2004 Northeast IPM Project
Progress Report

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Title: **Landscape Ecology and Management of Strawberry Sap Beetle in the Northeast**
PI: **Greg English-Loeb**, Associate Professor, Dept. Entomology, Cornell University, New York State Agricultural Experiment Station, Geneva, NY 14456, Phone: 315-787-2345, Fax: 314-787-2326, Email: gme1@cornell.edu
Team:
Kathy Demchak, Senior Extension Associate, Pennsylvania State University
Sonia Schloemann, Extension Small Fruit Specialist, University of Massachusetts
Wendell Roelofs, Professor of Entomology, Cornell University, NYSAES
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Nontechnical Summary
Strawberry sap beetle Stelidota geminata is a serious emerging threat to strawberry growers in the Northeast. Pesticide control options have not proven effective and moreover, are potentially disruptive. The long-term goal of this research is to acquire the necessary knowledge to develop and test cost effective and environmentally sound management alternatives for the strawberry sap beetle. To achieve this goal we propose accomplishing 4 specific objectives. Objective 1 is to assess quality of overwintering habitat in the vicinity of strawberry plantings. We have good evidence from one farm that SSB overwinters in woods surrounding strawberry fields, but not in strawberry fields, and then disperses into strawberry fields as fruit begins to ripen. We proposed to confirm this result at more farms, comparing overwintering abundance in woods, strawberry fields, and other perennial crops such as raspberries or blueberries. Objective 2 is to quantify SSB use of and population growth on alternative food sources. Although we have good laboratory data showing that SSB can use the residue of numerous crops, the importance of these crops under field conditions has not been well documented. This information will allow us to better estimate the contribution of alternative food sources to SSB pest problems and develop appropriate management recommendations. Objective 3 is to identify the aggregation pheromone used by SSB, and in combination with host volatile cues, field test as a bait to attract and kill overwintered adults. And objective 4 is to evaluate resistance/susceptibility of different strawberry cultivars and timing of renovation as management tactics.

Introduction
Strawberry sap beetle Stelidota geminata is a serious emerging threat to strawberry growers in the Northeast. The adult beetle feeds on the underside of ripe and overripe berries creating holes and likely spreading rot organisms. Of more significant concern, larvae contaminate harvestable fruit leading to consumer complaints and the need to prematurely close fields at great cost to the grower. Although strawberry sap beetle (SSB) has been reported from the Northeast for over 50 years and is widely distributed, only recently has it risen to high priority among growers. Only two pyrethroid pesticides are labeled for its control. Their use is problematic for several reasons. First, they need to be applied as SSB adults move into the fields just prior to harvest, a prospect not relished by growers concerned about public perceptions of pesticide risks. Second, because

of the secretive behavior of the adults and the protected position of the larvae, the insecticides are not particularly effective in the field. And third, the repeated use of broad-spectrum insecticides can disrupt biological control of other secondary pests such as spider mites. Sound IPM practices, developed over the last 20 years, are in flux due to SSB problems. Consequently, the overall goal of the research proposed here is to acquire the necessary background knowledge to develop and test cost effective and environmentally sound management alternatives for SSB.
Agriculture in the Northeast is changing. This seems especially true for fruit and vegetable growers. Starting in the late 70s there has been a trend toward direct marketing of produce through roadside stands and U-Pick operations. Strawberry production is a big part of direct marketing operations in New York, involving about 600 growers who sell nearly 70% of production directly to consumers worth an estimated $5.3 million in gross value. Direct marketing of agricultural produce is increasing in other states in the region as well. In fact, national state ranking for total value of direct sales of agricultural products is California, Pennsylvania, New York, Michigan, Ohio, Wisconsin and Massachusetts, respectively. This trend has several important implications for SSB pest management. First, preventing the build up of ripe, overripe and damaged fruit in U-Pick fields is problematic. Poor sanitation provides an opportunity for SSB to build up in strawberry fields. Second, in order to maintain a diverse selection for marketing, growers are tending to diversify the types of crops grown. It is not atypical to find strawberries, raspberries, cherries, apples, melons, and sweet corn, all potential food sources for SSB, growing on the same farm. It is probable, yet still unproven, that residues from these other crops promote higher overwintering populations of SSB that then can colonize strawberry fields in the spring. Thus, changes such as these may be responsible for the apparent increase in SSB problems in the Northeast.
Strawberries are an important crop in the region (economic value in NY in 2002 = $8.8 million and $10 million in Pennsylvania) with high public visibility. We are proposing research to understand why SSB has become a more severe problem in recent years and to test new approaches to its management that rely more on cultural practices and selective use of pesticides than are currently followed. Results from this research will be applicable to other strawberry producing states outside of the Northeast region, such as Michigan and Ohio, which also have serious problems with SSB.

Objectives

1) To assess quality of overwintering habitat in the vicinity of strawberry plantings. Results were obtained during the springs of 2004 and 2005 and the objective has been completed.

2) To quantify SSB use of and population growth on alternative food sources. Initial results were obtained during the 2004 field season and the objective will be completed during the 2005 field season.

3) To identify aggregation pheromone used by SSB, and in combination with host volatile cues, field test as bait to attract and kill overwintered adults. This objective has not yet been completed but we are making excellent progress.

4) To evaluate resistance/susceptibility of different strawberry cultivars and timing of renovation as management tactics. Initial results were obtained in 2004 and the objective will be completed during the 2005 field season.

Approach

Potential SSB overwintering habitat was sampled to determine the distribution of SSB adults in the spring of 2004 and 2005 before adults emerged from diapause. Samples were taken from established strawberry plantings with straw mulch, raspberry beds, beneath blueberry bushes, and in wood lots near strawberry fields. Two commercial farms from each of the three cooperating states were sampled in 2004 and one farm in each state in 2005. Abundance of diapausing adults was estimated by collecting multiple soil samples from each habitat type per farm. Berlese funnels were used to separate adults from soil. To assess movement of SSB from overwintering locations into strawberry fields we placed cup traps baited with bread dough (an attractive bait for SSB) at the periphery and into the strawberry field at one farm with a history of high SSB populations from May until late June. Trap contents were assessed every day or every other day during this period. To assess movement of SSB out of strawberries after harvest we monitored cup traps baited with bread dough within and outside several strawberry fields with a history of high SSB populations. Traps were placed in the field for 24 hours each week from mid-July to mid-September.

Two approaches were used to evaluate the importance of alternative food for SSB. First, we assessed population growth of SSB on different food sources (strawberry, cherry, blueberry, apple and corn) in rearing chambers. In the laboratory assay, 20 adult SSB were provided with one of the following food sources continuously: apple, blueberry, corn, cherry, raspberry, or strawberry. The larvae, pupae, and adults in each cage were counted after 5 weeks. Second, we conducted a general survey for the presence of adult SSB feeding on residue of the following crops: raspberries, apples, stone fruit, blueberries, melons, and sweet corn at multiple sites in the three cooperating states.

Three progressive steps are involved in identifying an aggregation pheromone used by SSB, and testing as a bait to attract and kill overwintered adults. The first step, which we are still engaged in, is to collect chemical volatiles produced by male SSB and assess antennal activity of females and determine chemical identity using solid-phase microextraction (SPME) and gas chromatography coupled with electroantennographic detection. Second, we will test the response of males and females in the flight tunnel to compounds and compound blends found to elicit high antennal responses in order to determine the most important volatile constituents and their proper concentrations. Finally, we will test under field conditions the attractiveness of the most promising compounds and the potential for reducing overwintered SSB populations and damage in strawberry through attract and kill techniques.

To evaluate resistance/susceptibility of different strawberry cultivars we used a replicated mixed variety planting of 28 different cultivars established at Pennsylvania State University. Approximately 100 ripe to overripe fruit from each plot were evaluated for proportion damaged by adult SSB (presence or absence). We also evaluated the proportion of ripe fruit touching the ground or straw using a mixed variety trial of 14 different strawberry cultivars at the NYSAES. To experimentally test the importance of fruit location, we used metal stakes to either force fruit of the cultivar Earlyglow to touch the ground or to hang above the ground and assessed damage from SSB adults under realistic field conditions. To test the hypothesis that prompt renovation helps reduce SSB populations, we compared emergence of SSB from both small plot and large plot strawberry plantings that were either renovated within 7 days of the end of harvest or after 2 weeks. Cages with attractive bait were used to cover approximately 1/3 m2 area of strawberry field and trap emerging adults over a 5 week period.

Progress to Date

In the summary below, I provide an overview of the progress we have made during the 2004 and early part of the 2005 growing season in addressing our primary objectives.

Overwintering location

The beetles are known to overwinter as adults in wooded areas, but the extent to which they overwinter in fields of strawberry or other crops is unclear. In spring 2004, soil cores were collected from wooded areas and fields of several crops (apple, blueberry, cherry, peach, raspberry, and strawberry) at multiple farms. A total of 6 SSB was found in the 220 samples collected from wooded areas and no SSB were extracted from the 480 samples taken from fields of other crops. In 2005 we repeated our sampling at three farms that had large SSB populations in 2005, focused on the edge of woods near strawberry fields, strawberry fields, raspberry fields, and blueberry fields. We collected approximately 30 adult SSB, of which 20 came from the edge of woods and remainder from under blueberry bushes plus one from under a raspberry planting. No SSB were extracted from strawberry fields. While the number of beetles found was rather small, results suggest that SSB overwinters primarily in wooded areas and not in strawberry fields.

Colonization of strawberry fields

Adult SSB can be sampled in the field using traps baited with whole wheat bread dough. When these attractive traps are placed in the edges of wooded areas near strawberry fields and in the strawberry field itself, beetles are caught as much as 3 weeks earlier in traps placed in the woods. In early to mid-June in New York, SSB adults can be caught both in the woods and strawberry fields, indicating the beetles are both active and searching for a food source. Adults can be found on fruit as ripe strawberries become available. Activity of the beetles is influenced by temperature, with the number of SSB in traps decreasing when the minimum temperature is below about 60oF.

Cultural practices in strawberry

Production practices, including cultivar and time of renovation, may impact SSB choice of host and survival in a particular field. In the manipulative experiment where fruit was either forced to touch or not touch the ground or straw, we found that fruit touching the ground appeared to have more damage than fruit propped up off the ground (data analyses not complete). Under these experimental conditions SSB was willing to feed on fruit propped up above the ground, however. We also surveyed a mixed strawberry cultivar planting at NYSAES in 2005 for tendency to hold fruit above the ground and found some differences. However, those cultivars that held fruit higher tended to have smaller fruit and thus, would not be favored by growers. Survey results from the mixed cultivar planting at Penn State did not reveal any striking differences in SSB preference for certain cultivars.

Development time for SSB from egg to adult is approximately 3 weeks, such that the first generation of adults is emerging about the time renovation is expected to take place. Some evidence exists that renovating early reduces the number of emerging SSB (Galen Dively, University of Maryland). A comparison of prompt and delayed renovation for potential to reduce number of emerging beetles in New York was conducted in a replicated research plot and two commercial strawberry fields in 2004. In all three locations, the number of SSB emerging was greater in the prompt renovation treatment. The reason for this is not clear and may be related to timing of beetle development or weather conditions. The experiment is being repeated in 2005.

Where do beetles go after strawberry harvest?

Adults emerging from the strawberry fields may 1) stay in the strawberry field to overwinter, 2) return to woods to overwinter, or 3) search for other sources of food. To help determine if beetles are remaining in the strawberry field or leaving for wooded areas, attractive traps were placed in 3 strawberry fields and associated wooded edges after renovation. The number of adults caught per trap peaked around mid-August. Mean number of SSB per trap was similar across the 3 strawberry fields, however the mean number varied with wooded edge. Despite the similar number of beetles emerging from strawberry fields, it seems the beetles may be more likely to move to certain wooded edges. SSB continued to be caught later in the woods than in the field, again suggesting the beetles are moving to wooded areas for overwintering.

Use of alternative food sources

Beetles emerging from strawberry fields potentially have enough time to produce a second generation of beetles if they are able to find an adequate food source (this hypothesis is being explicitly tested in 2005). SSB is not considered to be an economically important pest in crops such as apples, raspberries, blackberries, blueberries, cherries, pumpkins, melons, and various vegetables, however SSB adults and sometimes larvae have been reported in these crops. Populations of SSB developing from these alternative food crops could results in higher populations the following year.

In the laboratory trial, the beetles reproduced well on all food sources, although reproduction was much lower on apple and corn. The beetles were also present in all crops sampled in the field. The ability of the beetles to reproduce on a wide variety of food sources and to find these sources in the field provides the opportunity for the beetle population to increase in size substantially in late summer. It is unclear, however, whether a late summer increase in SSB numbers results in a greater number of SSB surviving the winter.

Identifying an aggregation pheromone for SSB

The strawberry sap beetle is quite mobile on a farm scale and is able to use a wide range of crops as a food source. It is difficult to control with conventional insecticides due to its secretive nature and that it is only in the strawberry fields when there is ripe fruit. The most promising control option is development of a trap-and-kill technique where attractive traps could be deployed in the early spring immediately before strawberry ripening with the idea of reducing the number of beetles entering the strawberry fields. A male-produced aggregation pheromone has been identified for several other Nitidulid species and successfully used with a food odor in an attract-and-kill system. Our goal is to develop a similar system for SSB. During the first year we developed a laboratory bioassay and successfully demonstrated that male SSB produce a volatile compound that is attractive to female SSB. We also developed a technique for collecting this volatile for further testing and identification. We currently are refining analytical techniques to determine the chemical identity of the attractive compound (aggregation pheromone). If research progresses as planned, we should have a tentative identification of the aggregation pheromone this summer, including some initial tests conducted in the field. Initial field-testing of attract-and-kill methodology may need to wait until the following year.