping System (EDDMapS) (https://www.eddmaps.org/swd/). This will enable all participating county agents, growers, and other stakeholders to report new detections of SWD (date, time, location, and crop) online using their computers or smartphones which instantly updates the SWD Distribution Map on our UGA Blueberry Blog and sends an update to all subscribers (growers and other stakeholders) via email.

In our trapping program, we observed the first spike in SWD numbers around mid-April at the beginning of southern highbush season and the numbers dropped quickly as weather became hot and dry. However, following a couple of rain events which led to lower temperatures and higher humidity, SWD numbers in traps increased significantly in early June at the beginning of rabbiteye season and continued that way even after the end of rabbiteye harvest. Over all SWD numbers were higher in the wooded areas than in higbush or rabbiteye blocks throughout the trapping period except for the first spike at the beginning of the highbush season. We plan to continue trapping program at sentinel sites to determine SWD population dynamics year-round.

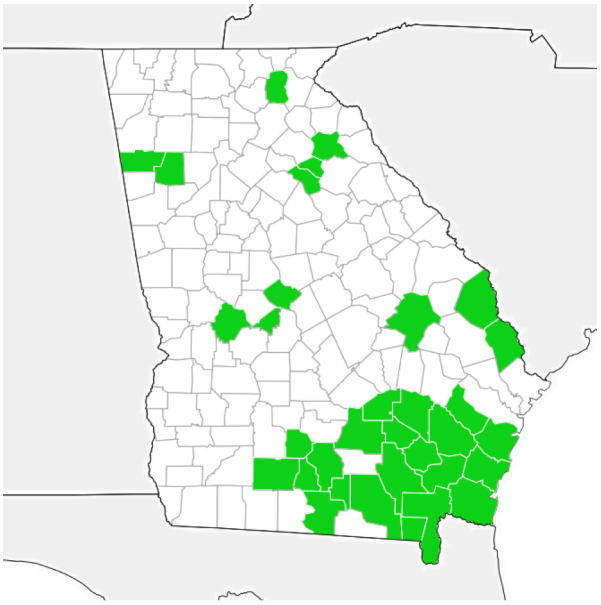

Fig. 2: 2015 SWD distribution map for the state of Georgia

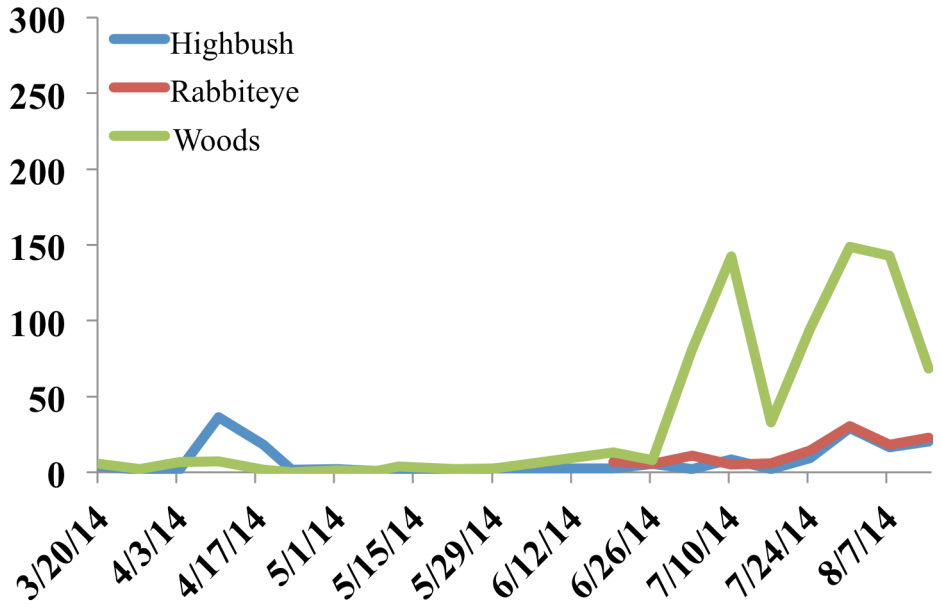

Fig. 3a: Number of SWD in Yeast-Sugar-Water traps in Appling County, GA

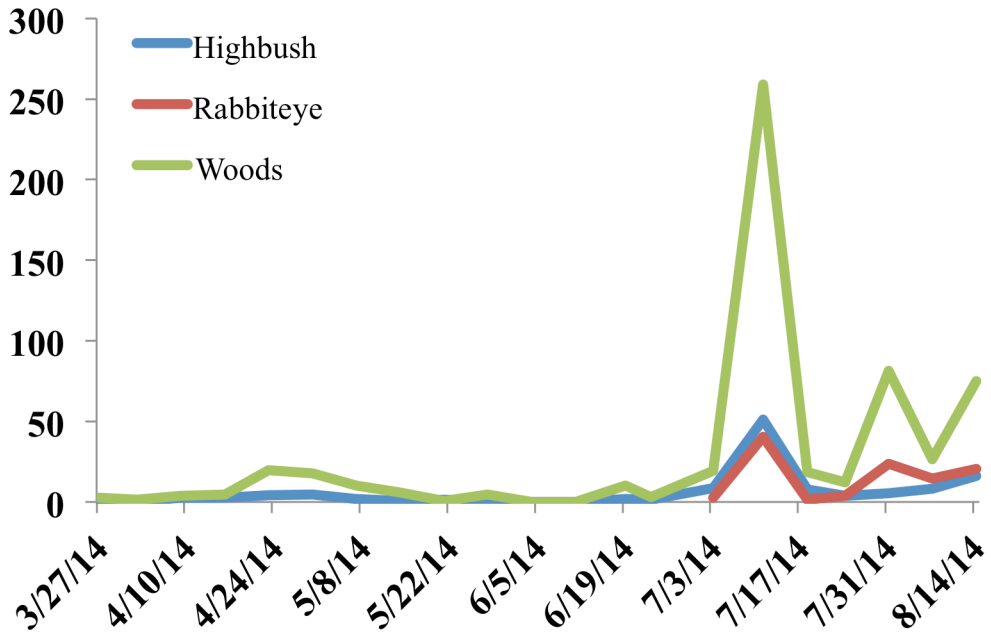

Fig. 3b: Number of SWD in Yeast-Sugar-Water traps in Bacon County, GA

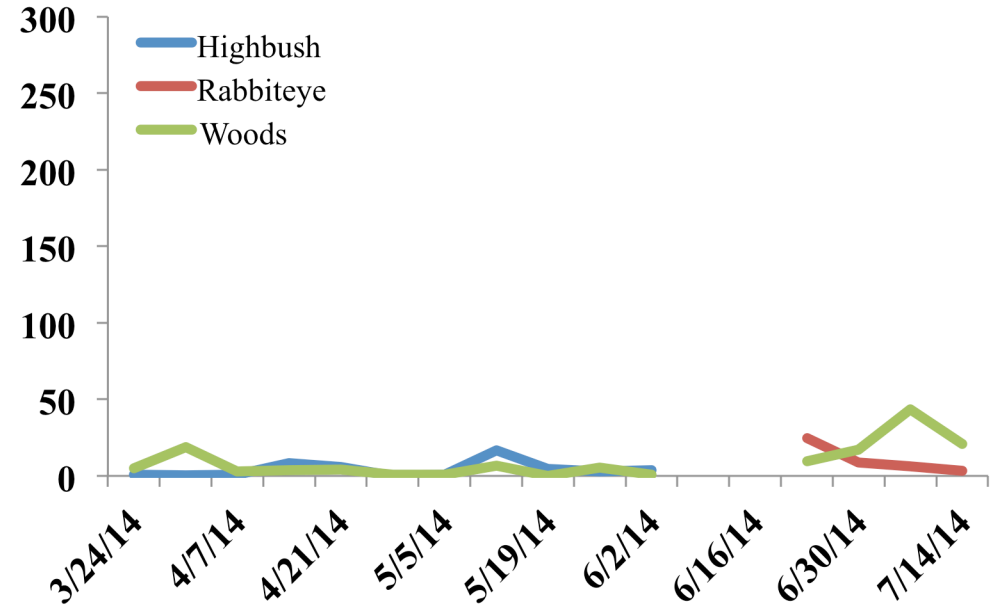

Fig. 3c: Number of SWD in Yeast-Sugar-Water traps in Brantley County, GA

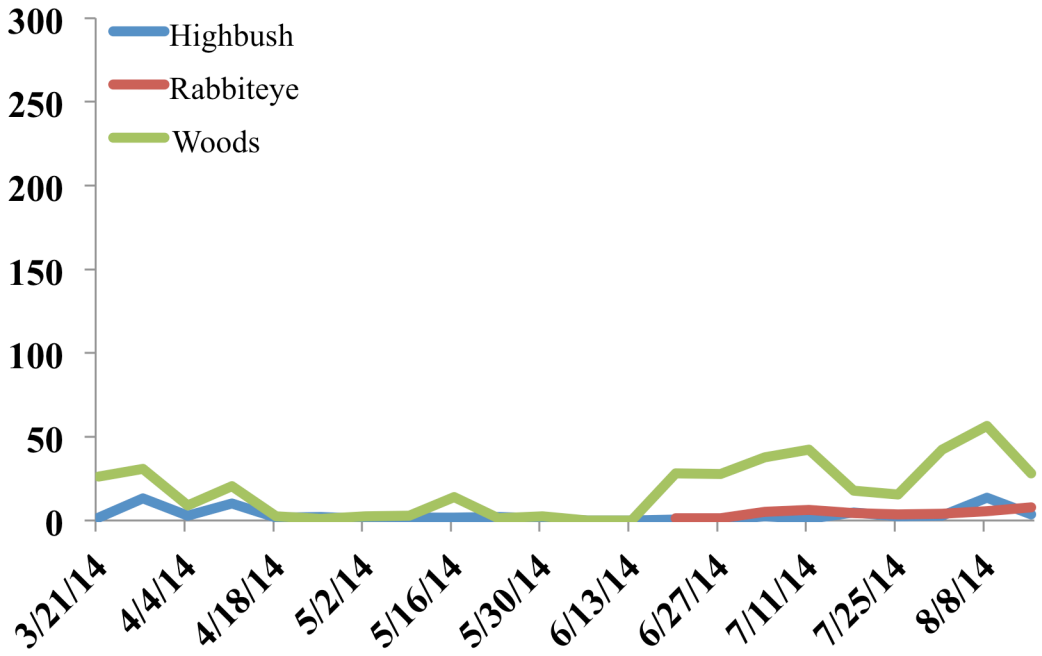

Fig. 3d: Number of SWD in Yeast-Sugar-Water traps in Clinch County, GA

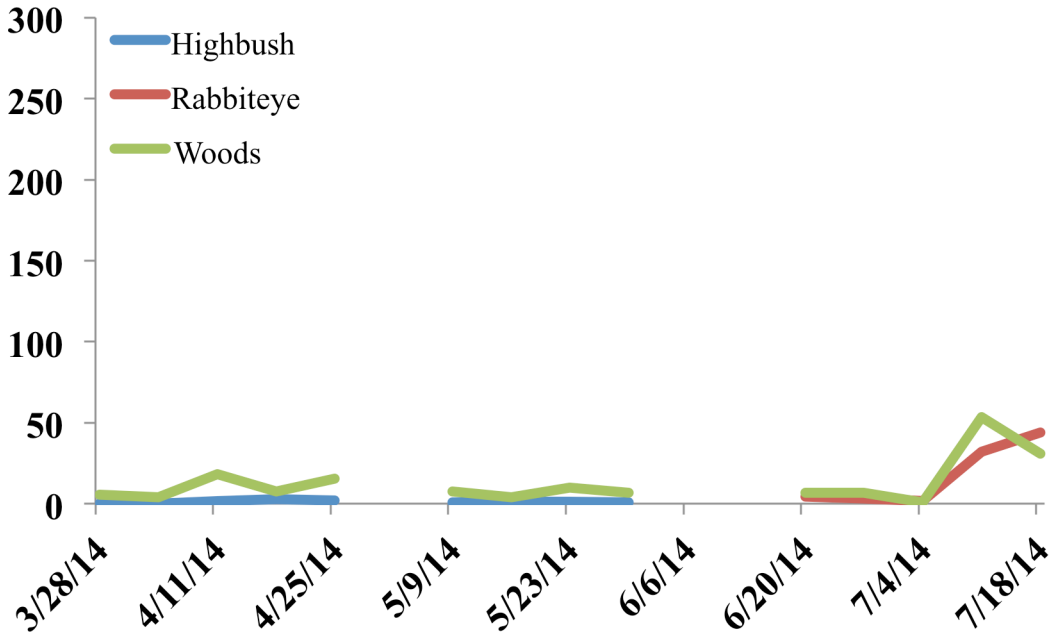

Fig. 3e: Number of SWD in Yeast-Sugar-Water traps in Coffee County, GA

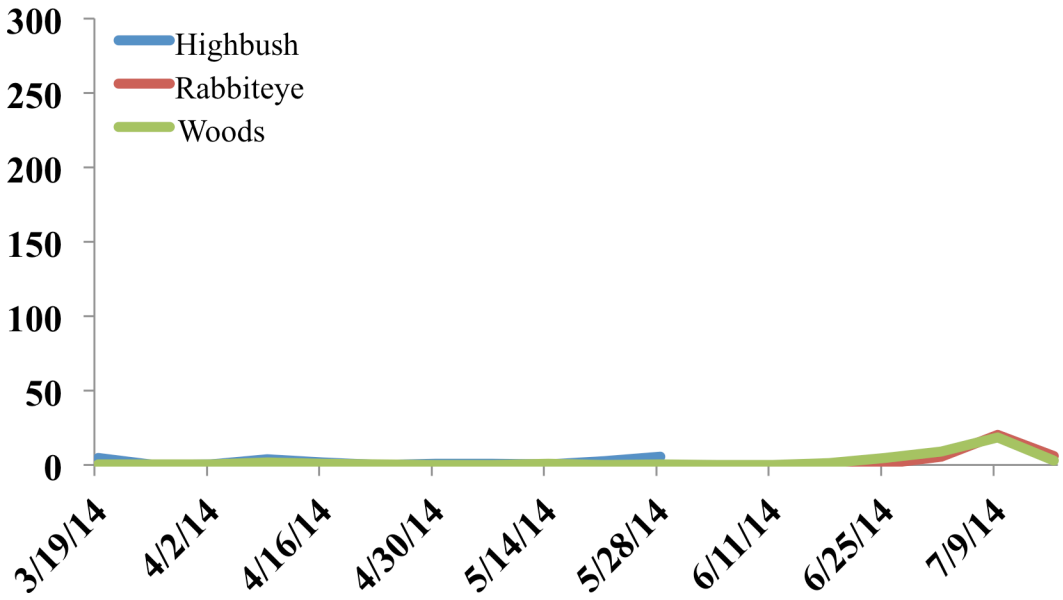

Fig. 3f: Number of SWD in Yeast-Sugar-Water traps in Ware County, GA

Conclusions:

The statewide survey has confirmed SWD presence in 32 counties which include most of the major blueberry producing counties in Georgia. These results emphasize the fact that blueberry and other small fruit growers in those counties must implement SWD management programs to protect their fruit from SWD infestations. Based on data from trapping program, wooded areas around the orchards seem to be the reservoir of SWD. We plan to continue trapping program through the fall, winter and spring to determine SWD population dynamics in orchards and the neighboring wooded areas year-round. However, further studies are needed to identify viable wild hosts of SWD in the wooded areas around orchards.

Impact Statement:

These findings will help blueberry and other small fruit growers in counties with confirmed SWD presence implement SWD management strategies in a timely manner to protect their fruit from SWD infestation. These results further highlight that if growers have wooded areas surrounding their orchards, they are more likely to have higher SWD pressure and therefore will need to be proactive in implementing SWD control programs to avoid crop losses. However, clear understanding of viable wild hosts of SWD in the wooded areas will enable growers to potentially eliminate those particular plants from wooded areas surrounding their orchards to minimize overwintering populations of SWD in the wooded areas.

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