Evaluating Vinegar-Based and Honey-Based Attractants as Trapping Solutions for Drosophila Suzukii (Diptera: Drosophilidae) (Matsumura)

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Abstract: Spotted wing drosophila, also known as *Drosophila suzukii* (Diptera: Drosophilidae) (Matsumura) is an invasive species to crops and a nuisance to humans. Studies were conducted to determine the most optimal trapping solution because of their prevalence. Types of vinegar and types of honey were tested to determine the most effective natural and non-toxic trapping solution. Five different 250 mL solutions either containing spring water, local honey, store-bought honey, regular vinegar, and apple cider vinegar contained in a red plastic cup were tested for their effectiveness in trapping *Drosophila suzukii*. Specimens were strained from each trap solution after each trial and were recorded to determine which solution trapped the most flies. Overall, the trap containing apple cider vinegar was the most effective at trapping *Drosophila suzukii*. This data demonstrates that Spotted wing drosophila are most attracted to acidic solutions, and therefore, make the best home-made traps.

Keywords: Drosophila suzukii, spotted wing drosophila, apple-cider vinegar, trap

Drosophila suzukii (Diptera: Drosophilidae) (Matsumura) is an invasive species that feeds on ripe fruit such as raspberries, blackberries, and blueberries (Rice et al. 2017). Such insects originate from Southeast Asia, and have migrated to create populations throughout North America, South America, and Europe (Calabria et al. 2012).

Adult *Drosophila suzukii* are 2-3 mm in length, yellow or brown in body color, with dark bands around their rounded abdomens. Both male and female flies have red eyes, however, males have a dark spot on each of their wings, while females do not. (Timmeren et al. 2012). Because of this spot on their wings, the common name for *Drosophila suzukii* is spotted wing drosophila. (Beers et al. 2010).

From egg to adult, *Drosophila suzukii* develop in about 8-11 days, with their egg stage lasting 1-3 days, larval stage lasting 3-13 days, and pupae lasting 4.5 days. Their life cycle in the field during growing season is about 2-3 weeks, and adults can live for 3-9 months during the winter. Further, they can create up to 27 generations per year (Beers et al. 2010; Schlesener et al. 2020).

Female flies have a serrated ovipositor to lay their eggs in soft skinned fruits, which provides the opportunity for the developing larvae to feed inside the fruit before harvest of the crop takes place. This results in damage to the fruit and overall crop. (Walsh et al. 2011). These flies are invasive to crops and are also a nuisance to humans in residential settings. Many trapping solutions have been tested to mitigate this pest. One

solution is to trap flies in solutions containing apple cider vinegar or grape wine (Steck et al. 2009; Beers et al. 2010). The purpose of this experiment was to test the effectiveness of vinegar solutions over honey solutions to determine which solution makes the optimal home-made fly trap.

Materials and Methods

The experiment was performed in the first week of November at a residential site in Montgomery, Texas (30.2414, -95.4058). The population of spotted wing drosophila came from the natural, surrounding environment and were trapped in the solutions. Specimens were identified using a magnifying glass and a guide to confirm species (Timmeren et al. 2012).

Trap Preparation. Five red, plastic, 18-ounce cups (Solo Brand, Dart Container Corporation, Mason, MI) were each filled with 250 mL of their respective trap-solutions using a measuring cup (Pyrex, Corelle Brands, Rosemont, IL). Five different solutions were tested, including local honey (Texas Cowboy Honey, Montgomery, TX), store-bought honey (Aunt Sue's, packaged by Sioux Honey Association, Sioux City, IA), 5% acidity regular vinegar (Kraft Heinz Foods Company, Pittsburgh, PA), apple cider vinegar (Bragg Live Food Products, LLC, Santa Barbara, CA) and spring water (Ozarka, Nestle Waters North America Inc, Stamford, CT). The spring water was the negative control. Each trap contained one drop of dish soap (Dawn, distributed by Proctor and Gamble, Cincinnati, OH) to act as a drowning solution.

Trap Placement. For each of the five trials, each trap was placed three feet apart in an L-shaped formation. Traps were placed on yellow, 5-gallon empty paint buckets (Encore Plastics Corp., Forsyth, GA) on a concrete slab bordering lawn grass. The order of trap solutions was local honey, spring water, store-bought honey, regular vinegar, and apple cider vinegar, respectively (from left to right in the L-shaped formation on the concrete slab). The traps were left out in 6-hour intervals. At the end of each trial, the liquids were poured through a kitchen strainer (Ecko Brand, San Antonio, TX) into an extra red plastic cup to accurately count the number of specimens in each trap that may have sunk below the surface of the solutions. Specimens were identified using a magnifying glass and counted. Any specimen that was obviously not spotted wing drosophila, such as unidentified species of bees, were immediately disregarded without

Figure 1: Individual trap design.

further analysis or identification. Solutions were re-measured and added from the stock containers into the original traps along with the dish-soap drowning solution. Traps were replaced in their original locations.

Figure 2: Trap placement of all five solutions.

Data Analysis. The number of flies in each solution per trial were recorded. The average of each trap solution from each trial was calculated. All data tests and graphs were performed using Microsoft Excel for Windows 10 (Microsoft Corporation, Redmond, WA).

Results

Spring water was the negative control group, which trapped zero flies during all five trials. Store-bought honey and local honey also trapped zero flies. Regular vinegar trapped one fly during each of the first three trials. It trapped zero flies in the remaining two trials. Apple cider vinegar trapped 2, 7, 13, 13, and 5 flies, respectively, during each of the five trials. This data is shown in Table 1 and Figure 3.

Table 1: Experimental data from each replication.

		Replication				
		1	2	3	4	5
Solution	Spring Water	0	0	0	0	0
	Store-bought Honey	0	0	0	0	0
	Local Honey	0	0	0	0	0
	Vinegar	1	1	1	0	0
	Apple Cider Vinegar	2	7	13	13	5

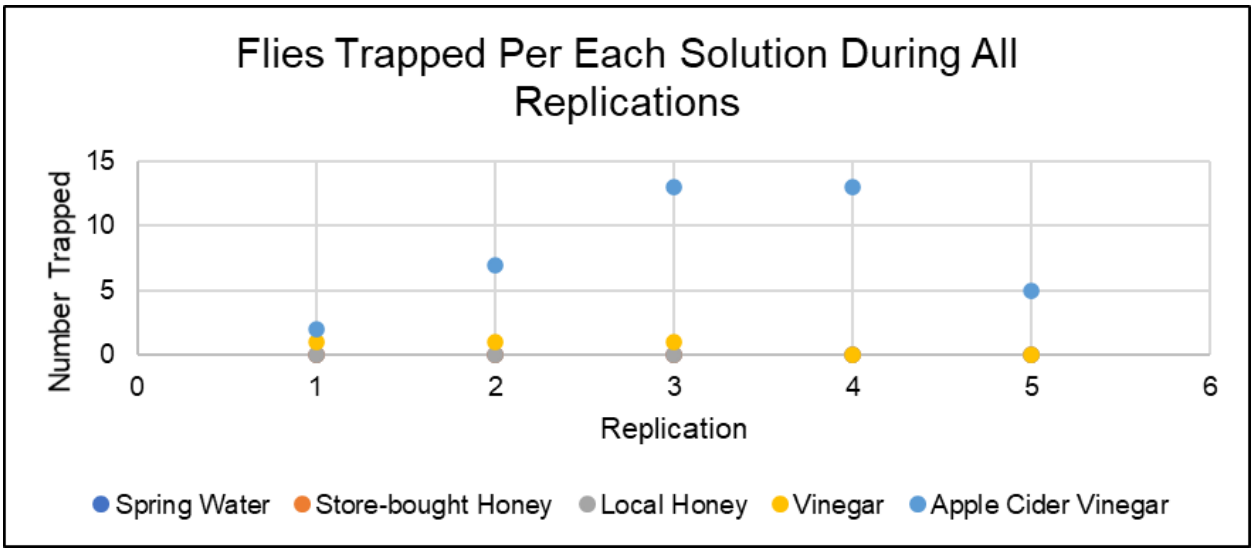

Figure 3: Graphical representation of experimental data from each replication.

The mean number of flies trapped by regular vinegar was 0.6, and 8 for apple cider vinegar. This data is shown in Figure 4.

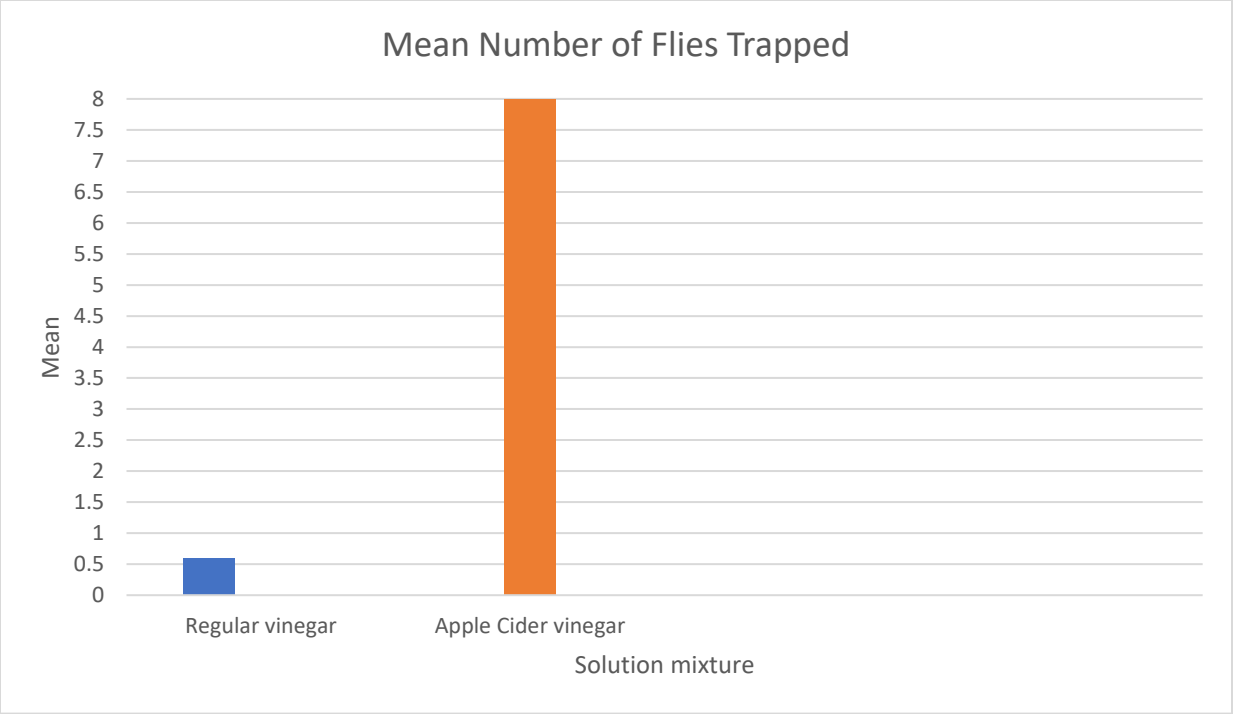

Figure 4: Mean Number of Flies Trapped.

There were unknown species of bees trapped in both traps containing honey solutions. The bees were not counted or further identified to specific species, as this data would be irrelevant to the experiment.

Discussion

Of the total of 40 flies trapped during each of the five replications in this experiment, overall, the flies were most attracted to traps with solutions containing a type of vinegar. Solutions containing honey did not show any attraction to the flies. Of those trapped in a vinegar solution, the majority were trapped in apple cider vinegar. This indicates a probable reason *Drosophila suzukii* are sometimes called vinegar flies. *Drosophila suzukii* are oriented to the odor of the solutions inside the trap (Landolt et al. 2011). Because flies were trapped in those containing vinegar and none were trapped in solutions containing honey, this indicates that *Drosophila suzukii* are attracted to acidic solutions such as various forms of vinegar. Further, *Drosophila suzukii* are attracted to apple cider vinegar (Steck et al. 2009; Beers et al. 2010). This was evident in the experiment. Previously conducted experiments demonstrated that *Drosophila suzukii* are attracted to acetic acid, but not ethanol. However, *Drosophila suzukii* were attracted to a combination of acetic acid and ethanol, and their attraction to this combination was greater than their responses to either solution alone. (Landolt et al. 2011). This information supports the observation of the flies in this experiment being more attracted to apple cider vinegar than regular vinegar and forms of honey. This leads into the possible investigation of other solutions of acidic combinations and their attractiveness towards *Drosophila suzukii*, which can lead to more effective trap and bait solutions.

While the findings were useful in determining an effective trap solution for *Drosophila suzukii*, the data does not

demonstrate whether the trap design consisting of a red, plastic cup had any role in the effectiveness of attracting and trapping vinegar flies. This is because only a single trap design and color was tested, and trap design and color were not the focus of the experiment. The color and color pattern of the trap influenced the attraction of *Drosophila suzukii* flies (Malmon et al. 2008). Furthermore, the most attractive colors to *Drosophila suzukii* are red, black, and burgundy (Basoalto et al. 2013). Testing the attractiveness of both color and odor of trap solutions may yield a more effective overall trap. The goal of this experiment was to test the effectiveness of vinegar fly traps containing vinegar solutions versus honey solutions. Of the tested honey-based and vinegar-based solutions, this experiment was a success in determining apple cider vinegar is effective at trapping *Drosophila suzukii*.

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