Can we mass-trap SWD (spotted wing drosophila)?

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Based on reports from Japan in the 1930s, economic control of *Drosophila suzukii*, or spotted wing drosophila (SWD) populations in sweet cherries was achieved by using narrow necked bottle traps baited with diluted molasses, grape wine, and rice vinegar; a region using this procedure did not have economic losses in cherries, whereas other producing regions continued to sustain losses from SWD (Kanzawa 1939). SWD appear to resume activity just as cherries are ripening; since seasonal populations are at their lowest level then, mass trapping may be easiest to achieve in this crop. Researchers in Japan, China, Europe, and the United States are intrigued by the potential for highly attractive traps to be used for direct reductions of spotted wing drosophila populations in other susceptible crops (Wu et al. 2007; Simoni et al. 2013). I will explore some aspects of mass trapping dynamics, and describe limitations that will require that mass trapping be used in conjunction with insecticide sprays to manage this pest on some crops.

Mass trapping is a method that removes insects by physically capturing them. Our ability to make use of mass trapping for managing pest populations depends on the following variables: effectiveness of chemical and visual attractants for bringing the target insect to the trap, the efficiency of the trap for capturing the insect, the number of traps placed per unit area, the population density of the insect, and our economic threshold. Some guesswork is needed to estimate the distance SWD are attracted to our best traps, but based upon my field trapping experience, this distance is approximately 10 m, and most responses are probably closer than that. If we were to place traps 10 m apart, this translates to 40 traps per acre (100 traps per hectare). This number would be modified as various factors warrant. We could decrease the trap density if (1) the chemical and visual attractants draw flies to the trap from greater distances, (2) the efficiency of capturing the flies per trap visit is increased, (3) fly mobility (diffusivity) increases, (4) the population density is lower, or (5) the economic threshold (tolerance for damage) is increased.

Insect response to odor attractants can vary dramatically. Male moths respond following detection of a few molecules of sex attractant pheromone, whereupon they travel upwind by an optomotor anemotaxis mechanism to locate a mate. The male moths can travel considerable distances (on the order of a kilometer) to reach a female. Contrast moth pheromonal response to SWD response to food-associated attractants: flies respond to what is probably an evolutionarily conserved blend of volatile chemicals closely associated with yeasts growing on spoiling fruits (Stökl et al. 2010, Landolt et al. 2012). The irony is that SWD are most competitive when they can colonize fruit before they rot, but they still respond to yeast-associated cues to find susceptible sound fruit. Because these chemicals are present as a complex blend, and presentation of any of these odor components at high concentrations may become deterrent to the flies, there may be practical limits for the distance from which we can expect to both elicit upwind flight to a trap, and landing on that trap.

Odor attractants are only part of making an effective trap. With diurnal insects visual cues usually interact with chemical attractants to guide orientation to potential hosts. My results are consistent with Basoalto, et al. (2013) regarding optimal color, pattern, and shape effects on SWD response to traps. Red traps catch slightly more flies than yellow traps, and a stripe pattern is significantly better than a plain trap or one with a black checkerboard pattern. Unfortunately, visual cues do not look as though they can be used to provide supernormal stimuli. Realistic small model fruit traps (red spheres) were preferred over medium and large sphere traps in a linear manner (3, 6, and 9 inch [7.6, 15.2, and 22.8 cm] diameter, respectively) by *Zaprionus indianus*, which may be a general trend for drosophilids.

How well do our traps work? One measure is competitiveness of our traps when they are placed among highly competitive fruits. If the traps catch large numbers of flies, it indicates that there is the possibility that mass trapping could work, if sufficient numbers of traps are placed in the crop. In 2013, we observed excellent ability of our traps to capture flies when surrounded with ripe blueberries, raspberries, and tree fruits (apples and pears). Our best trap is a 16 fl. oz. (470 ml) red cup with a tightly fitting lid, a single stripe of black electrical tape approximately one inch (2.5 cm) from the top rim, punctured with 40 one-eighth inch (3.2 mm) holes and placed in the fruit crop with a wire hanger. The attractant bait consists of 50 – 75 ml per trap of the following recipe: water (12 fl. oz. [350 ml]), whole wheat (1 cup [240 ml]), apple cider vinegar (1 Tbsp [15 ml]), active dry yeast (1 Tbsp) and a few drops of organosilicone surfactant.

Unfortunately, catching many flies doesn't necessarily translate into significant reductions in the fly population or protection of fruit. High trap catches certainly signify that there is a large population that threatens the crop. The conundrum is, to know whether we may be protecting fruit requires that we have some measure of the population of flies <u>not</u> being captured in traps, because these flies continue to jeopardize the fruit. This may be difficult to estimate with a highly mobile pest, unless conducted in a cage study with known numbers of flies, or with an independent sampling procedure (such as vacuum sampling). To get an idea of how many flies are attracted to the trap, versus the number that are actually captured and drown in the bait, I hung pairs of cup traps directly over 5 gallon [20 liter] buckets. For only one trap in the pair, I sprayed the exterior of the trap with an insecticide combination (bendiocarb plus bifenthrin) likely to cause nearly immediate knock-down and mortality of visiting insects. From this preliminary test, only about one-fifth of the SWD were captured by drowning in the bait when compared with the number recovered from the buckets. This is a sobering value, because it implies, via binomial modeling (Fig. 1), that about 14 visits of flies to traps would be required before we would see a 95% reduction in the fly population in the field. If flies have an opportunity to mate and lay eggs between visits to traps, then protection of fruit through mass trapping is unlikely. What may we do to improve upon this situation? One approach would be to improve trap design to increase the likelihood of capturing flies when they visit traps. Gated entry could improve retention of flies, but would considerably complicate manufacture of the traps (Birmingham et al. 2011). Another option is to expand the concept of the "trap" to include the surrounding vegetation and the outer surface of the trap itself. Rather than trying to achieve a 5-fold improvement in retention of flies in the trap, if we can guarantee that flies will succumb once they contact the trap or nearby surrounding vegetation, we will have achieved the same goal in reducing the fly population. Although the experimental insecticide combination I used would be illegal for application in a fruit field, there are a great number of insecticides that could be suitable for application to the surface of traps. Rapid fly response to the insecticide would be acceptable, rather than the immediate knock needed for my experiment. A broad choice of insecticides can be considered, because the limited quantity of insecticide applied to traps could make even expensive active ingredients economically practical. Furthermore, limiting insecticide application to the trap will limit the environmental impact of their use to a great degree, which could improve the odds of U.S. EPA registration and eliminate concerns of MRLs for trade of fruit to other countries.

If we change our perspective 180 degrees, it is clear that mass trapping complements conventional insecticide spray programs for managing SWD. Traps provide a convenient way to measure insecticide program performance. Furthermore, trapping survivors of insecticide treatment should also impact the evolution of insecticide resistance. By incorporating effective insecticides to the outside of attractant traps, we simultaneously can (1) improve upon performance of mass trapping, (2) broaden the range of insecticides that are practical to use for managing SWD, and (3) reduce the selection for insecticide resistance development.

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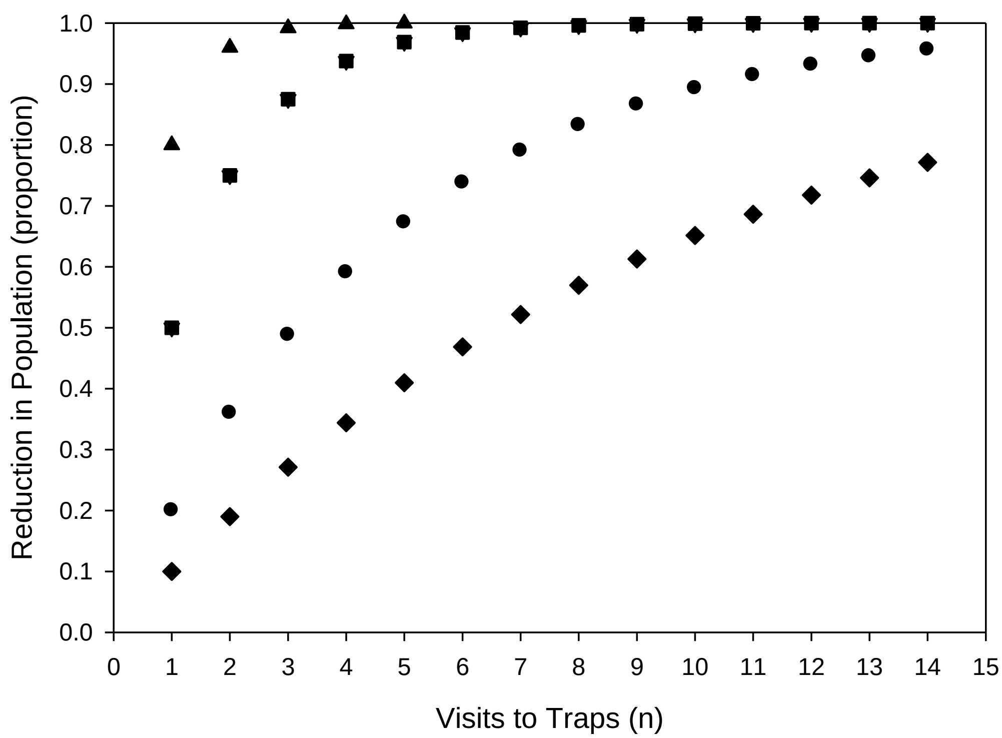

Fig. 1. Binomial model for reductions in a pest population based upon the probability of capture per visit, related to the numbers of visits to traps. Efficient reduction in pest populations requires a high probability of capture. Preliminary field tests suggest that our best capture efficiency is approximately 1 in 5 visits (p = 0.2). Values for the proportion captured per visit displayed above are: diamond, 0.1; circle, 0.2; square, 0.5; triangle, 0.8.