Hummingbirds can reduce spotted wing drosophila (SWD) fruit infestation

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Introduction & Rationale

Spotted wing drosophila (SWD), an invasive insect from East Asia, was first detected in New York in fall 2011. In 2012, it caused severe damage to berry crops—raspberries, blackberries, blueberries—which are not usually protected with insecticide sprays close to harvest. In 2017, much of the Lake Ontario region's tart cherry crop was rejected at the processor because of infested fruit. The sweet cherry crop is also at risk, as are elderberries, grapes, and other soft fruit.

In contrast to other Drosophilids (vinegar flies) that infest damaged or rotting fruit, SWD females slice through the skin of healthy, near-ripe and ripe fruit to lay their eggs inside. Inside the fruit, the eggs hatch into tiny (<1 mm long), white, first instar maggots that feed and grow creating dimpled, leaky fruit. Depending on the level of infestation, a few SWD larvae in a fruit may go unnoticed, because even the final, third instar is very small (~2 mm long). The third instar emerges either partially or completely from the fruit and pupates. Adults emerge from pupae about 4 to 15 days later.

A mated female can lay about 350 eggs during her 20- to 30-day lifespan. Usually adults are first detected in New York around mid-May to early June, and SWD populations build to enormous numbers by late summer. This places a tremendous burden on growers of susceptible fruit to protect their harvests from infestation.

When humid, wet, and warm environmental conditions favor early SWD population build up, unprotected susceptible fruit may suffer damage, resulting in 80% to 100% crop loss, depending on their designated markets. For growers to protect their fruit from SWD, once adults have arrived, they must treat repeatedly with insecticides throughout the harvest period, resulting in significant economic and environmental costs.

The New York berry industry has been decimated by SWD. Many growers didn't own sprayers because, before the advent of SWD, raspberries and blueberries were relatively untroubled by deleterious levels of pests and plant diseases. Late-season berries, such as fall raspberries and late-season blueberry varieties, have been pushed out and few new plantings have gone in. Organic growers have been hit particularly hard because there is only one organic insecticide active ingredient that is fairly effective against SWD and few rotational partners all of which have relatively poor efficacy.

Berry production in NY is primarily direct market or U-pick, which makes it difficult to protect the ripening and ripe crop with insecticides while also protecting the customers. Many growers choose to shut down U-pick and direct market operations once infestation in fruit has been detected, either with or without a spray program in place. Growers are weary of spraying and want alternatives to routine chemical sprays.

Many bird species eat insects. The ruby-throated hummingbird, *Archilochus colubris*, eats insects daily. Hummingbirds can consume 100% of their body's weight in sugar water or nectar every day, in addition to as many as 2,000 tiny insects. Before migration, it's not unusual for a hummingbird to double its weight, adding a huge amount of fat to power the long journey through Mexico or across the Gulf to the Yucatan peninsula. Hummingbirds eat aphids, spiders, small caterpillars, and insect eggs that they remove from plants, as well as gnats, mosquitoes, and vinegar flies (including SWD) that they capture out of thin air—hummingbird hawking (Newfield 2001, Thurston 1999). We want to encourage hummingbirds to develop a voracious appetite for SWD to help control their populations. Research on hummingbirds' feeding habits has shown that they learn, and remember, how to eat new things. They return in spring to feeding grounds; they will defend, but share feeding grounds; and will aggressively protect breeding, mating and nesting locations (Bené 1946).

Figure 1. Field plot experimental design in 2016, Darrow Farm, Cornell AgriTech. A different field with similar design was used in 2017 and 2018. Traps for SWD were placed along four transects (blue squares) and hummingbird feeders (yellow circles) were placed along the same transects in the treatment half of the field. Transects (two exterior and two interior) ran perpendicular to the rows in 2016 and parallel in 2017 and 2018.

Our objective was to observe the effect of using 25 hummingbird feeders per acre in brambles as a method to encourage predation of SWD by hummingbirds in the planting where feeders are hung. This method is being used by a grower in Mississippi in 4 acres of blackberry. To test this method's effectiveness we conducted observations of hummingbird behavior in a feeder-enriched raspberry planting, we measured levels of fruit infestation using salt flotation, and we measured the numbers of SWD in the planting by trap catch. We also determined the amount of time needed to maintain the feeders in the planting as a measure of the feasibility of this tactic for berry growers and to inform the practicality of conducting grower demonstration trials.

Methods

Raspberry field characteristics

The experiment took place over four years in raspberry fields containing collections from the raspberry breeding program. The fields received no insecticides or fungicides, minimal weed control, and canes were not pruned or trained. Sixteen feeders were placed at a density of 25 feeders/A in the treatment half of the field and the other half had no feeders. The field used in 2015 and 2016 was 1.25 A in size, the field used in 2017 and 2018 was 1.6 A.

In 2015, methods were inadequate to assess the effect of the hummingbird enrichment on the levels of SWD in traps and in fruit. Therefore, in 2016, 2017, and 2018, hummingbird feeders were placed in transects across the feeder-treatment area of the field. Insect traps were placed and fruit samples were collected along the transects through both the treated and untreated areas. This provided more data points to assess the effect on SWD. In 2016, transects were perpendicular to the raspberry rows (Fig. 1). In 2017 and 2018, transects were parallel to the rows.

Hummingbird observations

Hummingbird feeders were set in May and removed after hummingbirds were no longer seen. The cane sugar solution (1 part cane sugar and 4 parts tap water) was changed twice per week along with the feeders. Two sets of feeders were used, one clean ready for changing and one set up in the field, so feeders always had sugar solution in the treated half of the field. After each change, to prevent the growth of mold and bacteria on the hummingbird feeders, feeders were washed in warm soapy water, rinsed, then soaked in a 10% bleach solution for 10 to 30 minutes, rinsed thoroughly, and allowed to air dry.

Hummingbird observations were done once or twice per week in late morning to late afternoon. Hummingbird counts were obtained during hour-long observations of feeders through binoculars, counting hummingbirds seen. No attempt to differentiate hummingbird individuals was made during counts. The time hummingbirds spent in the field at feeders was clocked during a second hour-long observation period, noting arrival into the field to the feeder and departure from it.

Figure 2. Average and maximum number of hummingbird sightings with binoculars seen at feeders during an hour-long observation in the treated portion of the raspberry fields.

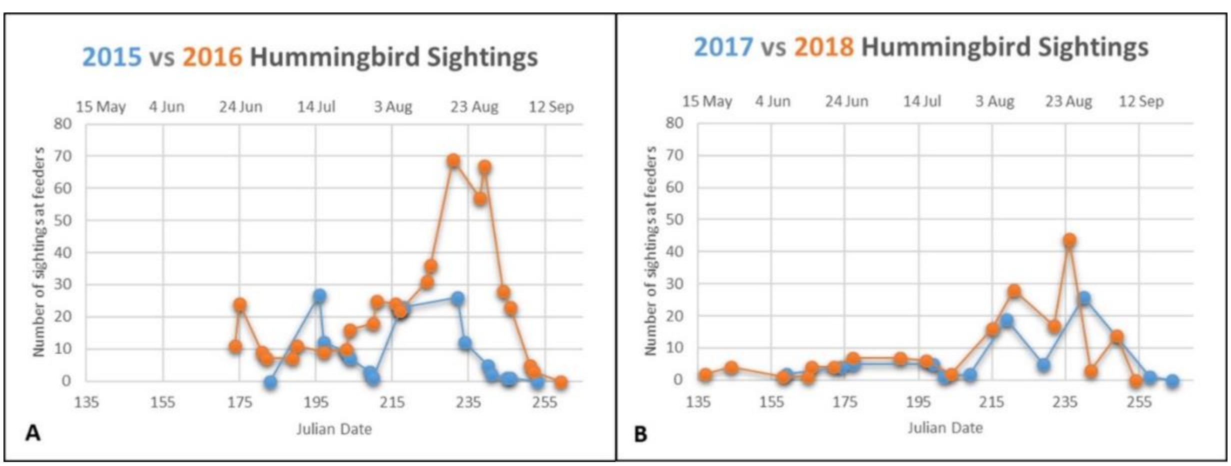
Efficacy against SWD

To determine if the hummingbirds drawn in by the feeders were having an effect on SWD in the treated half of the field, we monitored SWD traps set along transects (Fig. 1) and sampled fruit once SWD was caught in traps and fruit was ripe. Scentry traps and lures were placed in late May or early June and serviced weekly to enumerate male and female SWD. Once SWD was caught in traps, four marketable fruit were collected weekly from the nine trap locations along each of the four transects. Fruit were bulked for each of the nine exterior and interior transect locations (n=8 fruit). Salt flotation was used to enumerate SWD larvae in fruit. In 2016, due to the drought few fruit samples were collected (data not shown) and only SWD trap catch data was collected.

Results and Discussion

Hummingbird observations

Figure 3. Number of hummingbird sightings with binoculars seen at feeders during hour-long observations during 2015 and 2016 (A) and 2017 and 2018 (B) in the raspberry fields. Note peak numbers sighted in August, probably because of fledglings.



In the second year in both plots, more hummingbirds were sighted at feeders (Fig. 2) and they arrived earlier (Fig. 3A and B). Peak occurrence at feeders was in August in all years (Fig. 3A and B). Birds were no longer seen in mid-September and it was assumed they had begun their migration. The highest number of sightings of hummingbirds were seen in 2016, possibly due to the extreme drought and its impact on the availability of other floral resources.

Hummingbirds spent a split second to minutes at feeders. Flight patterns observed included male mating display flights and feeding territory challenge flights by females and males. When using feeders, the hummingbird behaviors that demonstrated spending time within the raspberry planting had high potential for SWD predation. These included behaviors a, b, and c, described below, where hummingbirds were seen to:

a) Fly up to the feeder from within the raspberries and then fly back into them.
b) Fly up to the feeder from within the raspberries and then fly out of the field.
c) Fly to the feeder from outside the field and then fly into the raspberries.
d) Fly to the feeder from outside the field and then fly out of the field.

Table 1 shows the proportion of the total observed behaviors (n) that had SWD predation potential and that indicated the hummingbird was remaining in the planting. Although the observation number was different in each year, the proportion of observed behaviors with predation potential were remarkably similar across years.

Table 1. The proportion of observed behaviors (n) that had SWD predation potential and that indicated the hummingbird was remaining in the planting.

Behavior at Feeder	2015	2016	2017	2018
# of observations (n)	59	138	27	42
Predation potential	81%	75%	81%	88%
Within the planting	39%	29%	44%	26%

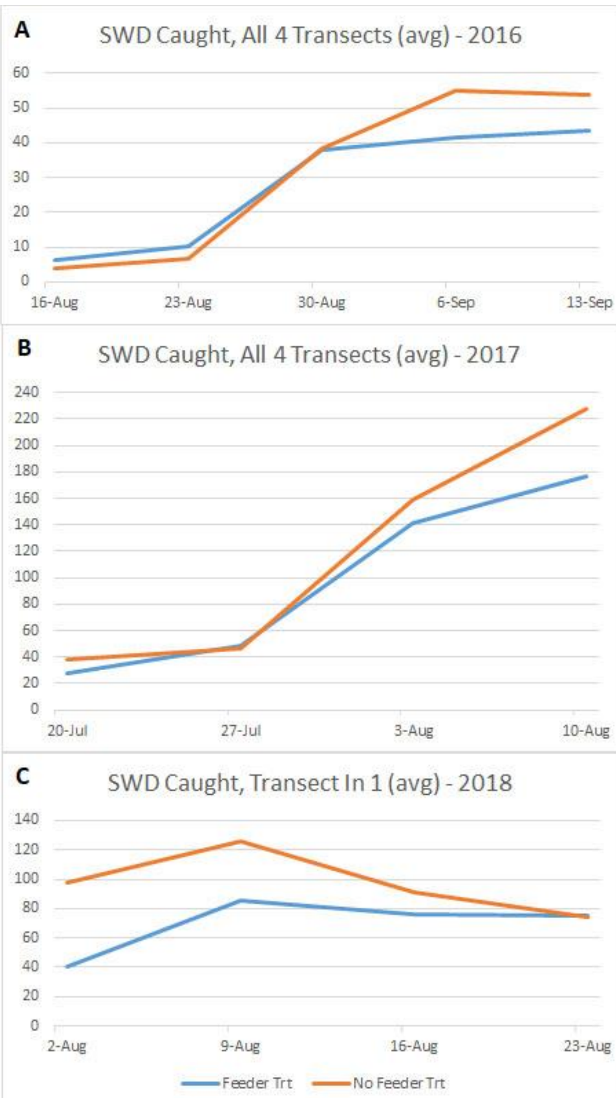
SWD trap catch & fruit infestation

When both hummingbird and SWD numbers were high, trap catch (average/trap) was reduced by up to 59% and fruit infestation (larvae/g) was reduced by up to 56% in the area of the field with the hummingbird feeders compared to the area without feeders. During the period when most hummingbirds were seen per hour (Table 2), a corresponding reduction in SWD trap catch was found in 2016 (Fig. 4A), 2017 (Fig. 4B), and 2018 (Fig. 4C) and a corresponding reduction in fruit infestation was found in 2017 (Fig. 5A) and 2018 (Fig. 5B). Insufficient fruit was available for sampling in 2016 due to the drought.

Table 2. For the date ranges when the most hummingbirds were sighted at feeders, the average, maximum, and minimum numbers sighted during the 1-hour-long observations for each year are given.

Year	Date Range	Average	Maximum	Minimum
2016	18 Aug – 2 Sep	49	69	23
2017	28 Jul – 28 Aug	13	26	2
2018	3 Aug – 24 Aug	26	44	16

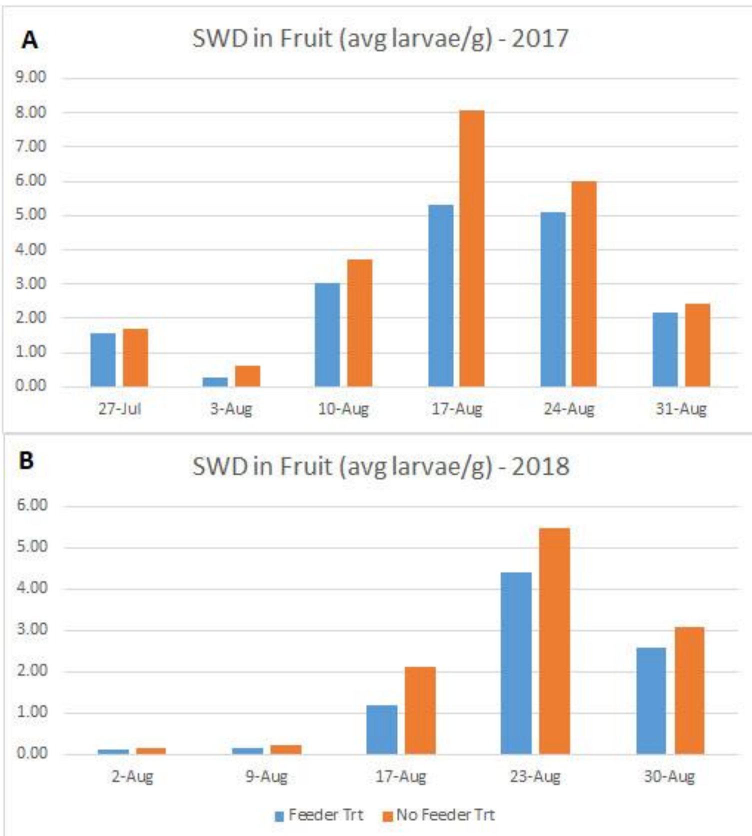
Figure 4. Average number of spotted wing drosophila caught in traps set along the transects in the hummingbird-feeder-treated and no-feeder-treated portions of the raspberry fields in (A) 2016, (B) 2017, and (C) 2018. In 2017, traps were removed from the field on 10 August. In 2018, only one interior transect (In1) was monitored during the dates shown. Dates coincide with when the most hummingbirds were seen per hour.



The beneficial effect of having the feeders in the field was seen consistently throughout the season for fruit infestation in both 2017 and 2018, but only in 2017 for trap catch. Lower average numbers of larvae/g in fruit were found in the feeder treatment in 10 out of 12 weeks (83%) in 2017 and in 7 out of 10 weeks (70%) in 2018. Lower average trap catch numbers in the feeder treatment were found in 7 out of 8 weeks (88%) in 2017, but only in 5 out of 11 weeks (45%) in 2018.

Statistically significant ($p \leq 0.05$) reductions in fruit infestation in the feeder treatment were found on 20 July and 3 August 2017 and in trap catch on 10 August 2017. Reductions, especially in SWD trap catch numbers, did not consistently occur across all weeks during the season. However, during the weeks when hummingbirds were most abundant in the field in all years, consistent reduction in SWD trap catch and fruit infestation in the feeder-treated portion of the field was found (Figs. 4 and 5) and the effect was more pronounced on fruit infestation than on trap catch.

Figure 5. Average number of spotted wing drosophila larvae found per gram of fruit in samples collected along the transects in the hummingbird-feeder-treated (blue bars) and no-feeder-treated (orange bars) portions of the raspberry fields in (A) 2017 and (B) 2018. Dates coincide with when the most hummingbirds were seen per hour.



Grower demonstrations

Because the time for labor to maintain hummingbird feeders in a one acre plot of raspberry was estimated to be two to three hours, including the time to wash feeders, fill them, and replace them in the field, it was decided to test the feasibility for growers to use the technique. Three grower demonstrations were done: one direct market raspberry grower in eastern NY (2018), one CSA raspberry grower in western NY (2019), and one organic blueberry grower in western NY (2018 and 2019). Growers were provided with instructions on how to maintain the feeders, as well as the hummingbird feeders and hangers (Fig. 6).

Hummingbirds were observed in all the fields where feeders were placed (Fig. 6). Growers were willing to use and maintain the feeders in their fields. The direct market grower in Eastern NY applied their normal SWD insecticide program. Spray applications, when needed, coincided with feeder maintenance when feeders would be out of the field. None of the insecticides registered against SWD in NY pose a risk to birds via exposure, according to the pesticide label. The CSA raspberry grower applied no insecticides for SWD and had no complaints about fruit infestation.

The organic blueberry grower, despite having lost the crop to SWD infestation in 2017, in 2018 and 2019, only a single spray of Entrust was applied, timed according to trap catch, and fruit was successfully marketed without complaints or rejection.

Conclusion

Figure 6. Ruby-throated hummingbird on a feeder set in a blueberry planting.

We have determined that, when hummingbird feeders are placed in berry plantings hummingbirds are attracted in and will spend time in the planting. In the raspberry plantings, hummingbirds were seen to spend time within the plant canopy where they would have the opportunity to feed on small insects. In both research plots, feeder enrichment brought more hummingbirds into the planting in the second year than in the first, significantly so in some cases, suggesting that hummingbirds will become more abundant in the planting over time. Research on hummingbird behavior (Bené 1946) found that hummingbirds learn about new foods by testing them and that they remember those foods, feeding on them in subsequent years. In this way, they learn about hummingbird feeders, new floral resources, and new insects to feed on. Perhaps the longer SWD is in New York, the better the ruby-throated hummingbird's appetite for this invasive insect will become.

Fruit infestation level and trap catch numbers were lower in the portion of the raspberry planting that had the hummingbird feeders, especially during the time when hummingbirds were most frequently seen. Reductions in fruit infestation and trap catch for the most part were not statistically significant. This may have been due to the planting being highly conducive to SWD infestation. Without the benefit of IPM cultural tactics such as pruning, clean picking, culling of infested fruit, and weed management, the field posed a severe test of the effectiveness of hummingbird enrichment on SWD management. It is likely that when combined with an IPM strategy for SWD, the use of hummingbirds would prove more successful against SWD than our research was able to show.

In addition, more hummingbirds were seen in the second year in both research plots, which suggests that over time hummingbirds will become increasingly numerous in a planting that has feeders. In turn, these hummingbirds may develop a taste for SWD and perhaps will eat more of them. A limiting factor might be the size of the planting and the cost of feeders, sugar, bleach, and labor. The grower who brought this technique to our attention grows four acres of blackberries. How large an area could this technique be used on? Could interplanting a berry field with plants hummingbirds feed on provide similar benefit with less maintenance or would it lower yields by reducing crop-growing area? Growers found it feasible to deploy hummingbird feeders in small berry plantings. Would they be willing to try this in larger plantings?

Hummingbirds are fascinating animals. Beautiful, fearless, tiny, and fast. We have found that enriching a fruit planting with hummingbirds shows promise as an alternative to pesticides for managing SWD.

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