Emerging Pests, Lower Mainland Horticulture 2018-2023: Winter and Spring Surveillance for Spotted Wing Drosophila (SWD) BC Berry Crops – Progress Report

Final report to:
BC Ministry of Agriculture, Food, and Fisheries

Prepared by:
Allyson Mittelstaedt, E.S. Cropconsult Ltd.

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Executive Summary

Trapping was conducted for spotted wing drosophila (SWD), a major pest of small fruit crops throughout the Fraser Valley and the rest of British Columbia (BC). Four SWD traps baited with an apple cider vinegar bait with added antifreeze solution were placed in hedgerows around each of four blueberry fields, three raspberry fields and one strawberry field (total of 32 traps) in the Fraser Valley, BC. Traps were checked bi-weekly from January 6 to March 31, 2021 and weekly from March 31 to May 28, 2021. Hourly temperatures were recorded by a temperature logger placed in each hedgerow. Two lab studies for SWD reported different lethal temperatures: -1.6°C which was lethal for 75% of female SWD (Kimura 2004) and -10.2°C which was the $LT_{80\text{-}1h}$ for winter morph SWD from a more recent study (Toxopeus *et al.* 2016). The first collection showed high SWD numbers at a couple of trapping sites, but after an extended period of cold weather below lethal temperatures, the trap catches greatly decreased. SWD continued to be caught throughout the trapping period and showed an increase in late March. Based on the Kimura (2004) study, lethal temperatures for the majority of SWD were reached at all trapping sites; the longest period was reached at the Abbotsford 1, Langley 3, and Langley 4 locations, with over 90 hours below -1.6°C. No trapping sites had temperatures recorded below -10.2°C this winter. When Abbotsford Airport temperatures were entered into the SWD degree day model, egg laying by overwintering females was predicted to begin on June 2, which was 19 days later than in 2020. The predicted date for subsequent life stages continued to be later than those of 2020 until the peak of the first emerging adults in early July (OSU Online Phenology and Degree Day Models). The milder winter temperatures after the cold spell in mid February and the continued presence of SWD in most hedgerow traps in spring suggested that there would be high SWD pest pressure for the spring of the 2021 growing season.

Introduction

Spotted wing drosophila (SWD), *Drosophila suzukii,* continues to be one of the most serious pest issues for the blueberry and raspberry industries in British Columbia (BC), as well as for other small soft fruits such as strawberries, cherries, and grapes. Hedgerow trapping in the Fraser Valley for this pest during winter and spring has been conducted since 2011.

Winter, spring and summer SWD trapping combined with winter and spring temperature tracking are valuable activities to help predict SWD levels in berry crops, and to apply this information to improve management practices. The lethal effect of cold has been demonstrated in lab-based studies; Kimura (2004) found that 75% of female SWD were killed by 24-hour exposure to -1.6°C. Another similar study performed more recently showed that at low temperatures of 0°C, -2.5°C, and -5°C the survival rate greatly decreased over time, with less than 20% survival after 12 hours at -2.5°C (Enriquez and Colinet 2017). Multiple studies done on the cold tolerance of SWD since Kimura's work have shown that there are two morphotypes of SWD that have different tolerances to cold temperatures. The winter morph traits occurred when reared from larval stage to adulthood in cooler temperatures (10-15^{o}C) (Toxopeus *et al.* 2016; Stockton *et al.* 2018). In these studies, both morphs were used in testing of cold tolerance. For the summer morphs, the temperature at which 80% of the test population was killed by an hour of exposure ($LT_{80\text{-}1h}$) was -7.5°C, whereas this was -10.2°C for the winter morphs (Toxopeus *et al.* 2016). Stockton *et al.* (2018) found that survival of both summer and winter morph SWD was high at temperatures above -5°C, but decreased for both (albeit slightly for winter morphs) when exposed for 72 hours to below -5°C. At 72 hours of -7.5°C, there was only about a 50% survival rate of winter morph; no summer morphs survived 24 hours at -7.5°C (Stockton *et al.* 2018).

Most studies to determine the cold hardiness of SWD were conducted in a lab setting, whereas in a study done by Jakobs *et al.* (2015), a portion of the study was done with SWD exposed to winter temperatures outdoors in Ontario, Canada. It was found that SWD adults could survive colder temperatures by sheltering in areas that provide some protection from cold exposure, such as under snow or by heated buildings (Jakobs *et al*. 2015). The number of female SWD that survive the winter affects the SWD pressure in the spring of the following growing season. For our study, 10 out of the past 11 winters saw Abbotsford Airport temperatures (Environment Canada) meet the lethal temperature criteria for SWD, and it was observed that colder winters resulted in lower SWD trap catches in the spring (Mittelstaedt 2020).

In the Fraser Valley, SWD adults may seek refuge in coniferous tree canopies, compost piles, leaf litter or tree bark crevices, but sustained temperatures below 0°C will likely be lethal to overwintering adults. In the hedgerow trapping conducted in the winter of 2016-2017, after a maximum of 69 hours below the lethal temperature -1.6°C and lowest minimum of -14.4°C at one site throughout the winter period, SWD numbers were very low throughout the spring and summer (Mittelstaedt and Scholefield 2017).

The objectives of the winter surveillance trapping for SWD in 2021 were to:

1. Develop better forecasting tools for SWD in British Columbia by possibly using degree day modeling or other predictive methods. The information collected will be shared with the berry industry growers via regular newsletters and berry events throughout the year, and especially in the spring and early summer.
2. Set and maintain SWD traps, and record SWD trap catches in hedgerows from January 6 until May 28, 2021.

Materials and Methods

Trapping

Contech fruit fly traps (Contech, product # 300000719) were baited and placed in hedgerows adjacent to four mature blueberry fields, three mature raspberry fields and one strawberry field in the Fraser Valley. At each site, four SWD traps were placed 20 m apart along a hedgerow adjacent to the berry field (Fig. 1a&b). Sites were in Delta, Surrey, Langley, and Abbotsford (Table 1), and traps were placed on January 6, 2021. Traps were attached to branches or wooden stakes using twist ties and hung approximately 1.5 m from the ground. Traps were baited with approximately 40 ml of apple cider vinegar, with an addition of approximately 10 ml of antifreeze during the winter months to prevent freezing. The bait and catch solutions were collected and replaced at two-week intervals until March 31, 2021, and then at weekly intervals until May 28, 2021 when they were removed. The trapping sites were reduced to six total (four blueberry and two raspberry) when weekly trapping commenced, due to funding restraints. Target flies caught in the traps were sorted and counted by sex, and a subset of flies from each trapping site were stored in ethanol and sent to Tracy Hueppelsheuser at the BC Ministry of Agriculture, Food, and Fisheries (BCMAFF) for confirmation of identification.

Temperature tracking

For the duration of the trapping period, hourly temperature data were recorded with temperature loggers (HOBO Pro v2 model #U23-00x) that were hung next to the first trap at each trapping site (Fig. 1b). Historical temperature data were accessed from the Environment Canada website to compare daily maximum and minimum temperatures at the Abbotsford Airport over the past 11 winters.

a.

b.

Figure 1a&b. Winter and spring hedgerow SWD trapping set up with Contech trap (a) and HOBO Pro v2 temperature logger (b).

Table 1. Trapping site locations and hedgerow characteristics for winter hedgerow spotted wing drosophila trapping between January 6 and May 28, 2021.

Location	Crop type	Hedgerow type	Hedgerow vegetation	Notes
Delta	Blueberry	Dense natural forest, mixed deciduous and coniferous trees	Holly, blackberry, salmonberry, elderberry, salal, birch trees	Trapping since 2018/19
Surrey	Blueberry	Blackberry and tall grasses	Blackberry, tall grasses	Trapping since 2018/19
Langley 1	Raspberry	Dense natural forest, mixed deciduous and coniferous trees	Salmonberry, blackberry, apple, hazelnut, maple, nettle	Trapping since 2011/12
Langley 2	Raspberry	Natural forest, mainly coniferous trees	Hemlock, blackberry, pine	Trapping since 2018/19
Langley 3	Blueberry	Dense natural forest, mixed deciduous and coniferous trees	Blackberry, birch trees, nettle	Trapping since 2018/19
Langley 4	Blueberry	Natural forest, mainly deciduous trees	Blackberry, maple, pieris	Trapping since 2018/19
Abbotsford 1	Raspberry	Natural forest, mainly deciduous trees	Weigela, blackberry, pieris, snowberry, deadly nightshade	Trapping since 2013/14
Abbotsford 2	Raspberry	Blackberries, mixed deciduous and coniferous trees	Blackberry, cedar	First year of trapping

Degree-day modeling

The Oregon State University spotted wing drosophila degree-day model was accessed to assess the predicted dates of key life cycle events, based on Abbotsford Airport temperatures (OSU Online Phenology and Degree Day Models). This degree-day model is single sine with a lower temperature threshold of 50°F and an upper threshold of 88°F.

Results and Discussion

Trapping

Very high numbers of spotted wing drosophila (SWD) were caught in most traps the first trapping collection in mid-January, with the highest numbers caught at the Abbotsford 2 (1284 SWD), Langley 1 (758 SWD) and Delta (429 SWD) sites (Fig. 2; Table A1). The Abbotsford 2 location was a new trapping site this year so has no previous year's data to compare to, however the Delta and Langley 1 trapping locations have consistently had trap catches that have been the highest compared to other locations in the past few years of study (Mittelstaedt 2020). This trend continues in this year with the first two periods of data (Fig. 2). The numbers greatly decreased at all locations in the second week of trapping with a total of 204 SWD (Abbotsford 2) and below, and to remain below 100 SWD for the remainder of the biweekly trapping period (Fig. 2).

Traps were removed from the Abbotsford 1 and Langley 1 trapping sites at the end of March, due to funding restraints. At this point, all other trapping sites switched to weekly collections. Trap counts were the highest in the first week of April in the Delta and Langley 4 sites, however by mid April, they were the highest in the Abbotsford 2 site (Fig. 3; Table A1). A decrease was observed at most locations in the last week of April as well as in during the third week of May. The Delta and Abbotsford 2 sites continued to have the highest number of SWD caught for the majority of the weekly trapping period (Fig. 3). The Surrey location had the lowest trap counts for the entire trapping period from January to late May (Figs. 2, 3).

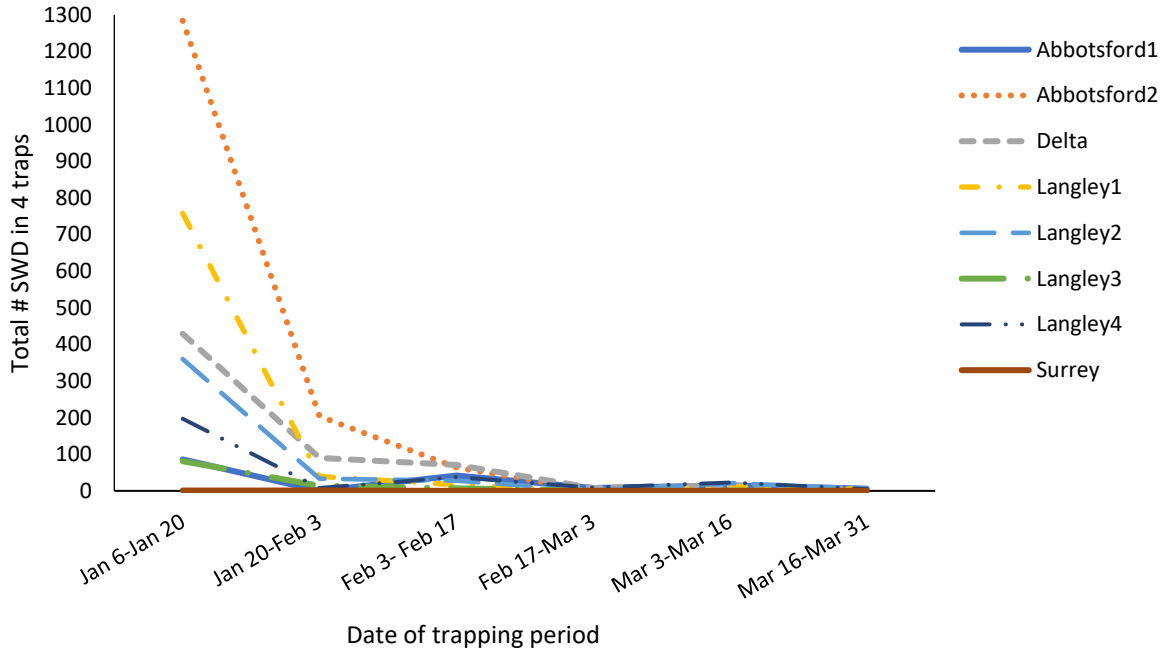

Figure 2. The total number of SWD caught in four traps placed in hedgerows at eight trapping sites across the Fraser Valley and collected at bi-weekly periods from January 6 to March 31, 2021.

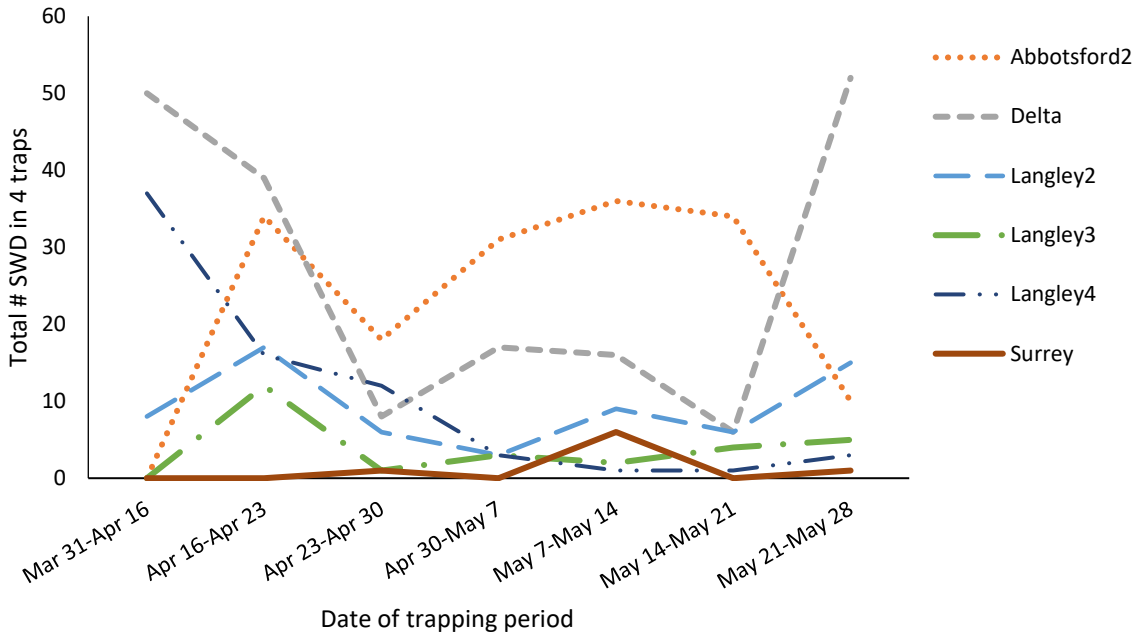

Figure 3. The total number of SWD caught in four traps placed in hedgerows at six trapping sites across the Fraser Valley and collected weekly from March 31 to May 28, 2021.

Temperature tracking

The past few years of this study have shown that the most extreme extended period of time with lethal temperatures has been in mid-February (Mittelstaedt 2020). Data collected from eight temperature loggers placed in January 2021 showed an initial drop in temperatures in late January to below -7°C, and another again in mid-February to around -9°C (Fig. 4). This corresponds with the initial drop in SWD trap numbers during the second trapping collection in late January (Fig. 2). Temperatures were not recorded below -10°C for the entire trapping period this year (Fig. 4). As the SWD counts did not reach the high numbers that were first seen in early January after both instances of longer periods of minimum temperatures below 0°C, the data indicate that this was enough time at below lethal temperatures to knock back a high proportion of active SWD until mid-April, when food was just becoming more readily available and temperatures began to increase once again (Figs. 2-4).

Antifreeze was added to the apple cider vinegar to prevent freezing, but even with this addition, some traps were found to be frozen during the cold periods. When the traps are frozen, they are not able to effectively capture SWD, so this could have impacted the efficacy of the traps.

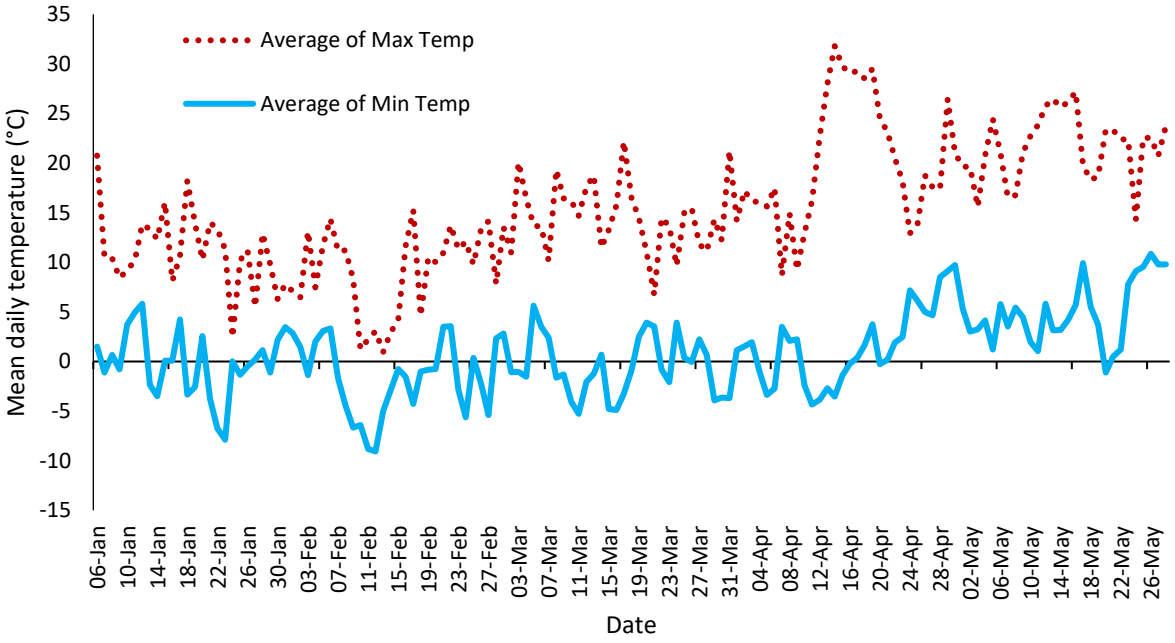

Figure 4. Mean maximum and minimum daily temperatures from eight temperature loggers placed in hedgerows at the Delta, Surrey, Langley, and Abbotsford sites from January 6 to March 31, 2021 and six loggers from March 31 to May 28, 2021.

The temperature loggers recorded a maximum of 17 to 92 consecutive hours below the lethal temperature (-1.6°C) for 75% of female SWD (Kimura 2004) depending on the field site (Table 2). The Abbotsford 1, Langley 4, and Langley 3 locations had the longest period of time at these lower temperatures, with 92, 91, and 90 hours respectively (Table 2). All but three trapping locations had recorded at least 24 hours below -1.6°C. This past winter, no field sites reached temperatures below -10.2°C, which in one study was the $LT_{80\text{-}1h}$ for winter morphs (Toxopeus *et al.* 2016). This may likely account for the fact that higher numbers of SWD adults continued to be caught at most trapping sites in collections following the longest cold snap in mid February; there was not sufficient time for SWD in these hedgerows to be exposed to extended lethal temperatures.

In the previous year of study, nearly all trapping sites had extended periods of time below -10.2°C, with the Abbotsford 1 field site at the highest with 39 hours (Mittelstaedt 2020). Based on the 2020 winter SWD trap catch numbers remaining below 10 for sites that typically caught more SWD (Delta and Langley 1), the overwintering adults took longer to rebound following the longer periods of even colder temperatures in 2020, only picking up in early May. In comparison, the 2021 winter site with the overall higher SWD counts (Abbotsford 2) began to increase following a few -5°C events in March and then remained near an average of 10 SWD caught per trap until the end of the trapping period at the end of May.

Table 2. Minimum temperatures and consecutive number of hours below -1.6°C and -10.2°C measured by individual temperature loggers placed in hedgerows from January 6 – May 28, 2021.

Site	Lowest daily minimum temperature (°C)	Maximum number of consecutive hours below -1.6°C	Maximum number of consecutive hours below -10.2°C	Calendar dates of maximum number of consecutive hours below -1.6°C	Hedgerow orientation
Delta	-6.0	17	0	February 11-12	South-facing
Surrey	-7.9	19	0	February 10-11	South-facing
Langley 1	-7.4	44	0	February 9-11	North-facing
Langley 2	-7.0	45	0	February 10-12	North-facing
Langley 3	-6.9	90	0	February 9-13	South-facing
Langley 4	-7.2	91	0	February 9-13	North-facing
Abbotsford 1	-9.1	92	0	February 9-13	North-facing
Abbotsford 2	-8.9	23	0	February 10-11	South-facing

Stockton *et al.* (2018) found that 50% of SWD winter morph mortality was observed after 72 hours at -7.5°C. In this study, the SWD were exposed to gradually decreasing temperatures so they had more time to acclimate to the cold (Stockton *et al.* 2018), whereas in the Toxopeus *et al.* (2016) study, they were abruptly transferred from 11°C to various colder temperatures for about an hour, thus determining the -10.2°C $LT_{80\text{-}1h}$. The more recent studies into the difference in cold hardiness between summer and winter morph SWD suggest that the previously discovered lethal temperature of -1.6°C (Kimura 2004) may be too mild of a temperature to be considered as lethal as it was thought before. These studies were conducted in a lab setting, so results would be expected to differ compared to the field, in regards not only to temperature, but other weather factors as well. In a field study of overwintering survival of SWD, Jakobs *et al.* (2015) recorded winter temperatures experienced by SWD under leaf litter, in areas directly exposed, and in an unheated building in Ontario. Prior to an extreme cold snap on December 12, 2013 when the study was conducted, most of the three-week trapping period for all three microhabitats had temperatures hovering around 0°C. There was, however, a difference in the maximum and minimum temperatures reached for each habitat. The temperatures fluctuated between approximately 8°C and -4°C in the protected leaf litter and unheated building, but were much more drastic in the directly exposed area, ranging from above 10°C to -10°C over the three weeks. The temperatures fluctuated much more readily where directly exposed, but still reached minimum temperatures ranging from -5.6°C to -14°C in all habitats for an extended period of time during the extreme cold spell on December 12, 2013, resulting in 100% mortality in all SWD placed in the field study, regardless of habitat (Jakobs *et al.* 2015).

In the Fraser Valley region of BC, there are many areas where SWD can take refuge during the winter months. Many berry farms are near urban areas, as well as abundant forests, which can provide overwintering SWD adults with shelter. The Jakobs *et al.* (2015) data demonstrate that even in protected areas, there is the potential that SWD can be killed by extended periods of sub-zero temperatures.

The consecutive length of time below -1.6°C in the winter of 2020-2021 was longer than that of 2019-2020, based on historical Abbotsford Airport temperatures, however the minimum temperatures were much lower in 2019-2020 (Table 3). The longest period of time below -1.6°C recorded at the Abbotsford Airport this past winter was seven days between February 8-14, which is consistent with what was

observed in the data from individual temperature loggers at each of the trapping sites for all regions (Table 2). This mid-February period of extended cold temperatures is also typical of the past few years of study as well (Table B1). The lowest minimum temperature reached in 2020-21 was higher than the lowest temperatures reached in both the 2018-19 and 2019-20 winters (Table 3).

Table 3. Coldest temperatures and consecutive number of days below -1.6°C measured at the Abbotsford Airport (Environment Canada) since 2018-19.

Year	Lowest daily minimum temp (°C)	Lowest daily maximum temp (°C)	Number of consecutive days below -1.6°C (calendar dates)	Total days below -1.6°C
2018-2019	-9.1	-3.6	4 days (Dec 4-7), 12 days (Feb 3-14), 4 days (March 4-7), 2 days (March 9-10)	22 days
2019-2020	-12.3	-9.5	3 days (Nov 29-Dec 1), 2 days (Dec 23-24), 7 days (Jan 12-18), 3 days (Feb 18-20), 2 days (March 17-18)	17 days
2020-2021	-8.4	-3.5	2 days (Dec 23-24), 2 days (Jan 22-23), 7 days (Feb 8-14), 2 days (Mar 15-16)	13 days

Degree-day modeling

Oregon State University's Degree-day model shows that the 2021 season was predicted to be later than 2020 until the peak emergence of the first spring adult generation. Then the predicted SWD development was earlier to the previous season for the rest of the summer by just over a week by mid-summer (Table 4). During the 2021 season, there was an extreme heat incident in the last week of June, where temperatures across the Fraser Valley reached 42°C in some areas. This likely had an impact on the SWD populations, decreasing the overall activity which resulted in the 2021 season being a lower pressure season than initially predicted solely based on the winter and spring trap catches (E.S. Cropconsult, field observation). This continues to suggest that, although winter temperatures can be a good predictor for SWD pressure entering the growing season, conditions during the spring and summer months can influence what is seen in the harvested crop and previous years have shown that SWD populations are capable of quickly rebounding following a cold winter.

Table 4. Dates corresponding with SWD development predicted by the SWD degree day model (OSU Online Phenology and Degree Day Models) and Abbotsford Airport temperatures in 2018-2021 (Environment Canada).

Year	First egg laying by OW females (261 DD_{50})	Peak egg laying by OW females (510 DD_{50})	First egg laying by 1st generation females (565 DD_{50})	Peak 1st generation adult emergence (755 DD_{50})	Peak egg laying by 1st generation females (995 DD_{50})	Peak 2nd generation adult emergence (1249 DD_{50})	Peak egg laying by 2nd generation females (1489 DD_{50})
2018	May 27	June 22	June 25	July 7	July 23	Aug 6	Aug 20
2019	May 15	June 11	June 17	June 30	July 15	July 28	Aug 8
2020	May 14	June 12	June 19	July 4	July 20	Aug 3	Aug 17
2021	May 21	June 17	June 21	June 28	July 11	July 26	Aug 7

Conclusion

The objectives of this project were to set up spotted wing drosophila (SWD) traps in winter and spring 2021, to record temperatures, and to compare data with previous years. These data were then used to help predict the SWD pressure for the 2021 season, and this prediction was shared with berry growers in the Fraser Valley via newsletters (Fig. C1).

High levels of SWD were caught in the traps baited with apple cider vinegar and antifreeze in the first trapping period. Following two instances below the lethal temperature of -1.6°C for an extended period of time, SWD trap catches decreased, however they continued to be caught at low to moderate levels for the remainder of the trapping period. These decreases in counts following a cold period continue to show a close link between the temperature and overwintering SWD adult survival, which has been seen in previous trapping years as well, especially when the temperature remains below the lethal temperatures of -1.6°C for 24 hours (Kimura 2004).

As SWD continue to be present each season, it has been a concern of berry growers in all growing regions that there are surviving adults every winter, despite long periods of sub-zero temperatures. The survival of SWD adults is likely due to their ability to find shelter in buildings or treed areas, allowing them to be protected from sub-zero temperatures. Continuing to track temperatures in the winter and trap SWD in the early spring, using the most effective traps each year is a valuable tool to help estimate the survival rates of SWD and to forecast pest pressure for the upcoming berry season. Even with long periods of cold weather to potentially reduce the number of SWD for the early spring pressure, it is important for growers to adopt best management practices throughout the growing season. Once wild fruit is available in the spring as a food source for SWD, and with the right environmental conditions, populations can quickly build. With their propensity to rapidly increase in population size, cold winters are not the only factor keeping SWD pressure low for the berry growing season.

Acknowledgements

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Appendix A – Summary of mean SWD numbers

Table A1. Summary of mean SWD numbers (± standard error of the mean) in four Contech traps placed in hedgerows adjacent to eight berry fields in the Fraser Valley from January 6 to March 31, 2021, and six berry fields from March 31 to May 28, 2021. Trap catches are reported at bi-weekly intervals from January 6 to March 31 and weekly intervals from March 31 to May 28, 2021.

Location		Jan 6-Jan 20	Jan 20-Feb 3	Feb 3-Feb 17	Feb 17-Mar 3	Mar 3-Mar 16	Mar 16-Mar 31	Mar 31-Apr 16	Apr 16-Apr 23	Apr 23-Apr 30	Apr 30-May 7	May 7-May 14	May 14-May 21	May 21-May 28
Delta	**Mean**	**107.25**	**22.5**	**17.75**	**2**	**5**	**1.25**	**12.5**	**9.75**	**2**	**4.25**	**4**	**2**	**13**
	±s.e.m.	18.41	3.80	3.35	0.91	1.50	0.48	3.18	3.20	0.58	0.63	1.47	0.50	2.86
Surrey	**Mean**	**0.25**	**0.25**	**0**	**0**	**0**	**0**	**0**	**0**	**0.25**	**0**	**1.5**	**0**	**0.25**
	±s.e.m.	0.25	0.25	0	0	0	0	0	0	0.25	0	0.65	0	0.25
Langley 1	**Mean**	**189.5**	**9.75**	**4.25**	**0**	**3**	**1**	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	±s.e.m.	57.26	1.97	0.85	0	1.08	0.58							
Langley 2	**Mean**	**90**	**8.25**	**7**	**0.25**	**5.25**	**1.5**	**2**	**4.25**	**1.5**	**0.75**	**2.25**	**1.5**	**3.75**
	±s.e.m.	27.82	1.89	3.24	0.25	0.85	0.87	1.08	1.49	0.87	0.48	0.63	0.5	2.50
Langley 3	**Mean**	**20.25**	**3.5**	**1.75**	**0**	**0.25**	**0**	**0**	**3**	**0.25**	**0.75**	**0.5**	**1**	**1.25**
	±s.e.m.	3.54	1.32	0.48	0	0.25	0	0	0	0.25	0.48	0.29	0.71	0.75
Langley 4	**Mean**	**49.25**	**2**	**9.5**	**2.25**	**5.75**	**1.25**	**9.25**	**4**	**3**	**1**	**0.33**	**0.33**	**1**
	±s.e.m.	3.82	0.41	2.10	1.31	1.93	0.95	2.29	1.29	1.91	0.5	0.29	0.29	0.5
Abbotsford 1	**Mean**	**21.5**	**0**	**10.5**	**2**	**3.75**	**1.5**	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	±s.e.m.	6.44	0	3.66	1.22	1.25	0.65							
Abbotsford 2	**Mean**	**321**	**51**	**16**	**0.25**	**0**	**0**	N/A	**8.5**	**4.5**	**7.75**	**9**	**8.5**	**2.5**
	±s.e.m.	33.81	23.48	5.96	0.25	0	0		3.66	1.66	1.70	6.35	0.96	1.5

Appendix B – Historical Temperature Data

Table B1. Coldest temperature and consecutive number of days below -1.6°C measured at the Abbotsford Airport (Environment Canada) since 2010-11.

Year	Lowest daily minimum temp (°C)	Lowest daily maximum temp (°C)	Number of consecutive days below -1.6°C (calendar dates)	Total days below -1.6°C
2010-2011	-10.9	-4.1	3 days (Nov 22-24, 2010)	3 days
2011-2012	-14.8	-9	2 days (Jan 18-19, 2012)	2 days
2012-2013	-7.7	-0.1	1 day (Jan 13, 2013)	1 day
2013-2014	-11.3	-3.4	4 days (Dec 6-9, 2013), 2 days (Feb 4-5, 2014)	6 days
2014-2015	-9.2	-2.3	1 day (Nov 29, 2014)	1 day
2015-2016	-6.5	1.6	0 days	0 days
2016-2017	-11.9	-4.8	6 days (Dec 5-10, 2016), 8 days (Dec 12-19), 3 days (Dec 24-26), 6 days (Jan 2-7, 2017), 8 days (Jan 9-16), 7 days (Feb 3-9), 2 days (Feb 27-28)	40 days
2017-2018	-6.6	-2.1	2 days (Dec 20-21, Feb 12-13), 5 days (Dec 30-Jan 3), 6 days (Dec 23-28), 7 days (Feb 18-24)	25 days
2018-2019	-9.1	-3.6	4 days (Dec 4-7), 12 days (Feb 3-14), 4 days (March 4-7), 2 days (March 9-10)	22 days
2019-2020	-12.3	-9.5	3 days (Nov 29-Dec 1), 2 days (Dec 23-24), 7 days (Jan 12-18), 3 days (Feb 18-20), 2 days (March 17-18)	17 days
2020-2021	-8.4	-3.5	2 days (Dec 23-24), 2 days (Jan 22-23), 7 days (Feb 8-14), 2 days (Mar 15-16)	23 days

Table B2. Dates corresponding with SWD development predicted by the SWD degree day model (OSU Online Phenology and Degree Day Models) and Abbotsford Airport temperatures in 2011-2021 (Environment Canada).

Year	First egg laying by OW females (261 DD_{50})	Peak egg laying by OW females (510 DD_{50})	First egg laying by 1st generation females (565 DD_{50})	Peak 1st generation adult emergence (755 DD_{50})	Peak egg laying by 1st generation females (995 DD_{50})	Peak 2nd generation adult emergence (1249 DD_{50})	Peak egg laying by 2nd generation females (1489 DD_{50})
2011	June 8	July 2	July 6	July 21	Aug 6	Aug 24	Sept 8
2012	May 26	June 28	July 4	July 16	Aug 3	Aug 16	Sept 4
2013	May 17	June 21	June 25	July 6	July 21	Aug 6	Aug 20
2014	May 18	June 17	June 23	July 6	July 18	Aug 3	Aug 16
2015	May 10	June 2	June 7	June 19	July 2	July 14	July 29
2016	April 28	May 25	June 1	June 18	July 8	July 25	Aug 10
2017	May 22	June 10	June 16	June 29	July 14	July 30	Aug 10
2018	May 27	June 22	June 25	July 7	July 23	Aug 6	Aug 20
2019	May 15	June 11	June 17	June 30	July 15	July 28	Aug 8
2020	May 14	June 12	June 19	July 4	July 20	Aug 3	Aug 17
2021	June 2	June 24	June 27	July 5	July 21	Aug 4	Aug 16

Appendix C – Excerpt from Blueberry IPM Newsletter

Winter and Spring Spotted Wing Drosophila Trapping

Spotted wing drosophila (SWD) traps have been placed in hedgerows adjacent to berry fields (blueberries, raspberries and strawberries) since January 2021 to monitor the overwintering and early spring populations of adults. Eight hedgerows had traps placed from January to mid-April, reduced to six locations from mid-April to the end of May. This monitoring has been used to help identify what effect freezing temperatures have on the survival of SWD populations and in turn how that effects the coming season's pressure. SWD have been caught since they were set in January, with a significant decrease in numbers between the first and second collection periods. The decreases observed early in the year align with prolonged periods of below freezing temperatures on January 23 (12 hours), and February 8-14 (148 hours), based on Environmental Canada weather data from the Abbotsford Airport. Trap catches remained low from mid-February to mid-April, with the average catch remaining below 4 SWD per collection. The trap catches began to increase in mid-April, with the average around 5-7 SWD per trap from mid-April to late May. For comparison, in years with major SWD issues average SWD fly catches have been between 5 and 10 from March to May. With the variability in weather so far this spring, the effect on SWD populations have been hard to predict, but optimal SWD reproduction occurs at 22°C. Based on what we have seen so far in trap catches for 2021 we are anticipating moderate to high SWD pressure in the early season. Populations can build drastically once suitable egg-laying hosts are present.

Growers are encouraged to be diligent with their SWD management practices, before, during and after harvest in berry crops.

In Spring 2020, the BC Ministry of Agriculture has started a survey project in collaboration with Agriculture and Agri-Food Canada to learn more about the parasitoids of SWD which are now present in BC, which is continuing in the 2021 season. Fields visited for the IPM Newsletters will be part of the survey. Thank you to all growers for your participation in this important initiative.

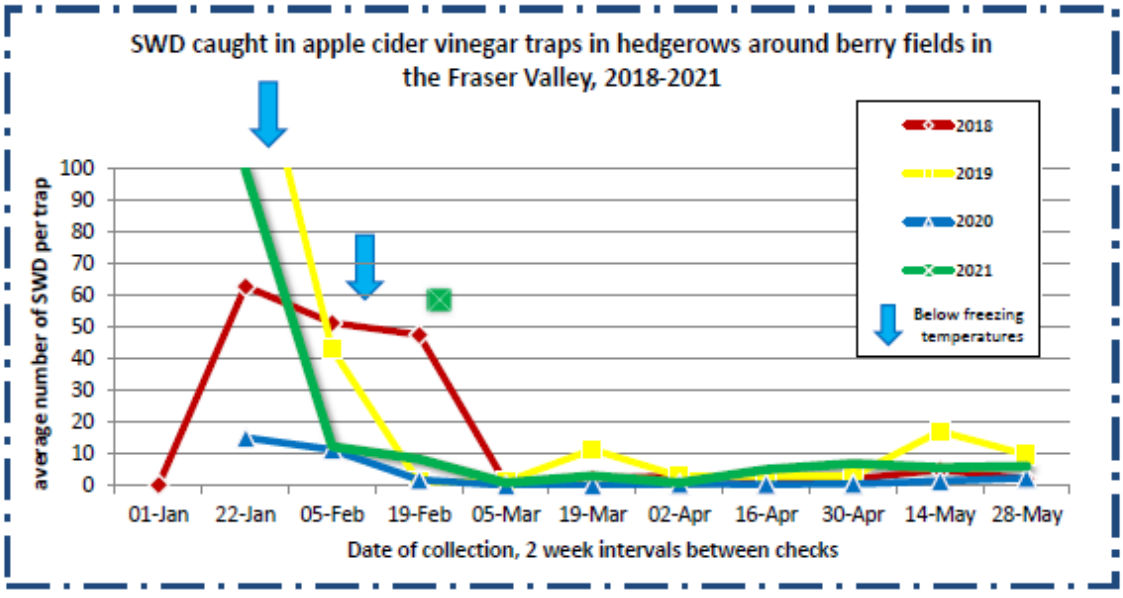

Figure C1. Winter SWD Trapping Update for BCBC IPM Newsletter – May 28, 2021