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Francis A. Drummond
University of Maine, fdrummond@maine.edu

Judith A. Collins
University of Maine, Collinsj@maine.edu

Gabriel Al-Najjar
University of Maine, gabealnajjar89@gmail.com

Jade Christensen
University of Maine

Itty-bitty traps for monitoring spotted wing Drosophila (*Drosophila suzukii* Matsumura), does size matter?

Francis A. Drummond[1,2], Judith A. Collins[1*,] Gabriel Al-Najjar[1,3], and Jade Christensen[4]

[1] *School of Biology and Ecology, University of Maine, 5722 Deering, Orono, ME 04469*
[2] *Cooperative Extension, University of Maine, 5722 Deering, Orono, ME 04469*
[3] *Present address: 3105 Northbrook Rd., Baltimore, MD 21208*
[4] *Department of Wildlife Ecology, University of Maine, Nutting Hall, Orono, ME 04469*

Abstract

The objective of this study was to determine an optimal trap design and bait for spotted wing drosophila, *Drosophila suzukii* (Matsumura), in the wild blueberry agro-ecosystem. Two preliminary experiments were conducted in 2013 and 2014 to address this objective. In 2018, an experiment was conducted to evaluate the effect of the physical trap size, as perceived by the spotted wing drosophila, on trap capture efficacy. We found that the red Solo® cup trap was an optimal trap for monitoring spotted wing drosophila in wild blueberry and that inserting a yellow sticky card inside the trap or painting a black contrast ring around the top entrance holes resulted in no benefit. We also found in early experiments that the live yeast bait with sugar syrup either alone or with apple cider vinegar was a superior bait. Trap size affected trap capture abundance; when considering catches based on adjustments for bait volume or two-dimensional trap area, the small trap size was more efficient than the standard.

Index Words: *Drosophila suzukii*, wild blueberry, trap design and bait, trap size

Introduction

The spotted wing drosophila (SWD), *Drosophila suzukii* (Matsumura), is a serious insect pest of soft fruits and tree fruits in its introduced range (Lee et al. 2011). It was first introduced into the continental United States in 2009 and rapidly spread east within a few years (Hauser 2011). It was first detected in Maine in November 2011 (Drummond et al. 2018). The basis of integrated pest management is knowledge of pest density in relation to risk of crop loss (Pedigo et al. 1986). Trapping became the method employed for this insect pest as a means of estimating relative density. Any effective IPM program relies heavily on effective monitoring and early detection of the target pest. Many trapping studies have been conducted in an array of geographic regions and crops (Lee et al. 2011, Bellamy et al. 2013, Lee et al. 2015, Poyet et al. 2015, Klick et al. 2016, Ballman and Drummond 2017). Our research efforts focus on monitoring SWD in wild blueberry, a native crop that is commercially produced in Maine and the Canadian Maritime provinces.

Wild blueberries are comprised of several species and hybrids of native *Vaccinium* taxa (Jones et al. 2014). The most abundant wild blueberry species in Maine is *Vaccinium angustifolium* Aiton, the sweet low (wild) blueberry (Bell et al. 2009, Jones et al. 2014). Maine currently produces 10 percent of all blueberries (consisting of highbush, rabbiteye, and wild) in North America (NASS 2016). Wild blueberry production generated $250 million of farm gate revenue between 2007 and 2012 and are grown on 45,200 acres (18,291 ha) in Maine (NASS 2016). These fields have been developed from native plants that occur naturally in the forest understory (Jones et al. 2014). Most wild blueberry fields are pruned to the ground every other year either by flail mowing or burning. In the growing season immediately following the pruning (vegetative/prune year), vegetative and formative growth takes place. In May of the following year, (fruiting/crop year) the flower buds open and bloom (Yarborough 2015). Fruit, the stage susceptible to SWD, begins to ripen in late June and early July.

Our study was conducted in 2013, 2014, and 2018. The initial objective, addressed in two preliminary experiments, was to determine an optimal trap design and bait for monitoring SWD in the wild blueberry agro-ecosystem. The main experiment in this paper was conducted in 2018, to evaluate the effect of the physical trap size on efficacy of traps for monitoring SWD.

Material and Methods

Preliminary Experiments – trap type and bait. We conducted two preliminary studies over two years in order to determine the optimal trap and bait for monitoring SWD in Maine wild blueberry. In 2012, three baits were evaluated using Solo® (Dart Container Corp., Mason, MI) 473.2 ml red polystyrene cup traps with clear lids. In 2013, three baits were evaluated in two types of Solo® 473.2 ml red polystyrene cup traps, one with clear lids and one with black stripes painted around the top circumference of the cup trap.

In 2012, traps were constructed from 473.2 ml red Solo® polystyrene cups with clear lids. Seven to ten, 6.4 mm diameter holes were punched near the top of each cup, evenly spaced around the rim. A yellow sticky card (2.54 x 2.54 cm) was hung inside each trap. Two trials were completed to determine the effectiveness of three baits in attracting SWD. The baits are described in Table 1. For each trial, four traps per treatment were hung approximately 1.2 m high and 9.1 m apart along the edge of a wild blueberry field in Jonesboro, ME. Traps were deployed in four statistical blocks for one week (Trial #1 - 15-22 August, Trial #2 - 11-17 September). All traps were collected at the end of each trial and were examined in the laboratory under magnification to determine the number of male and female SWD on the yellow sticky card and in the bait solution. Negative binomial regression (RCB) was used to compare the number of SWD captured in traps with different baits. Student's t all pairwise comparisons were used with least square means to determine bait treatment differences (JMP 2015).

Table 1. Composition of bait solutions for the 2012, 2013, 2018 SWD trap and bait trials.

Preliminary Experiments – trap type and bait

2012

1. Live yeast (14.8 g) + sugar (59.1 g) + 354.9 ml water; makes enough for 4 traps
2. Apple cider vinegar (commercially available, 88.7 ml per trap)
3. Cowles SWD bait – 57% white grape juice from concentrate, 37% apple cider vinegar, 6% 95% ethyl alcohol

2013

1. Live yeast (16 g) + sugar (59.1 g + wheat flour (59.1 g) + 354.9 ml water
2. Apple cider vinegar (90% apple cider vinegar and 10% ethanol, 88.7 ml per trap) alone or in combination with Live yeast bait
3. Water

Trap Size Experiment

2018

1. Live yeast (14.8 g) + sugar (59.1 g + 354.9 ml water; makes enough for 4 traps

In 2013, a second trapping study was conducted at the University of Maine Blueberry Hill Farm in Jonesboro, ME. Traps consisted of red Solo® 473.2 ml polystyrene cups with opaque lids. There were three trials with 12 traps per trial; each trap had 6.4 mm diameter holes punched down three equally spaced lines to within 5 cm from the bottom of the cup. Half of the traps had a black ring painted around the rim; baits used were either water or an apple cider vinegar/ethanol solution, alone or in combination with a yeast solution to produce three different treatments with four traps per treatment (Table 1). For each treatment, one black painted and one unpainted red cup trap was set with a yellow sticky card hung from inside of the lid. Traps were filled with 88.7 ml of the bait mixtures.

Beginning on 16 August, traps were baited and hung from a fence (approximately 1.2 m above ground) along the edge of a pruned-year wild blueberry field. Traps were placed in order of bait contents (i.e., all cups with water, all cups with vinegar solution only, and all cups containing vinegar solution with yeast mixture). Individual cups were spaced out approximately 9.1 m apart along the fence. SWD were collected from cups at four to ten day intervals for the five week experiment (16 August – 21 September). Fresh baits were re-applied before resetting the cups on the fence in their original positions after each collection of flies. In the laboratory all non-spotted wing arthropods were discarded and the number of SWD male and female flies were counted and recorded. Negative binomial regression (with block as a non-replicated stratum) was used to determine whether trap type or bait affected male, female, or total (male + female) fly captures. These models were assessed with the total cumulative fly captures over the duration of the experiment. Student's t all-pairwise comparisons were used with least square means to determine bait treatment differences (JMP 2015).

Trap size Experiment. In 2018 two different size red Solo® cups (29.6 ml and 473.2 ml) were compared for trap efficacy using the same bait (sugar-yeast fermentation syrup). Standard and miniature traps were constructed from red Solo®, 88.7 ml and 473.2 ml polystyrene cups with light-blocking lids constructed from a piece of red foam hot glued to the lids. Seven to ten, (standard) or four (miniature), 6.4 mm diameter holes were punched on the side of each cup near the top, evenly spaced around the rim. Bait for both trap sizes was the live yeast bait described in Table 1. All traps were hung 0.4 – 0.7 m above the top of the canopy using 0.9 m metal plant stands. Miniature traps were attached to the stands with rubber bands (Fig. 1) and standard traps were placed into the stand holder. There were four replications of each trap type set in pairs (statistical bocks) along the perimeter of a fruit-bearing wild blueberry field at the University of Maine Blueberry Hill Farm in Jonesboro, ME, which previous monitoring had shown to be infested with spotted wing drosophila. Throughout the study, on each sample date, traps set the previous week were filled with fresh bait and flies were collected and returned to the laboratory for identification of male and female spotted wing drosophila. Traps were initially deployed on 8 August 2018 and checked weekly for three weeks.

Multiple analyses of variance (MANOVA, RCB) was used to compare male, female, and total (male + female) abundance of adults captured in each trap over the three dates. Two additional sets of models were run with adjusted trap captures. The two adjustments were used to account for the difference in trap size as potentially perceived by searching flies. The first was based on the visible two-dimensional area of the trap types (120.9 vs. 22.6 cm^2). The second was based on the difference in the amount of yeast/sugar bait in each trap type (29.6 ml in each miniature trap compared with 88.7 ml in each standard trap). The adjustment was made by multiplying the trap captures in each miniature trap by 120.9 cm^2 / 22.6 cm^2 = 5.35 and 88.7 ml / 29.6 ml = 3.0, for size and bait adjustments, respectively.

Figure 1. Miniature and standard size Solo® red cup traps, 2018.

Results

Preliminary Experiments – trap type and bait. In 2012, there was a significant difference in fly captures due to bait type. This was the case for males ($X^2_{(2)}$ = 29.589, $P < 0.0001$), females ($X^2_{(2)}$ = 58.706, $P < 0.0001$), and total flies ($X^2_{(2)}$ = 38.940, $P < 0.0001$). There was no significant difference between fly captures on yellow sticky cards placed in the traps and fly captures in the liquid bait $P > 0.05$). Figure 2 shows the average trap captures for fly sex category, for each bait, as well as the multiple comparison results.

In 2013, only bait significantly determined male ($X^2_{(2)}$ = 20.161, $P < 0.0001$), female ($X^2_{(2)}$ = 18.040, $P < 0.0001$), and total fly captures ($X^2_{(2)}$ = 21.471, $P < 0.0001$). Block was also significant in all models. Trap type, presence of a sticky panel inside a trap or black stripes painted around the outside perimeter of the trap, and all interactions were not significant ($P > 0.05$). Figure 3 depicts the observed mean, standard errors, and mean comparisons for the baits across both fly sexes and total fly captures.

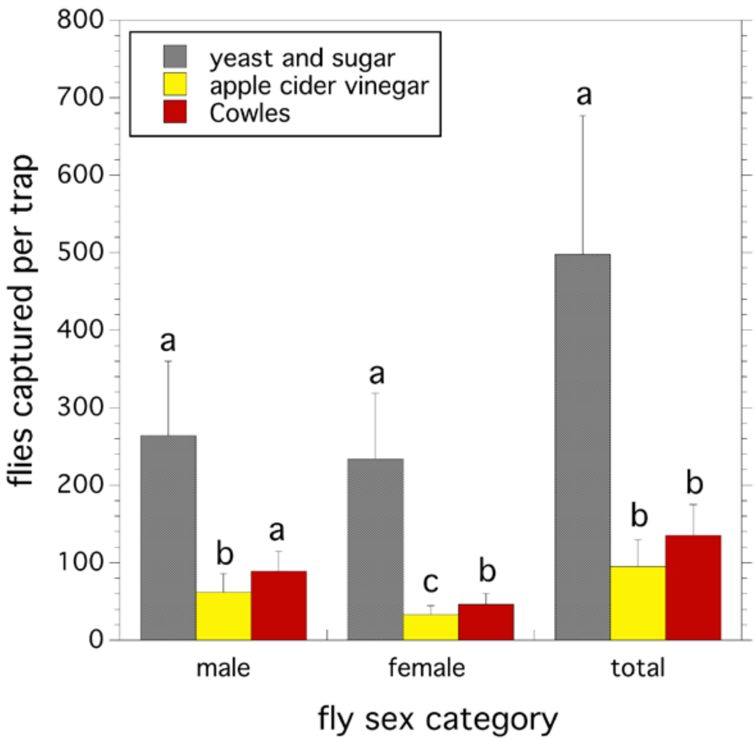

Figure 2. Average fly trap-captures for each of three baits (observed means and standard errors plotted), 2012.

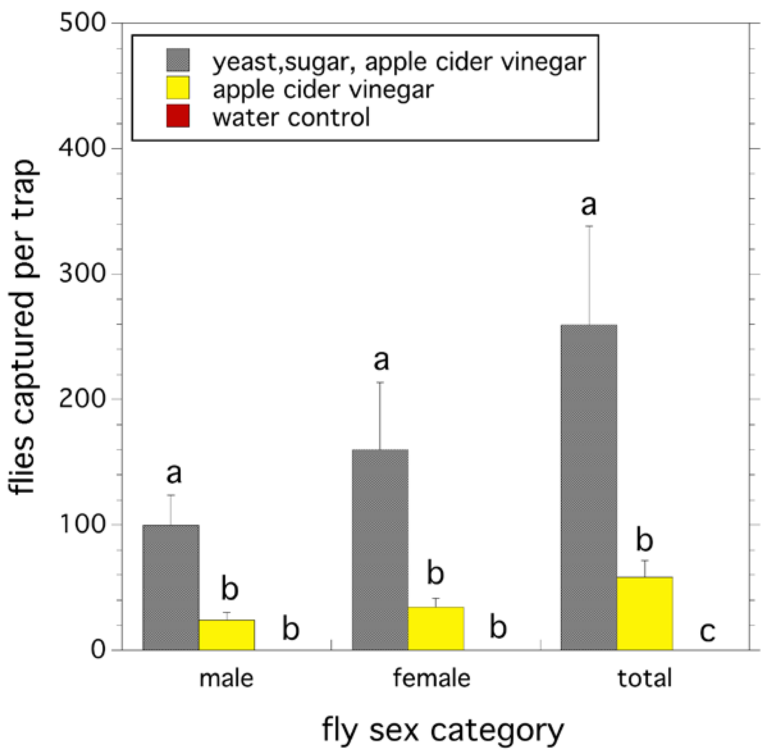

Figure 3. Average fly trap-captures for each of three baits (observed means and standard errors plotted), 2013.

Trap Size Experiment. In 2018, there was a significant difference between the two trap sizes (Fig. 4). More males ($F_{(1,2)}$ = 9.865, P = 0.047), females ($F_{(1,2)}$ = 86.572, P = 0.006), and total flies ($F_{(1,2)}$ = 85.955, P = 0.011) were captured in the standard traps compared to the miniature traps. There was no significant interaction (P > 0.05) between sample date and trap size in any of the three models. When all dates were combined, miniature traps captured 39.67% as many female SWD compared to standard traps, 42.25% as many males, and 47.74% as many total (males + females) flies.

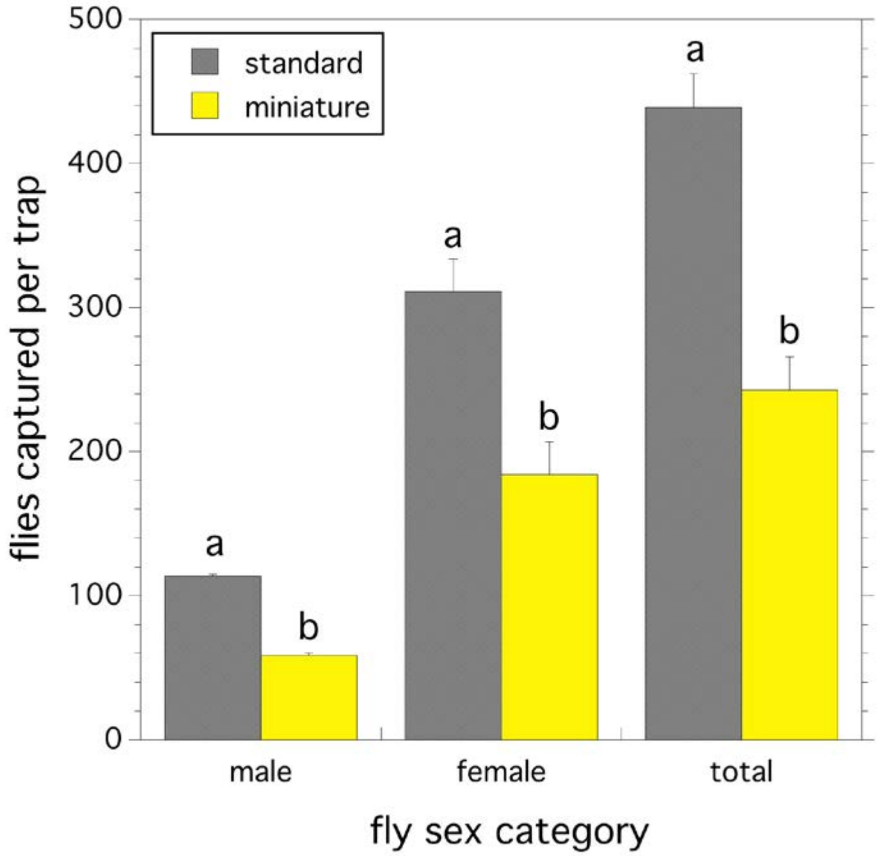

Figure 4. Average fly trap-captures for two trap sizes (observed means and standard errors plotted), 2018.

However, when total fly captures in the miniature size traps were adjusted for the amount of yeast/sugar bait in each trap type (29.6 ml vs. 88.7 ml) there was no significant difference between miniature and standard traps ($F_{(1,2)}$ = 8.611, P = 0.099), but there was a sample date by trap size interaction ($F_{(2,4)}$ = 25.315, P = 0.015, H-F epsilon adjustment) (Fig 5). The interaction suggests that there was little difference in the bait volume adjusted trap captures for the first two dates and then at the third date, bait volume adjusted miniature trap capture was much higher (173%) than the unadjusted standard trap captures of total flies. When total fly captures of miniature size traps were adjusted for differences in size, there was a significant difference in adjusted miniature trap captures compared to the standardized trap captures. The size adjusted miniature trap captures were greater than the standard trap captures ($F_{(1,2)}$ = 16.989, P = 0.028). There also was a sample date by trap size interaction ($F_{(2,4)}$ = 32.509, P = 0.003, H-F epsilon adjustment) (Fig 5). The interaction suggests that there was a significant difference in the size-adjusted trap over all three dates, but this difference was very large at the third date. On the third date, size-adjusted miniature trap capture was much higher (310%) than the unadjusted standard trap total captures.

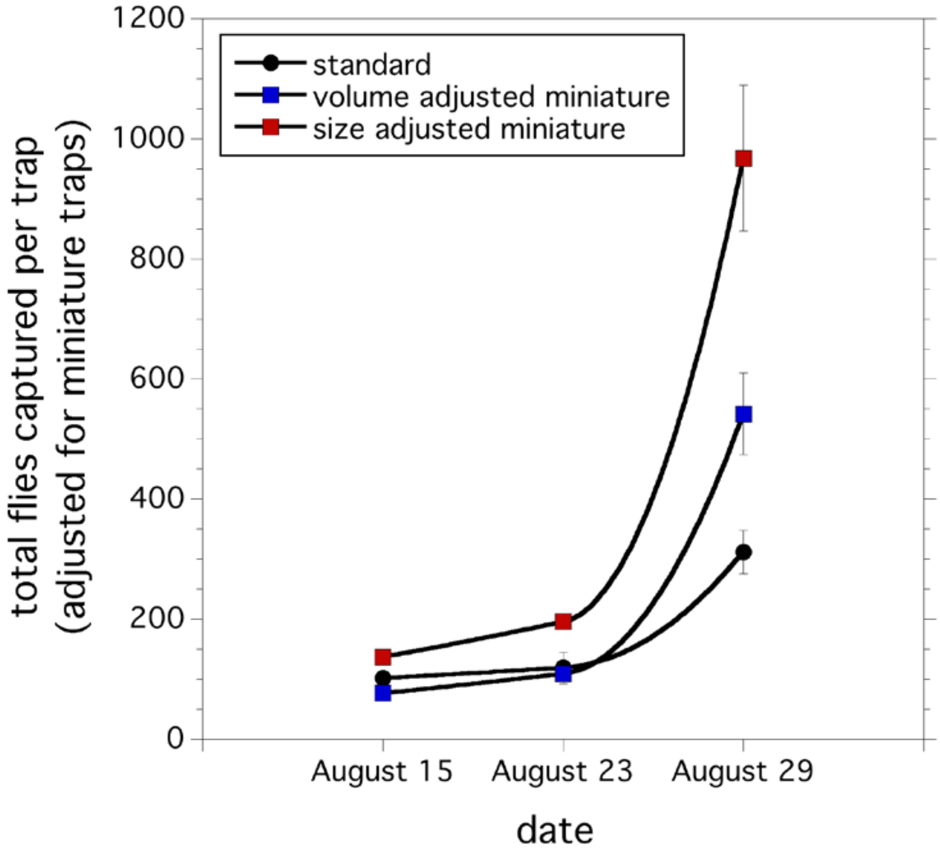

Figure 5. Mean (±SE) SWD captured in miniature (adjusted for bait volume and trap size) vs. standard cup traps over the duration of the study. Means are for total (males + females) spotted wing drosophila.

Discussion and Conclusions

In the preliminary experiments we found that the red Solo® cup trap with or without a black stripe painted around the outside cup perimeter was an optimal trap. Yellow sticky cards did not capture a different number of flies in a trap compared to the drowned flies in the liquid bait. We also found that the live yeast bait with sugar syrup either alone or with apple cider vinegar was a superior trap. This was also the case in a later multi-state study involving blueberry and cranberry cropping systems throughout the U.S. (Burrack et al. 2015). While trap size has not been investigated specifically (only when confounded with different trap types and baits), it might have important implications for IPM.

In our main trap size experiment, we found that trap size of the red Solo® cup trap does affect trap capture abundance; although, when considering a per volume bait amount or a per two-dimensional trap area, the small trap size that we compared to the standard trap size was actually more efficient. The important implications of our study suggest that when the traps are used to assess threshold levels for spotted wing drosophila, a standard trap size is important as trap size determines the abundance of flies captured. This is especially important for the Maine wild blueberry agro-ecosystem where thresholds are based upon the capture of male flies and risk of fruit infestation increases with increasing cumulative male fly capture (Drummond et al. 2018). We demonstrated that we have an optimal trapping system for the spotted wing drosophila and unless more traps and baits are developed, the red standard Solo® cup trap with a live yeast bait will provide growers with an adequate tool for assessing the risk of spotted wing drosophila.

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References

Ballman, E.S., and F.A. Drummond. 2017. Infestation of Wild Fruit by *Drosophila suzukii* Surrounding Maine Wild Blueberry Fields. J. Agric. and Urban Ent. 33(1): 61-70.

Bell, D.J., L.J. Rowland, J. Smagula, and F.A. Drummond. 2009. Recent advances in the biology and genetics of wild blueberry. Maine Agric. For. Exp. Sta., University of Maine, Orono. Tech. Bull. 36 pp.

Bellamy, D.E., M.S. Sisterson, and S.S. Walse. 2013. Quantifying host potentials: indexing postharvest fresh fruits for spotted wing drosophila, *Drosophila suzukii*. PLOS ONE 8(4): e61227. https://doi.org/10.1371/journal.pone.0061227

Burrack, H.J., M. Asplen, L. Bahder, J. Collins, F.A. Drummond, C. Gue'Dot, R. Isaacs, D. Johnson, A. Blanton, J.C. Lee, G. Loeb, C. Rodriguez-Saona, S. Van Timmeren, D. Walsh, and D.R. McPhie. 2015. Multistate comparison of attractants for monitoring *Drosophila suzukii* (Diptera: Drosophilidae) in blueberries and caneberries. Environ. Entomol. 44(3): 704–712

Drummond, F., E. Ballman, J. Collins, and D.E. Yarborough. 2018. Spotted Wing Drosophila: Pest Biology and IPM Recommendations for Wild Blueberries. Extension Fact Sheet 210 University of Maine Cooperative Extension, Orono, ME., 6 pp. https://extension.umaine.edu/blueberries/factsheets/insects/210-spotted-wing-drosophila/

Hauser, M. 2011. A historic account of the invasion of *Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae) in the continental United States, with remarks on their identification. Pest Manag. Sci. 67: 1352–1357.

Jones, M.S., H. Vanhanen, R. Peltola, and F.A. Drummond. 2014. A global review of arthropod-mediated ecosystem-services in Vaccinium berry agroecosystems. Terr. Arthro. Rev. 7: 41-78.

JMP®. 2015. Version 12. SAS Institute Inc., Cary, NC, 1989-2007.

Klick, J., W. Q. Yang, V. M. Walton, D. T. Dalton, J. R. Hagler, A. J. Dreves, J. C. Lee, and D. J. Bruck. 2016. Distribution and activity of *Drosophila suzukii* in cultivated raspberry and surrounding vegetation. J. Appl. Entomol. 140: 37–46.

Lee, J C., D.J. Bruck, H. Curry, D. Edwards, D.R. Haviland, R.A. Van Steenwyk, and B.M. Yorgey. 2011. The susceptibility of small fruits and cherries to the spotted-wing drosophila, *Drosophila suzukii*. Pest Manage. Sci. 67: 1358–1367.

Lee, J. C., A. J. Dreves, A.M. Cave, S. Kawai, R. Isaacs, J.C. Miller, S. Van Timmeren, and D.J. Bruck. 2015. Infestation of wild and ornamental noncrop fruits by *Drosophila suzukii* (Diptera: Drosophilidae). Ann. Entomol. Soc. Am. 108: 117–129.

(NASS) National Agricultural Statistics Service. 2016. New England Agricultural Statistics 2015. USDA National Agricultural Statistics Service, New England Field Office.

Pedigo, K. P., S. H. Hutchins, and L. G. Higley. 1986. Economic injury levels in theory and practice. Ann. Rev. Entomol. 31: 341-368.

Poyet, M., V. Le Roux, P. Gibert, A. Meirland, G. Prevost, P. Eslin, and O. Chabrerie. 2015. The wide potential trophic niche of the Asiatic fruit fly *Drosophila suzukii*: the key of its invasion success in temperate Europe? PLoS One. 10: 26.

Yarborough, D. E. 2015. Wild blueberry culture in Maine. Extension Fact Sheet No. 220, University of Maine Cooperative Extension, Orono, ME. https://extension.umaine.edu/blueberries/factsheets/production/wild-blueberry-culture-in-maine/ Last accessed 12 September, 2018.