Applying Landscape Ecology to Improve Strawberry Sap Beetle Management

Rebecca Loughner and Gregory Loeb
Department of Entomology
Cornell University, NYSAES, Geneva, NY

The lack of effective control measures for strawberry sap beetle is a problem at many farms. The beetles appear in strawberry fields as the berries ripen. The adult beetle feeds on the underside of berries creating holes, and the larvae contaminate harvestable fruit leading to consumer complaints and the need to prematurely close fields at great cost to the grower. Our research has shown that the beetles do not overwinter in strawberry fields. This may lead to a bait and trap control strategy.

The strawberry sap beetle (SSB), *Stelidota geminata*, is a significant insect pest in strawberry in much of the Northeast. The small, brown adults (Figure 1) are approximately 1/16 inch in length and appear in strawberry fields as the berries ripen. The adult beetle feeds on the underside of berries creating holes. Beetles prefer to feed on over-ripe fruit but will also damage marketable berries. 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. The beetles are widespread and present at all of 14 New York farms sampled in 2002 (Figure 2), but seem to be a significant problem only in certain locations. Concern regarding SSB centers on the lack of effective control measures if the beetles become a problem at a farm. Understanding why SSB reaches high densities on some farms and not others is a key goal of our current research since it should provide insights into new management strategies.

Current recommendations for control include applying pyrethroids, improving field sanitation, and renovating promptly after harvest. Keeping fields sufficiently clean of ripe and overripe fruit is nearly impossible, especially for U-pick operations, and the effectiveness of the two labeled pyrethroids in the field is highly variable. Both Brigade [bifenthrin] and Danitol [fenpropathrin] have not provided sufficient control in New York and since they are broad spectrum insecticides they can potentially disrupt predatory mite populations that provide spider mite control. The beetles are not resistant to pyrethroids but rather tend to feed underneath fruit where they are unlikely to come in contact with insecticide. The use of large quantities of water (200 gallons/A) only marginally improves control.

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 to support direct marketing of produce through roadside stands, U-Pick operations, and farmer's markets. These alternate food sources potentially help promote large overwintering populations of SSB that colonize strawberry plantings in the late spring, causing economic damage.

Some possibilities for reducing SSB damage include: 1) altering management practices to lower susceptibility of fruit to SSB, 2) planting strawberries at a sufficient distance from alternate food sources and overwintering sites to minimize access to resources that contribute to a larger overwintering SSB population, and 3)

Figure 1. Strawberrry Sap Beetle (SSB)

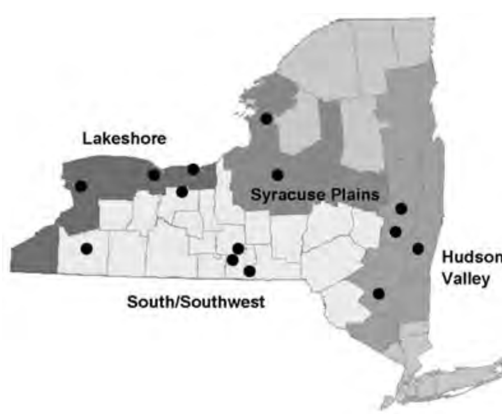


Figure 2. Agricultural region classifications used to group New York strawberry farms. Approximate locations of sampling sites are indicated by black circles. Strawberry sap beetles were found at varying levels at all 14 sites during a survey conducted in 2002.

developing traps that would attract and kill adults before they enter strawberry fields in the late spring/early summer.

In this article we summarize the results of three years of research that examines how cultural practices (plant structure and time of renovation) and habitat surrounding strawberry fields (wooded areas and alternate food sources) influence the size of the SSB population. This work has led to some initial progress in understanding SSB biology needed to develop alternative management tactics.

Overwintering habitat

A total of five adult SSB were found in the 220 soil cores collected from wooded areas in the spring of 2004, while no SSB were present in the 480 samples taken from fields of other crops during the same time period. All beetles in the samples came from wooded areas at one farm known to have high densities of SSB. More beetles were found in 2005 after increasing the area sampled from 0.16 m^2 (wooded area) or 0.26 m^2 (crops) in 2004 to 2.03 m^2 in 2005. Beetles were found in both of the two wooded areas sampled, in blueberry, and in raspberry for samples collected before fruiting occurred in the late winter/early spring and after fruit residue was present during the field season (Table 1). No SSB were found in any of the three strawberry fields for the overwintering sample, but beetles were found in samples collected when fruit began to ripen in the field. The absence of SSB from early season samples in strawberry confirms that most, if not all, beetles move into berry fields as fruit ripens. This has important management implications. First, it makes no sense to apply insecticides for controlling SSB before fruit ripening. Second, we may be able to exploit this colonization pattern by intercepting the beetles before they enter the field using traps baited with an attractive lure and an insecticide (see below).

Strawberry plant structure

Sampling and manipulative experiments were designed to better understand how variation in plant structure of strawberry cultivars could impact fruit resources available to the SSB population. Specifically, since SSB adults and larvae are generally found on fruit touching the ground, cultivars that tend to hold their fruit off the ground may experience less damage. To address this hypothesis, we sampled 14 strawberry cultivars planted out at NYSAES for the proportion of berries held off the ground in 2005 during one time period when all cultivars had at least some ripe fruit (Figure 3). Although there was a significant positive correlation between fruit being ripe and in contact with the ground, certain cultivars did not fit this trend. The cultivar 'Serenity' had a high proportion of fruit touching the ground before most of the fruit had ripened, while 'Evangeline' had a low proportion of fruit in contact with the ground at peak ripeness. The finding that berries on 'Evangeline' are less likely to come in contact with the ground even when fruit is ripe fits with anecdotal reports that the cultivar tends to hold fruit off the ground and thus is less damaged by SSB in the field.

The hypothesis that plant structure may be useful in developing control tactics is based on the assumption that berries in contact with the ground are more likely to be damaged by SSB. To test this assumption, we conducted an experiment at NYSAES where we assigned three-foot sections of a three-year-old strawberry

Table 1

Mean total ± standard error and range for adult SSB collected in wooded areas and crops before and during fruiting in 2005.

Crop/Habitat	n	Mean total SSB[a] (before fruiting)	Range SSB (before fruiting)	Mean total SSB[a] (fruit present)	Range SSB (fruit present)
Blueberry	3	2.3 (1.2)	0 – 3	223.0 (52.3)	131 – 312
Raspberry (summer)	2	0.5	0 – 1	908.5	566 – 1251
Raspberry (fall)	1	1.0		194.0	
Strawberry	3	0.0 (0.0)		177.7 (148.7)	25 – 475
Wooded areas	2	21.5	5 – 38	na[b]	na[b]

[a]Standard error of the mean shown only for crops with >2 fields sampled
[b]Late season samples were collected only from crops and not wooded areas

Figure 3

Mean ± standard error of the mean for A) Proportion of ripe fruit touching the ground and B) Proportion of total fruit ripe for 14 strawberry cultivars in a trial garden planting at NYSAES.

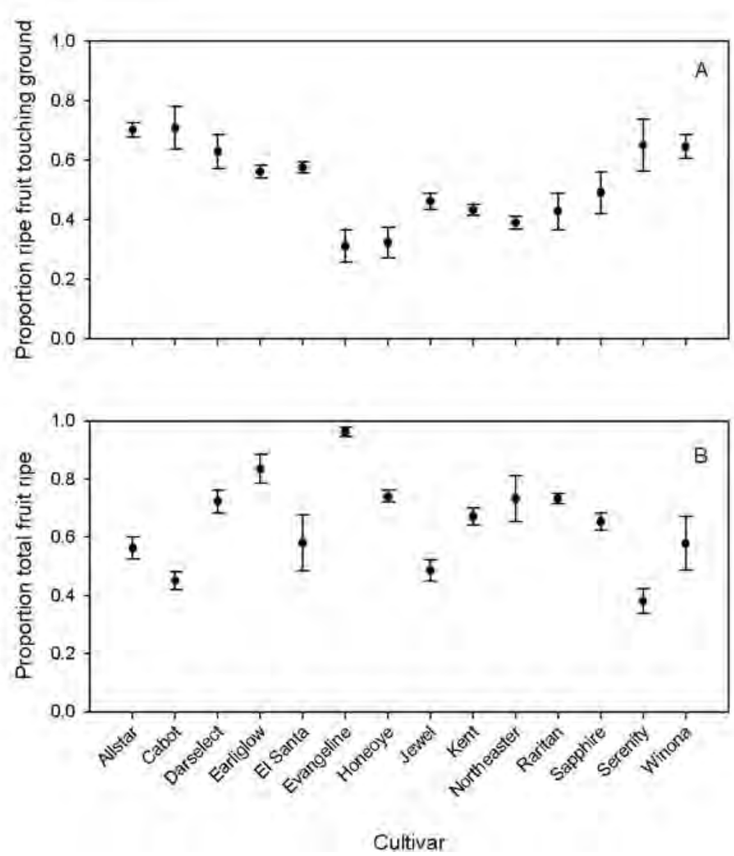
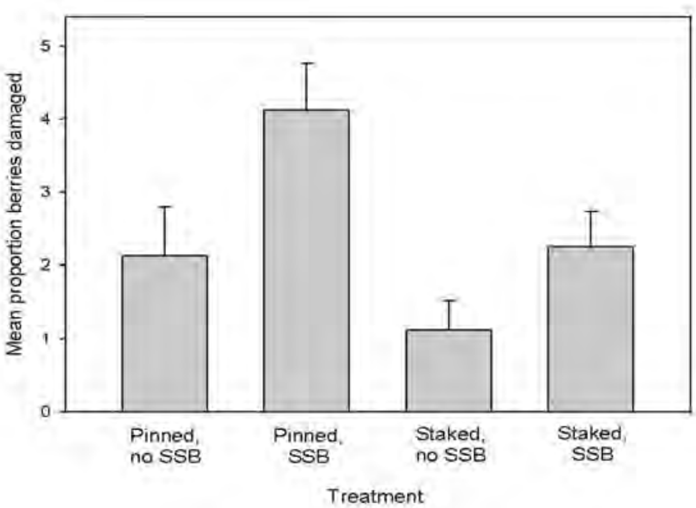


Figure 4

Mean ± standard error of the mean for the proportion of berries damaged in cages assigned to treatment combinations of strawberry clusters pinned down or staked up and inoculated with strawberry sap beetle or not. Non-inoculated plots were included to control for slug damage, which can appear similar to feeding damage caused by adult SSB.



planting to four treatments: 1) all clusters of fruit pinned to the ground, no SSB, 2) all clusters pinned down to the ground, SSB added, 3) all clusters staked up off the ground, no SSB added, and 4) all clusters staked up, SSB added. Plots were covered with a cage, and fruit was evaluated for damage two days later. The proportions of damaged fruit suggest that berries in direct contact with the ground are more likely to be damaged by SSB than berries in the canopy, although the results also clearly show that SSB was willing to feed on fruit not touching the ground (Figure 4).

While proportion of fruit touching the ground may vary with cultivar, some fruit in all cultivars is in contact with the ground. The beetles may preferentially feed on fruit touching the ground and only damage fruit in the canopy when densities of SSB are high. Damage to fruit in the plant canopy has been reported in such situations at commercial farms. Even a comparatively low proportion of fruit in contact with the ground may provide SSB with a greater food resource than needed. In such a case, we would expect a similar density of beetles across all cultivars as was found in a sampling of 28 cultivars in a strawberry cultivar trial monitored at Penn State University by Kathy Demchak, Senior Extension Associate for small fruit. Although the population of SSB in the planting was low, beetles were found in almost all plots. Overall, the potential appears limited for directly impacting the SSB population by choosing a strawberry cultivar with a particular growth habit.

Time of strawberry plot renovation

A manipulative experiment was used to investigate the effect of time of renovation on the number of SSB emerging from strawberry with the idea that rototilling may kill or wound SSB larvae and pupae before they have time to complete development and leave the field. Plots within a strawberry planting at NYSAES were randomly assigned to either rototilling immediately after mowing (prompt renovation) or rototilling 7 to 10 days after mowing (delayed renovation). Emergence cages were placed in both treatments on the same day and the cages in the delayed rototilling were removed briefly on the day tilling was done. Emerging adults were captured with attractive baits in the cages and the total number of adult beetles emerged over five weeks was determined.

Year was the primary factor contributing to variation in the total number of SSB adults emerging, while time of renovation had no statistically significant effect (Figure 5). Peak emergence occurred from late July to early August 2004, while emergence in 2005 resulted in much less of a peak with a smaller number of beetles overall. In contrast to data from Maryland (Dr. Galen Dively, University of Maryland) that showed significantly fewer beetles emerging from plots renovated promptly following harvest, this study suggests that prompt renovation does not consistently reduce the number of emerging SSB, at least in New York. Although prompt renovation does not appear to reduce the number of beetles in the next generation, current recommendations to renovate

Figure 5

Mean strawberry sap beetle per trap in strawberry plots renovated either promptly after the end of harvest or after a delay of 7 to 10 days. Data was collected for five weeks following the early renovation treatment in both 2004 and 2005 in all plots.

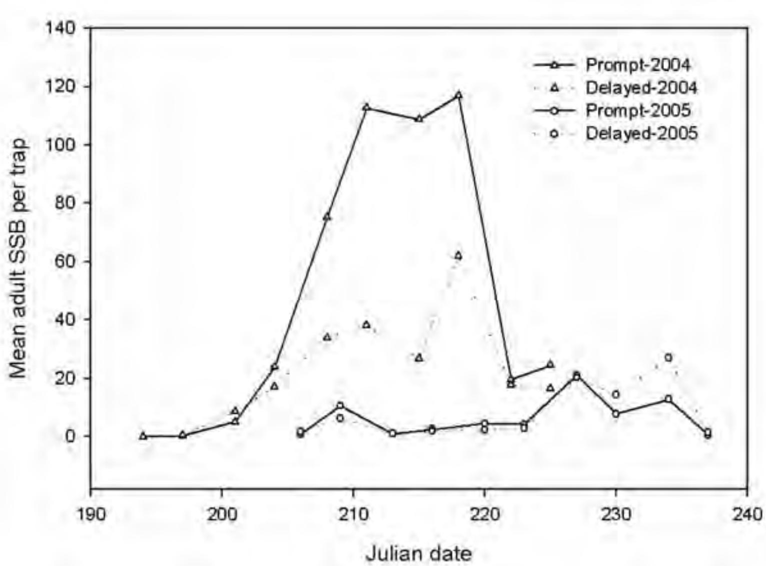
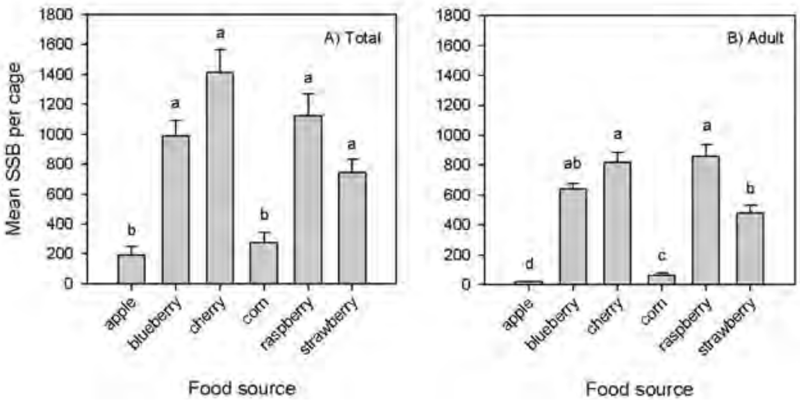


Figure 6

Mean ± standard error of the mean for A) Total and B) Adult strawberry sap beetles in a no-choice feeding assay. Bars with the same letter are not significantly different at $P < 0.05$.



promptly still have value given other benefits such as improved weed control.

SSB alternate food use

The summer generation of adult SSB emerging from 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. Beetles emerging from strawberry fields could produce a second generation of beetles if they are able to find an adequate food source. 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. Two studies were conducted to better understand whether SSB reproduction in late season crops contributes to SSB damage in strawberry the following spring: 1) a laboratory assay to evaluate SSB reproduction on potential alternate food crops and 2) a field study to quantify the number of SSB adults per unit area in various crops.

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 five weeks. Although reproduction was much lower on apple and corn, the beetles reproduced on all food sources (Figure 6). The up to 70 fold increase in mean number of SSB in no-choice cages indicates that considerable reproduction can occur on blueberry, cherry, raspberry, and strawberry. Sampling of crops with ripe fruit, including summer-bearing raspberry, peach, blueberry, and cherry, confirms that the beetles are present, often in high densities (up to 109 SSB per m2), in commercial fields during fruiting (see Table 1). In summary, the beetles are able to feed, complete development, and overwinter in habitats other than strawberry. An effective integrated pest management program to control SSB will need to consider the type of habitat surrounding strawberry fields.

Development of trap-and-kill technique

Modifying cultural practices seems unlikely to significantly reduce the SSB population or damage to marketable fruit. However, the finding that SSB does not overwinter in strawberry offers an alternative approach to SSB management. Sap beetles have a male-produced aggregation pheromone that could be included in a trap along with a food odor and insecticide. These traps should be attractive to male and female beetles and would be placed near fields in the spring to capture and kill SSB before they enter strawberry fields. In laboratory flight tunnel assays, female SSB are more attracted to whole wheat bread dough when male SSB are present with the dough. We have also had some response in the flight tunnel of female beetles to volatiles collected from male SSB feeding on bread dough. We are currently working to collect enough of the attractive material to be able to identify the chemical components of the SSB specific aggregation pheromone and to begin testing blends of synthetic pheromone in our flight tunnel. The research summarized here will be used to guide placement of attract-and-kill stations to maximize the impact of traps in reducing the SSB population and fruit damage, while minimizing the cost of using the traps for controlling the beetle.

Acknowledgements: The research summarized in this article was supported, in part, by grants from the New York Berry Grower's Association, USDA CREES Northeast Regional IPM Program (#2004-34103-14379) and Federal Formula Funds provided by USDA and distributed by Cornell's College of Agriculture and Life Sciences. We are appreciative of the assistance of a number of technicians, summer employees, the NYSAES Farm Crew and colleagues at Cornell, Pennsylvania State University, and University of Massachusetts as well as cooperating fruit growers in New York, Pennsylvania and Massachusetts.

Rebecca Loughner is completing her Ph.D. in Entomology at Cornell University and Greg Loeb is research and extension professor of entomology at Cornell's Geneva Experiment Station.