Progress Toward Developing an SWD Risk Model

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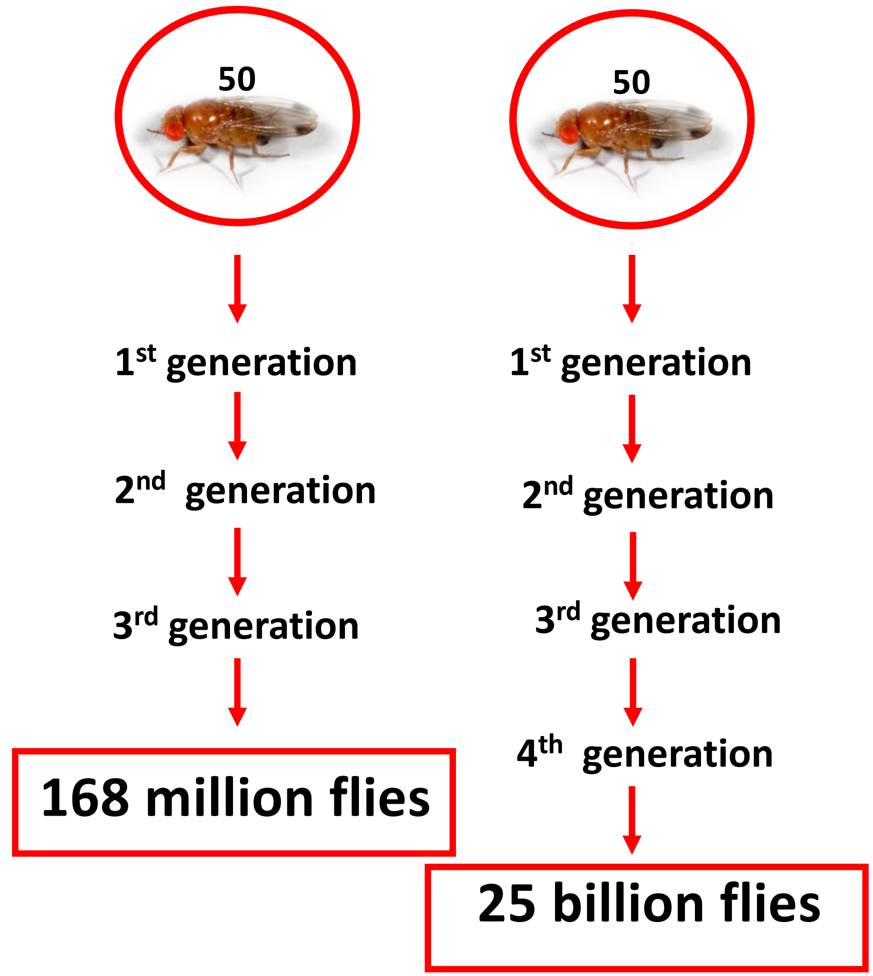
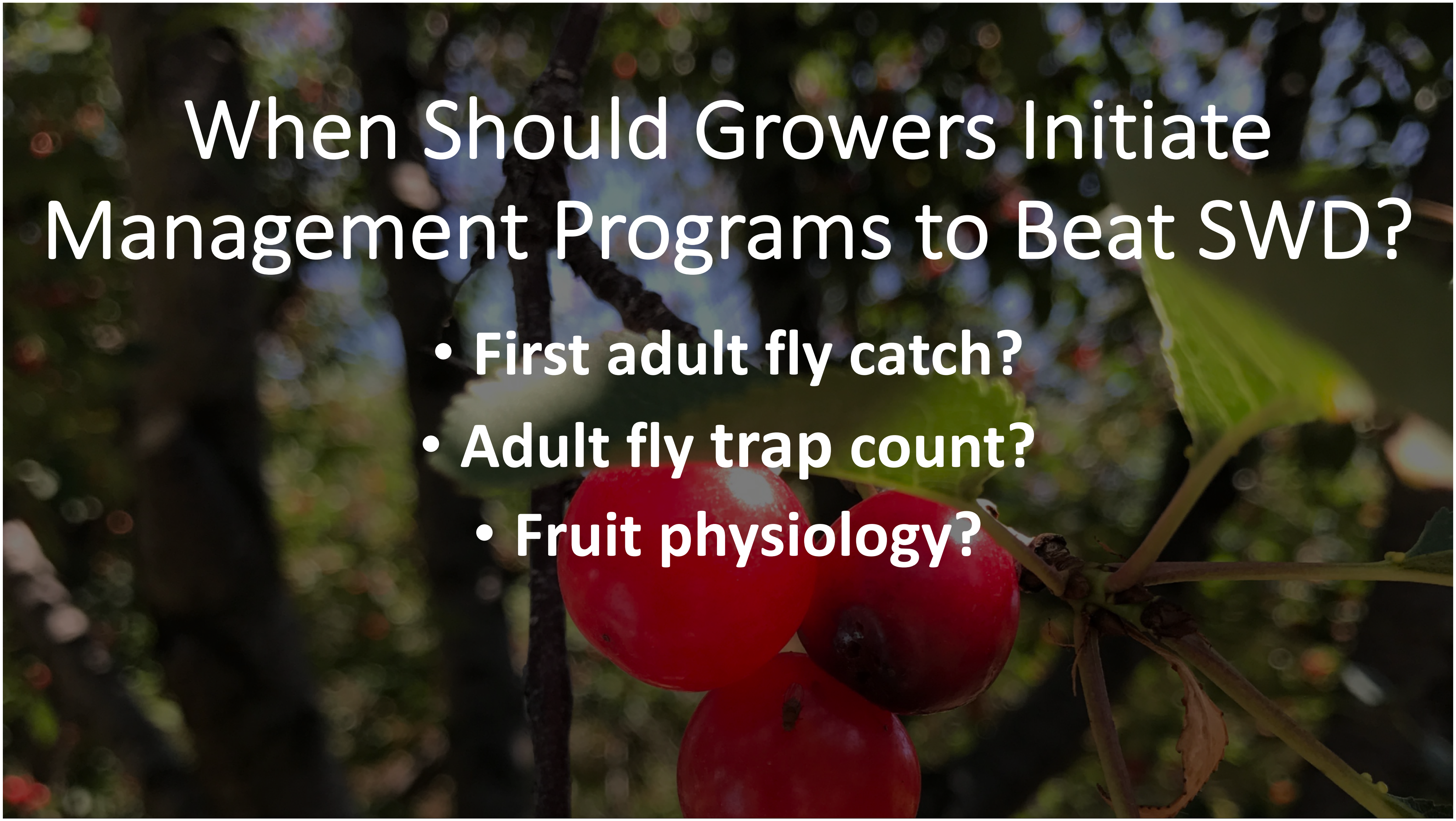
Spotted Wing Drosophila

- Females have a serrated ovipositor
    - Able to lay eggs in underripe fruit
        - When are fruit susceptible to infestation?
- Complete one generation in 7D
    - Exponential population growth
    - Growers can't beat the numbers' game




When Should Growers Initiate Management Programs to Beat SWD?
• First adult fly catch?
• Adult fly trap count?
• Fruit physiology?

Should Growers Initiate SWD Management Programs at First Catch?

Region	1st Adult Catch		1st Detection of Larvae		Harvest Date	Larvae before harvest
	Date	# of flies	Date	# of larvae		
NW 1	12-Jun	2	26-Jul	2	28-Jul	Yes
NW 2	10-Jul	1	N/A	0	27-Jul	No
NW 3	12-Jun	3	19-Jul	1	23-Jul	Yes
NW 4	29-May	2	28-Jun	3	12-Jul	Yes
NW 5	12-Jun	1	19-Jul	2	20-Jul	Yes
NW 6	5-Jun	1	21-Jul	3	25-Jul	Yes
NW 7	19-Jun	2	19-Jul	7	26-Jul	Yes
NW 8	19-Jun	3	26-Jul	2	5-Aug	Yes
NW 9	5-Jun	1	27-Jul	16	6-Aug	Yes
NW 10	12-Jun	1	1-Aug	4	29-Jul	No
WC 1	19-Jun	1	26-Jul	25	19-Jul	No
WC 2	19-Jun	1	21-Jul	11	14-Jul	No
WC 3	12-Jun	1	11-Jul	2	19-Jul	Yes
WC 4	19-Jun	8	19-Jul	5	12-Jul	No
WC 5	22-May	1	11-Jul	2	18-Jul	Yes
WC 6	12-Jun	1	21-Jul	2	14-Jul	No
WC 7	22-May	1	24-Jul	640	17-Jul	No
WC 8	19-Jun	8	6-Jul	2	11-Jul	Yes
WC 9	22-May	1	19-Jul	71	11-Jul	No
WC 10	19-Jun	10	N/A	0	12-Jul	No
SW 1	31-May	1	10-Jul	1	4-Jul	No
SW 2	24-May	1	10-Jul	16	5-Jul	No
SW 3	24-May	1	26-Jun	2	3-Jul	Yes
SW 4	24-May	2	N/A	0	7-Jul	No
SW 5	31-May	2	26-Jun	14	5-Jul	Yes

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NW 4	29-May	2	28-Jun	3	12-Jul	Yes
NW 5	12-Jun	1	19-Jul	2	20-Jul	Yes
NW 6	5-Jun	1	21-Jul	3	25-Jul	Yes
NW 7	19-Jun	2	19-Jul	7	26-Jul	Yes
NW 8	19-Jun	3	26-Jul	2	5-Aug	Yes
NW 9	5-Jun	1	27-Jul	16	6-Aug	Yes
NW 10	12-Jun	1	1-Aug	4	29-Jul	No
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WC 2	19-Jun	1	21-Jul	11	14-Jul	No
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SW 4	24-May	2	N/A	0	7-Jul	No
SW 5	31-May	2	26-Jun	14	5-Jul	Yes

First catch: 5/29-6/19

8 of 10 orchards were infested before harvest

Region	1st Adult Catch		1st Detection of Larvae		Harvest Date	Larvae before harvest
	Date	# of flies	Date	# of larvae		
NW 1	12-Jun	2	26-Jul	2	28-Jul	Yes
NW 2	10-Jul	1	N/A	0	27-Jul	No
NW 3	12-Jun	3	19-Jul	1	23-Jul	Yes
NW 4	29-May	2	28-Jun	3	12-Jul	Yes
NW 5	12-Jun	1	19-Jul	2	20-Jul	Yes
NW 6	5-Jun	1	21-Jul	3	25-Jul	Yes
NW 7	19-Jun	2	19-Jul	7	26-Jul	Yes
NW 8	19-Jun	3	26-Jul	2	5-Aug	Yes
NW 9	5-Jun	1	27-Jul	16	6-Aug	Yes
NW 10	12-Jun	1	1-Aug	4	29-Jul	No
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WC 2	19-Jun	1	21-Jul	11	14-Jul	No
WC 3	12-Jun	1	11-Jul	2	19-Jul	Yes
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SW 3	24-May	1	26-Jun	2	3-Jul	Yes
SW 4	24-May	2	N/A	0	7-Jul	No
SW 5	31-May	2	26-Jun	14	5-Jul	Yes

First catch: 5/22-6/19

2 of 10 orchards were infested before harvest

Region	1st Adult Catch		1st Detection of Larvae		Harvest Date	Larvae before harvest
	Date	# of flies	Date	# of larvae		
NW 1	12-Jun	2	26-Jul	2	28-Jul	Yes
NW 2	10-Jul	1	N/A	0	27-Jul	No
NW 3	12-Jun	3	19-Jul	1	23-Jul	Yes
NW 4	29-May	2	28-Jun	3	12-Jul	Yes
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SW 4	24-May	2	N/A	0	7-Jul	No
SW 5	31-May	2	26-Jun	14	5-Jul	Yes

First catch: 5/24-5/31

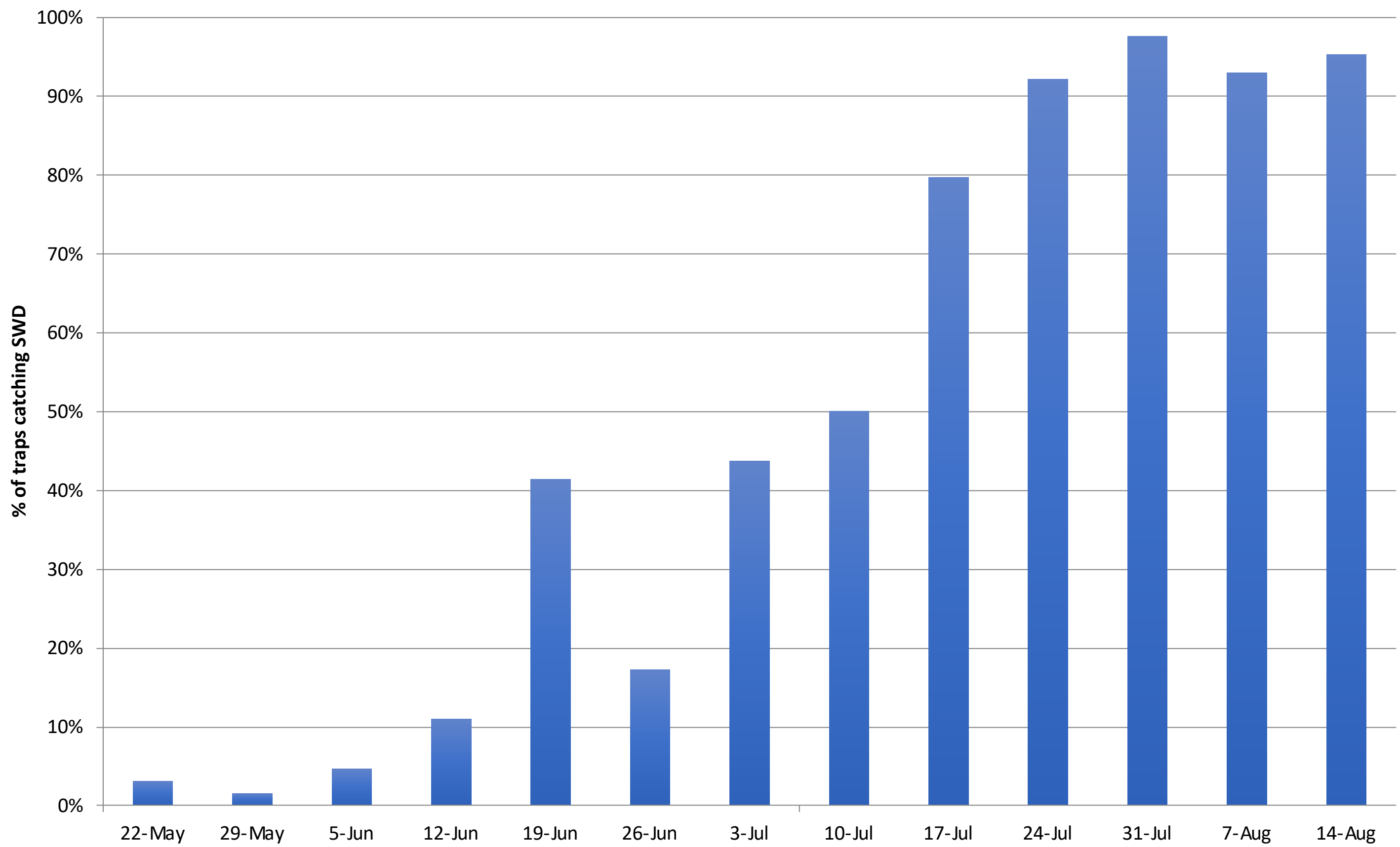
2 of 5 orchards were infested before harvest

First Catch: What Does it Mean?

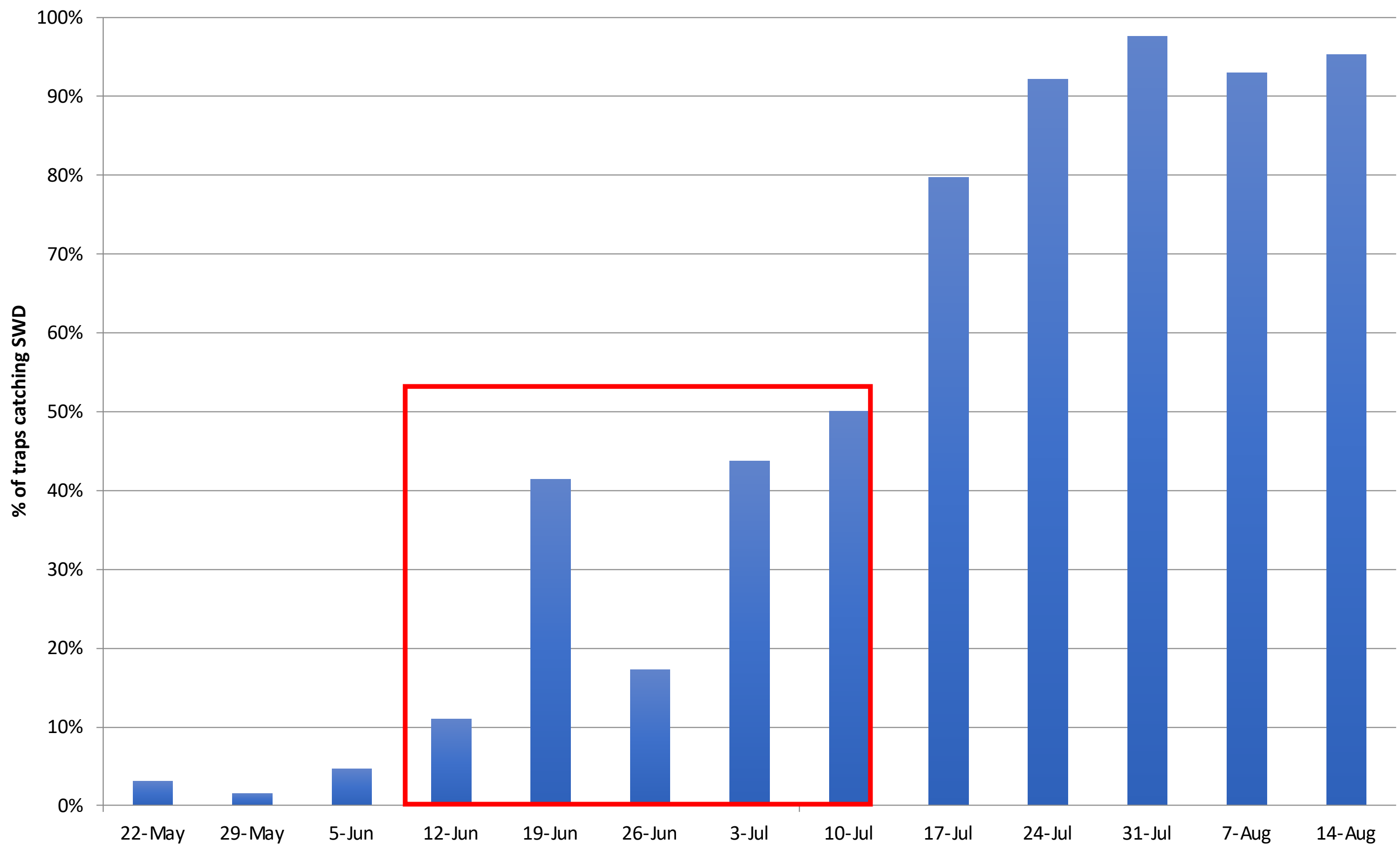
- First catch timing did not influence overall populations/success of harvesting clean fruit
  - No correlation between first catch and potential for infestation in any MI region
  - Farms with early/late 1st catch were infested
- First catch also is not good indicator of when to begin SWD sprays
  - Earliest first catch: May 22
  - Latest first catch: June 19

Should Growers Initiate SWD Management Programs Based on Adult Trap Count?

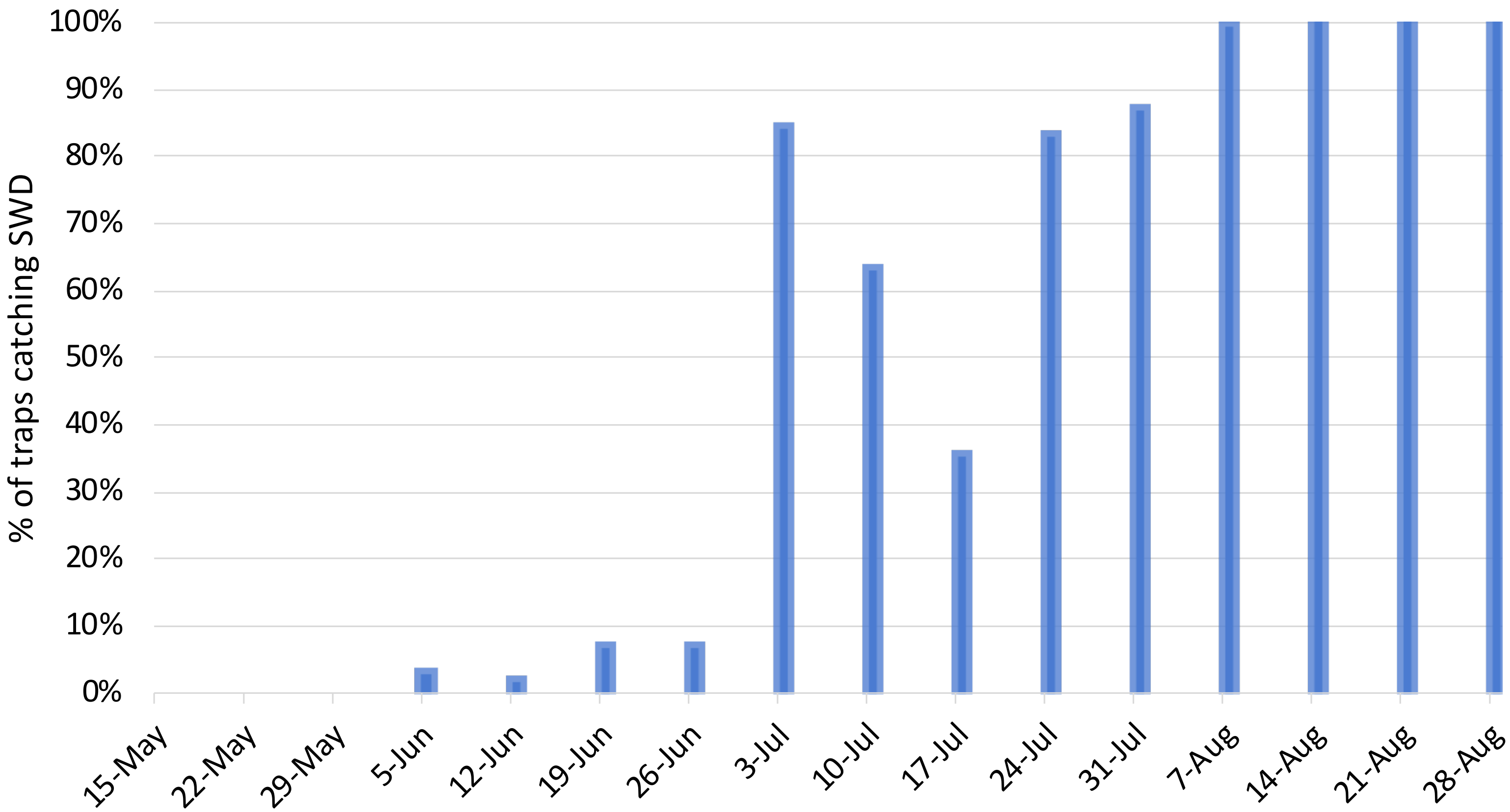
2017 NW SWD Trap Catch Data



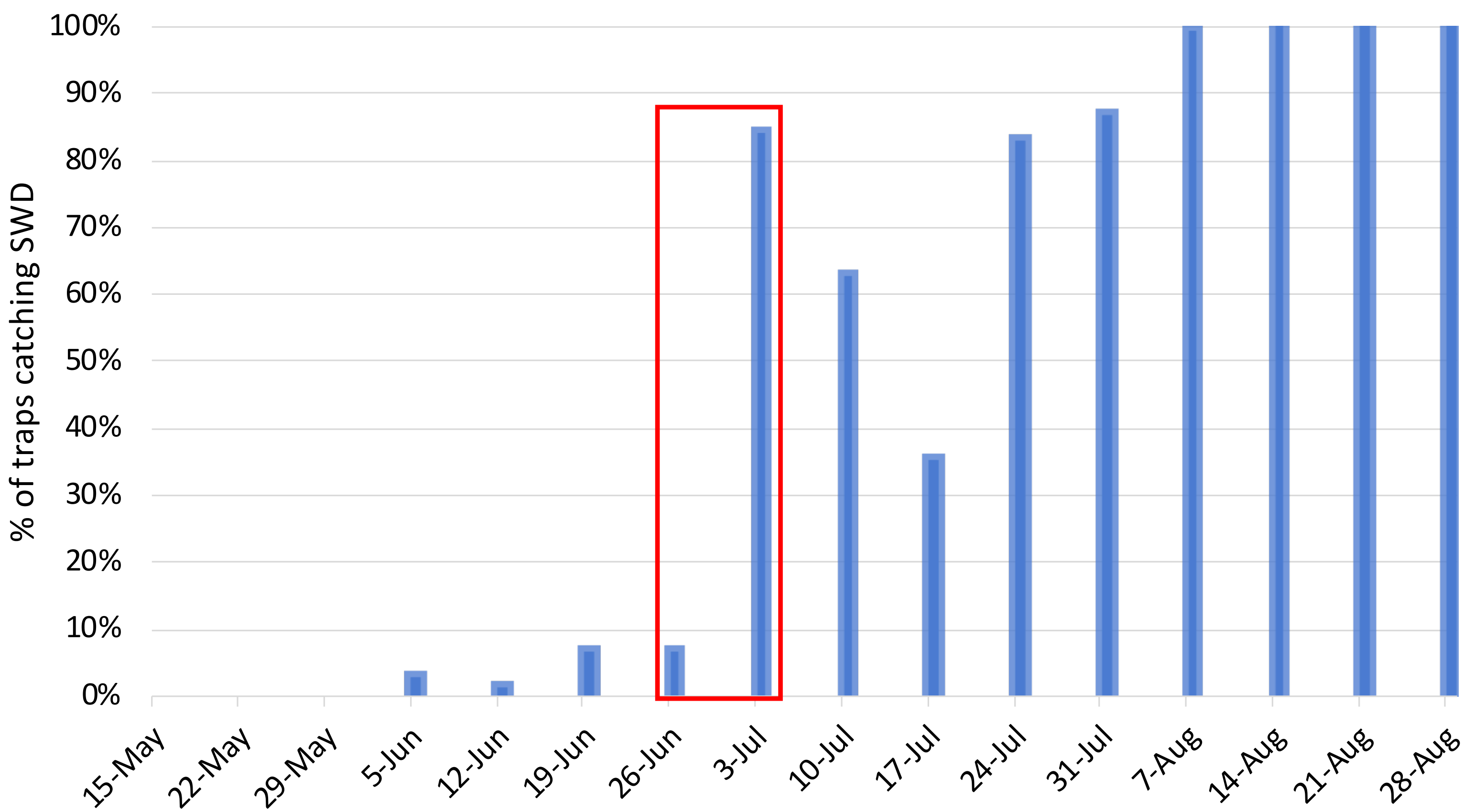
2017 NW SWD Trap Catch Data



2018 NW SWD Trap Catch Data



2018 NW SWD Trap Catch Data



Fly catch and larvae collected from four NW Farms, 2016

		27-Jun	5-Jun	11-Jul	17-Jul	25-Jul
Farm A	Traps	1	0	4	5	67
	Larvae				4	33
Farm B	Traps	1	2	1	1	16
	Larvae				0	5
Farm C	Traps	3	3	13	25	23
	Larvae				1	15
Farm D	Traps	1	1	4	7	6
	Larvae				8	16
Farm E	Traps	0	0	1	2	3
	Larvae				1	0

Total number of adult flies and larvae from 20 traps and larvae from 600 fruit

Fly catch and larvae collected from four NW Farms, 2017

		12-Jun	19-Jun	28-Jun	5-Jul	12-Jul	19-Jul
Farm A	Traps	2	16	4	15	10	89
	Larvae			4	0	0	3
Farm B	Traps	3	5	0	7	5	7
	Larvae			0	0	0	1
Farm C	Traps	1	13	6	12	17	48
	Larvae			0	0	0	2
Farm D	Traps	0	2	1	0	4	23
	Larvae			0	0	0	6
Farm E	Traps	0	3	1	1	1	13
	Larvae			0	0	0	0

Total adults from 10 traps and larvae from 300 fruit

Fly catch and larvae collected in NWMHRC pruning trial

No pruning treatment, no insecticides were applied

No Pruning Trt	Rep	22-May	29-May	5-Jun	12-Jun	19-Jun	26-Jun	3-Jul	10-Jul	17-Jul
Trap	1	0	0	0	0	0	0	2	0	9
	2	0	0	0	0	0	2	20	10	19
Larval Sample	1						7	0	0	0
	2						0	0	0	1
	3						3	0	0	3
	4						1	0	0	5

Total adult fly catch from two traps and total larvae from 100 fruit collected per rep

Should Growers Initiate SWD Management Programs Based on Adult Trap Count?

- Relationship between adult trap count and larval infestation is weak
- Trap counts should not be used as a stand alone indicator to initiate programs
  - Single traps in individual orchards should not be used for management decisions
  - Regional trap numbers provide better indicator of potential risk
    - When regional trap numbers rise ‘exponentially’, risk increases and growers should begin programs
- More effective traps are needed

Should Growers Initiate SWD Management Programs Based on Fruit Physiology?

When are Tart Cherries Susceptible to SWD?

	SWEETS		Anova
Cherry Stage	adults at 14 days		p<0.0001
	mean		sem
Not Ripe	0	a	0
Ripening	24	b	3.5
Ripe	1.2	a	0.8
	TARTS		Anova
Cherry Stage	adults at 14 days		p<0.0001
	mean		sem
Not Ripe	0	a	0
Ripening	43.3	b	3.4
Ripe	32.8	b	0

Data courtesy of Haas and Gut; unpublished

	SWEETS		Anova
Cherry Stage	adults at 14 days		p<0.0001
	mean		sem
Not Ripe	0	a	0
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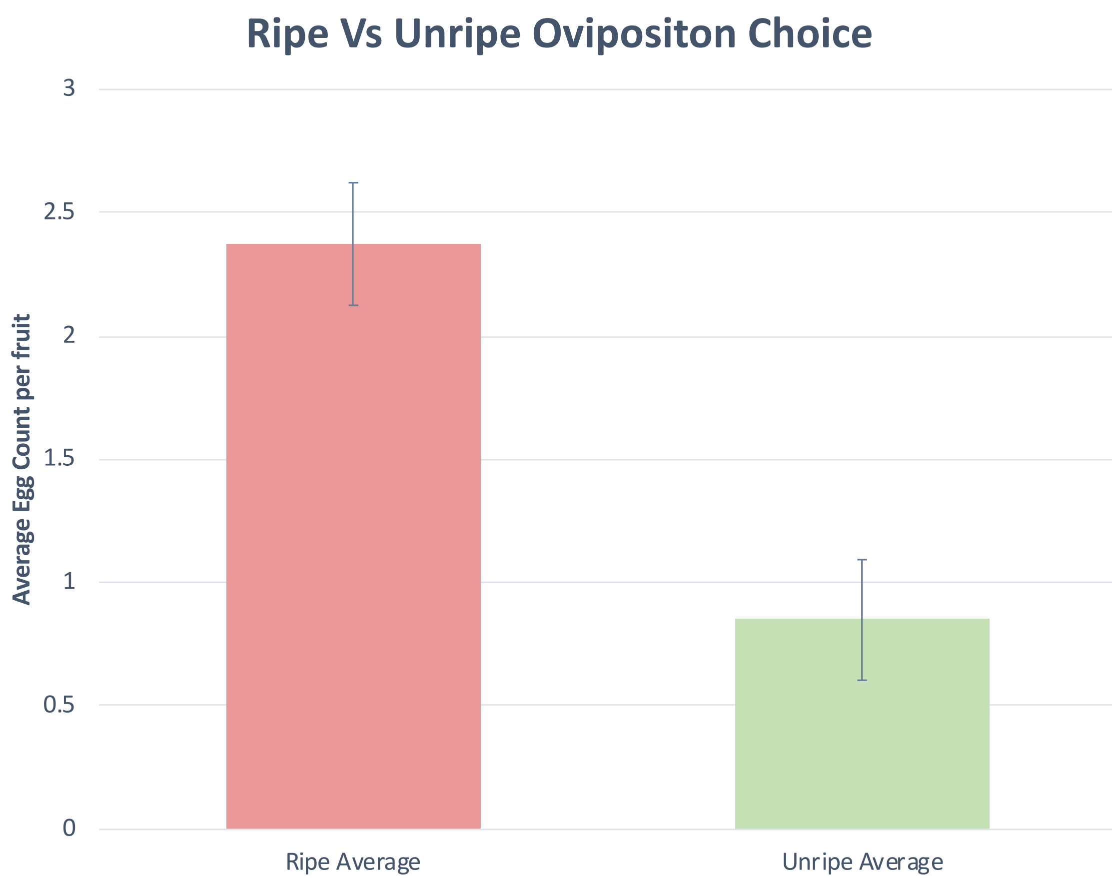
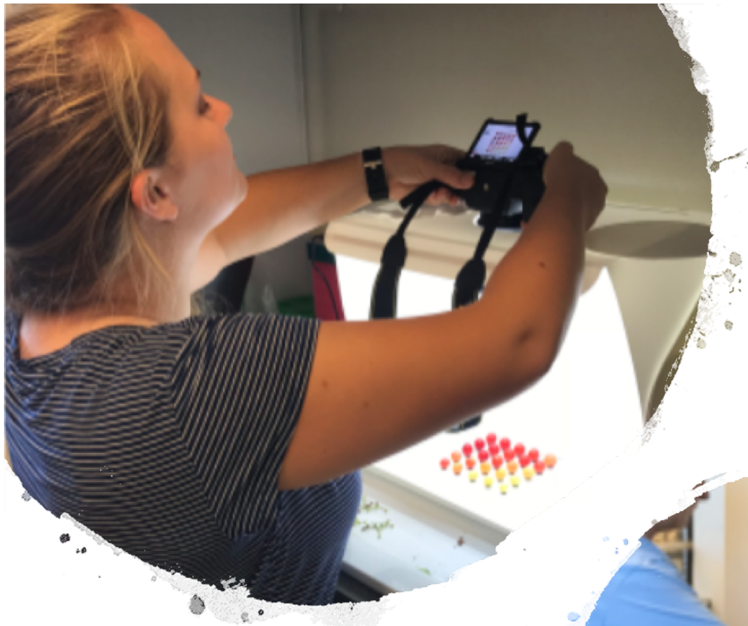
Montmorency Cherry Choice Test 2018

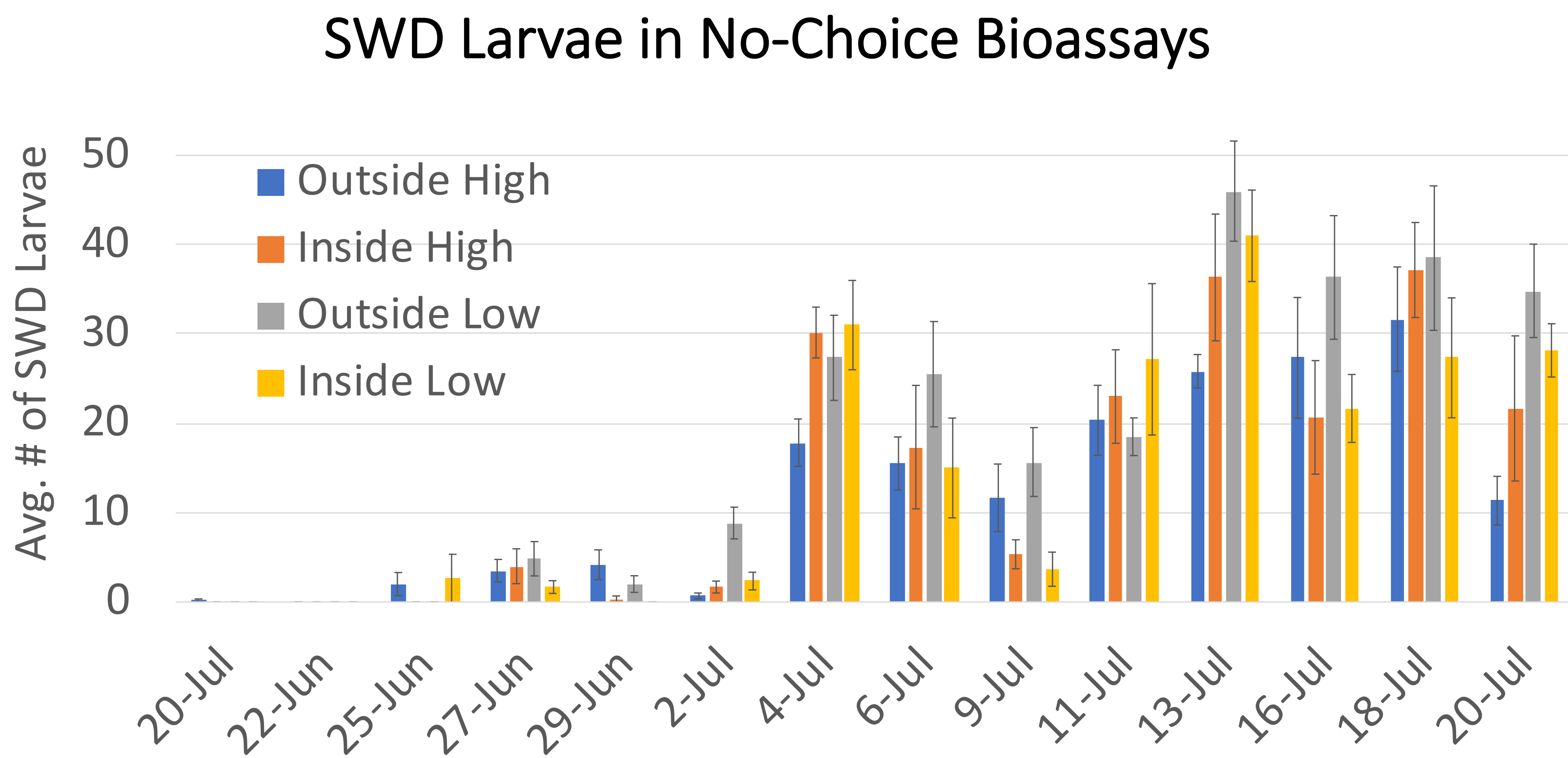


Data courtesy of S. Dietrich, et. al; unpublished

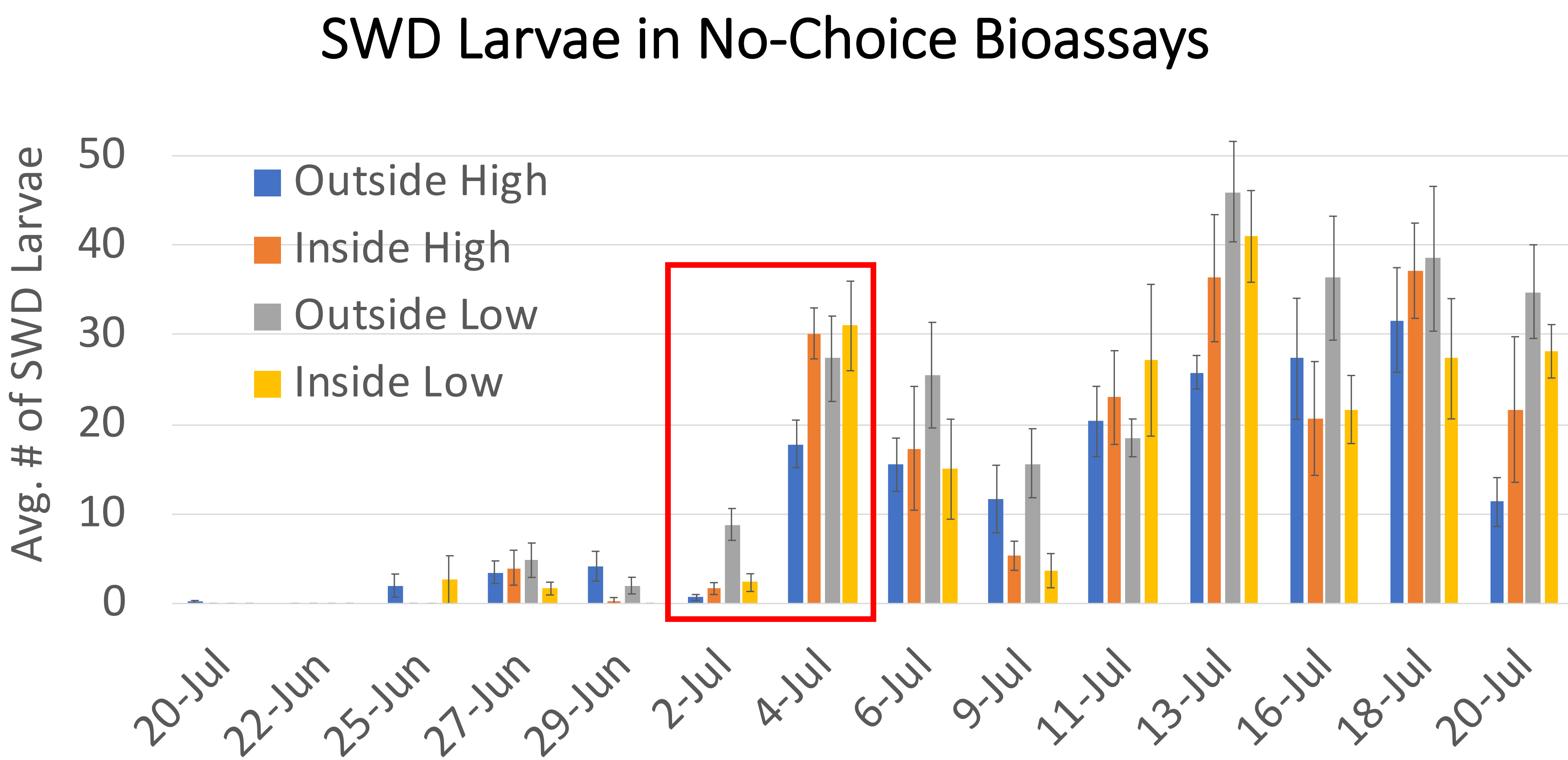


Determining Relationship between Fruit Physiology and SWD Infestation

- Fruit was collected 3x/week
- Tested for the following:
  - Weight
  - Brix
  - Firmness with FirmTech,
  - Penetration force (i.e. force to penetrate the fruit skin)
  - RGB analysis
- No-choice bioassay was performed with each collection timing



Fruit collected in the field, placed into bioassay containers, and exposed to male and female SWD



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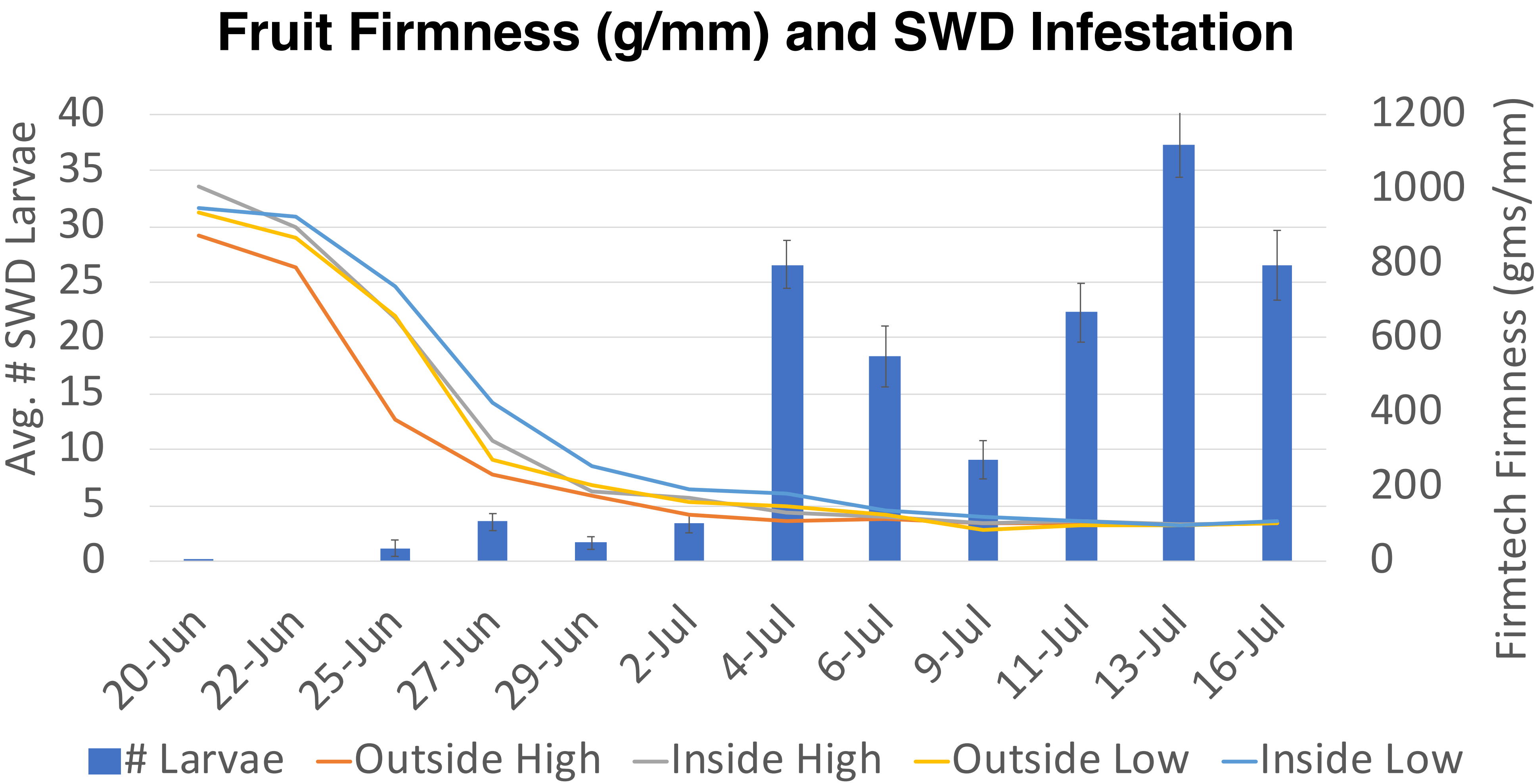
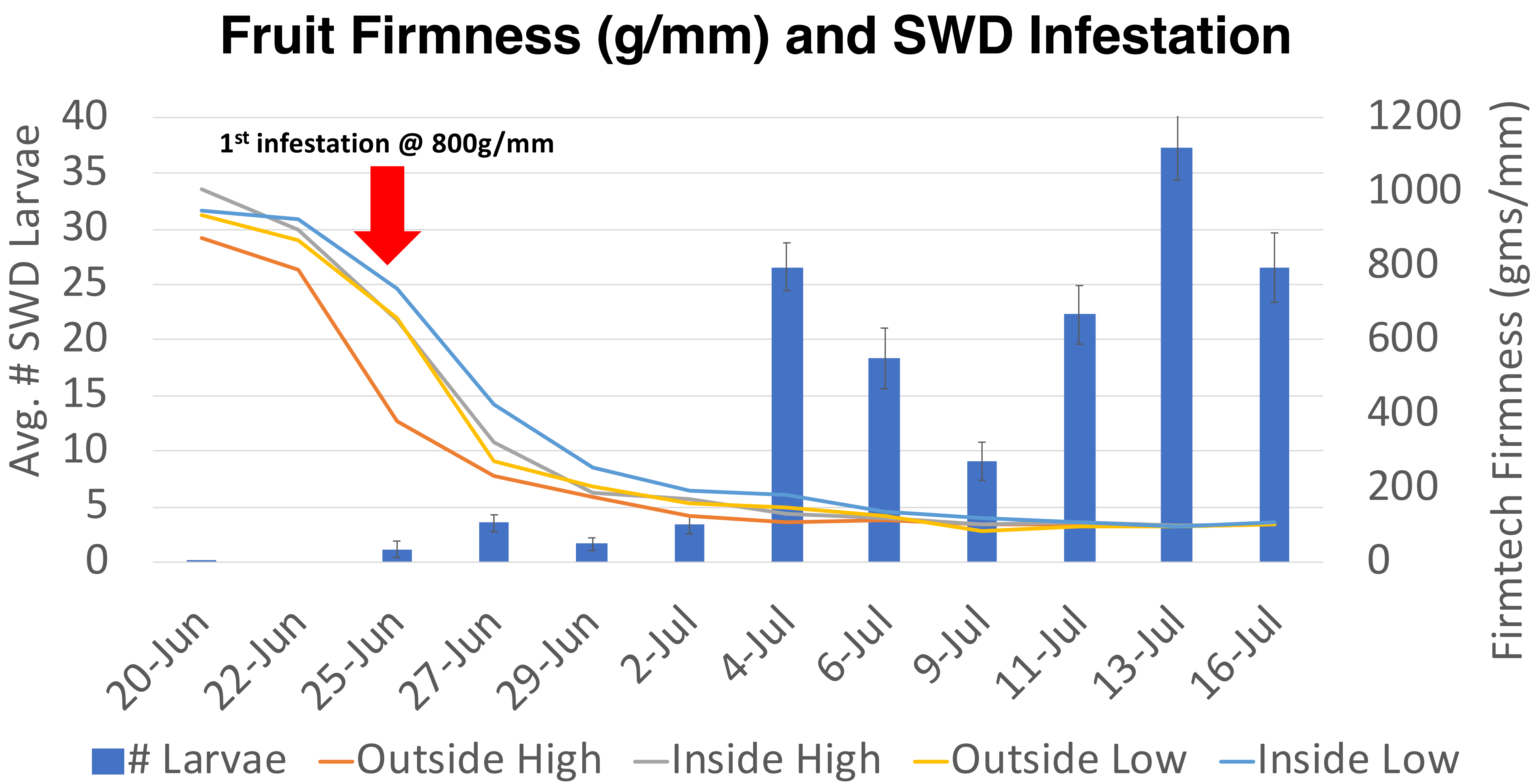
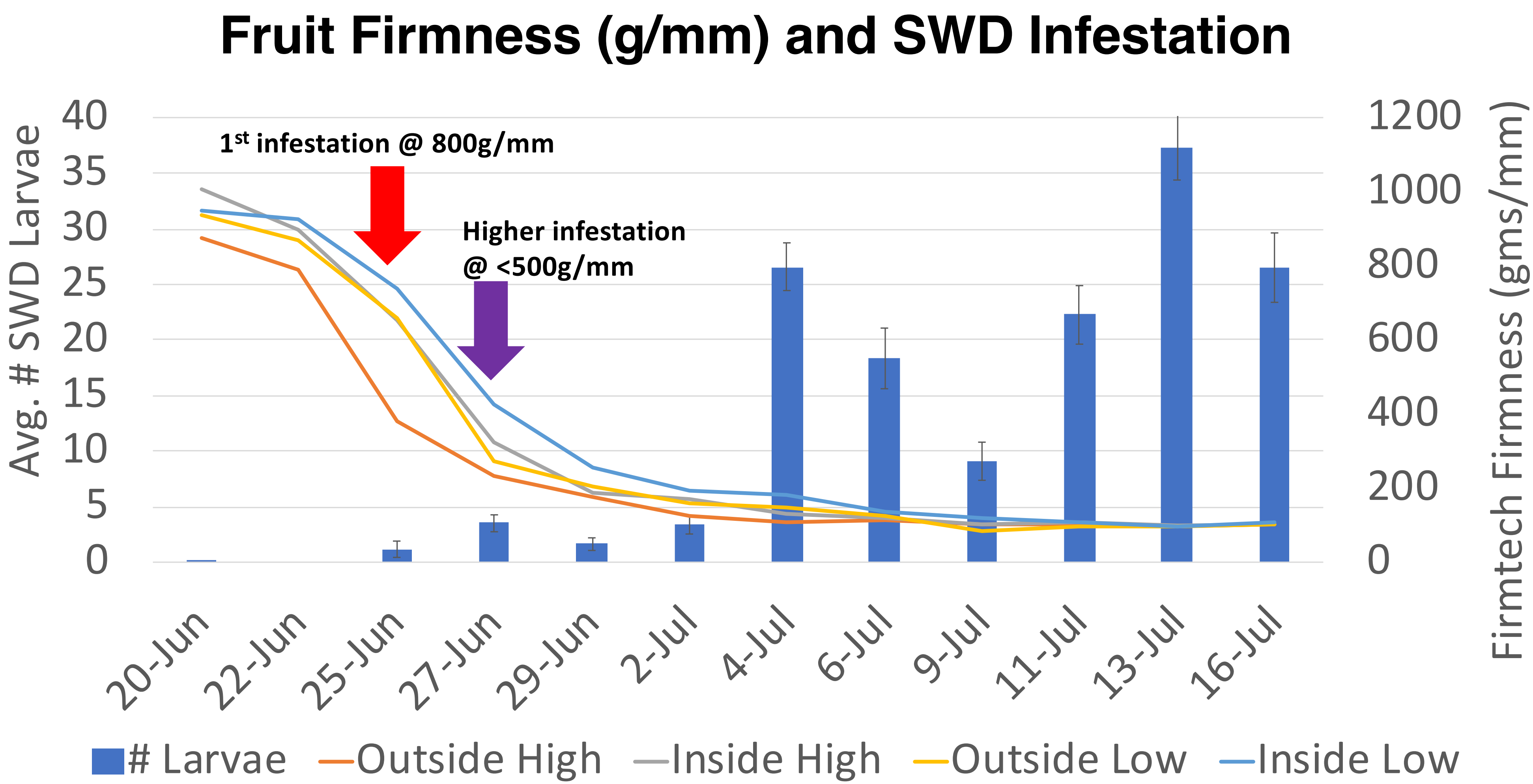
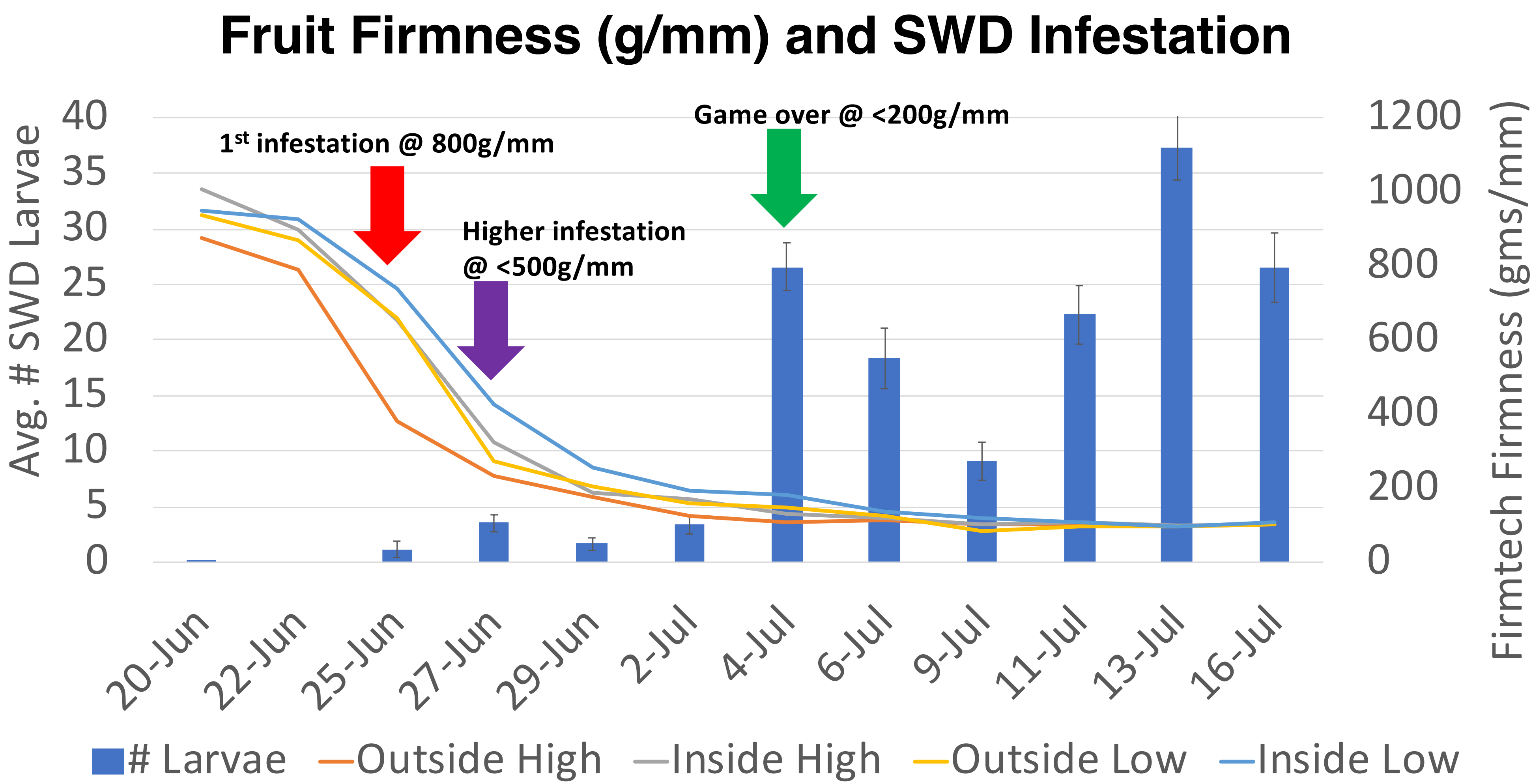
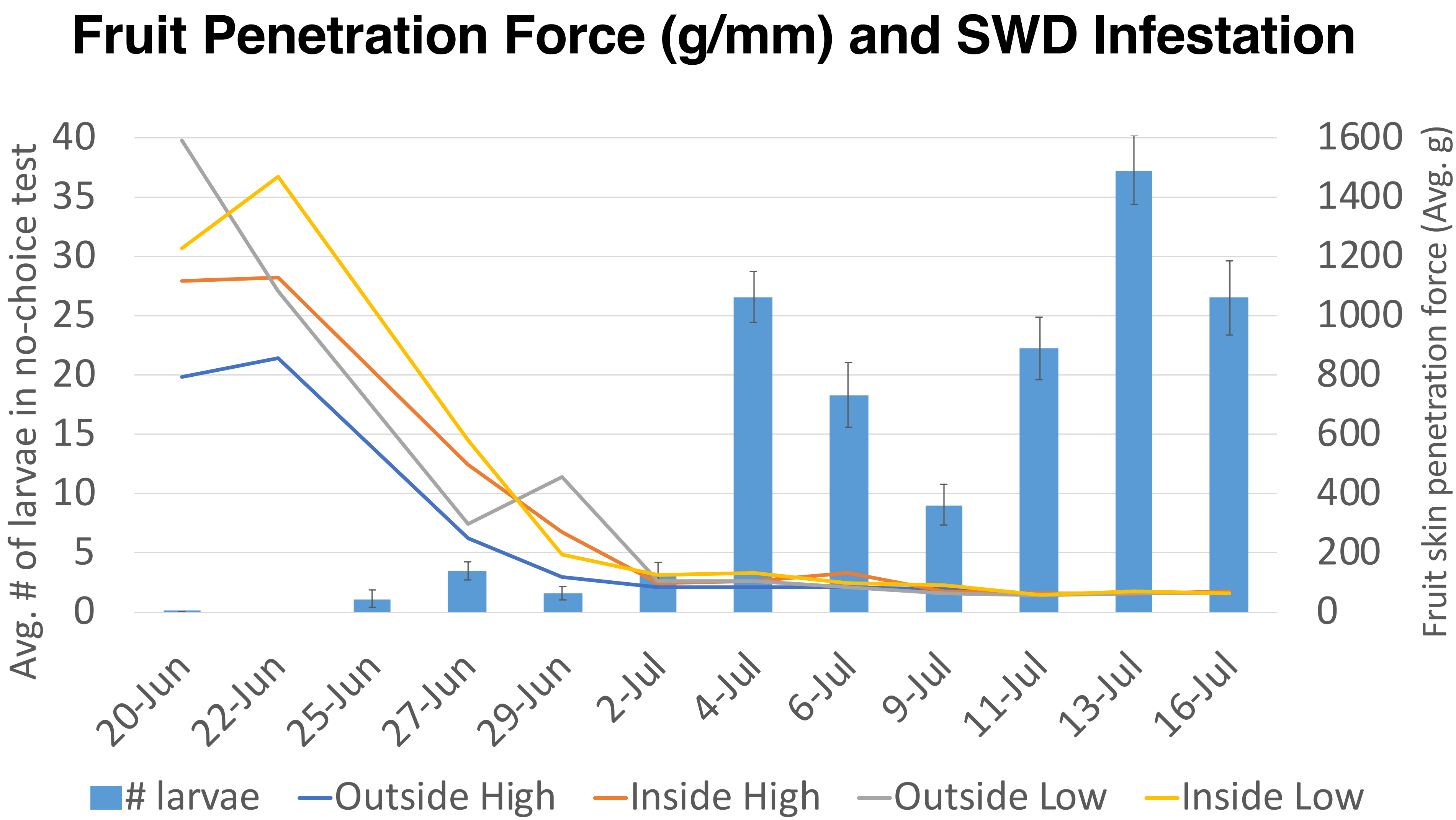

Fruit Firmness (g/mm) and SWD Infestation
Avg. # SWD Larvae
Firmtech Firmness (gms/mm)
0
5
10
15
20
25
30
35
40
0
200
400
600
800
1000
1200
20-Jun
22-Jun
25-Jun
27-Jun
29-Jun
2-Jul
4-Jul
6-Jul
9-Jul
11-Jul
13-Jul
16-Jul
Larvae
Outside High
Inside High
Outside Low
Inside Low



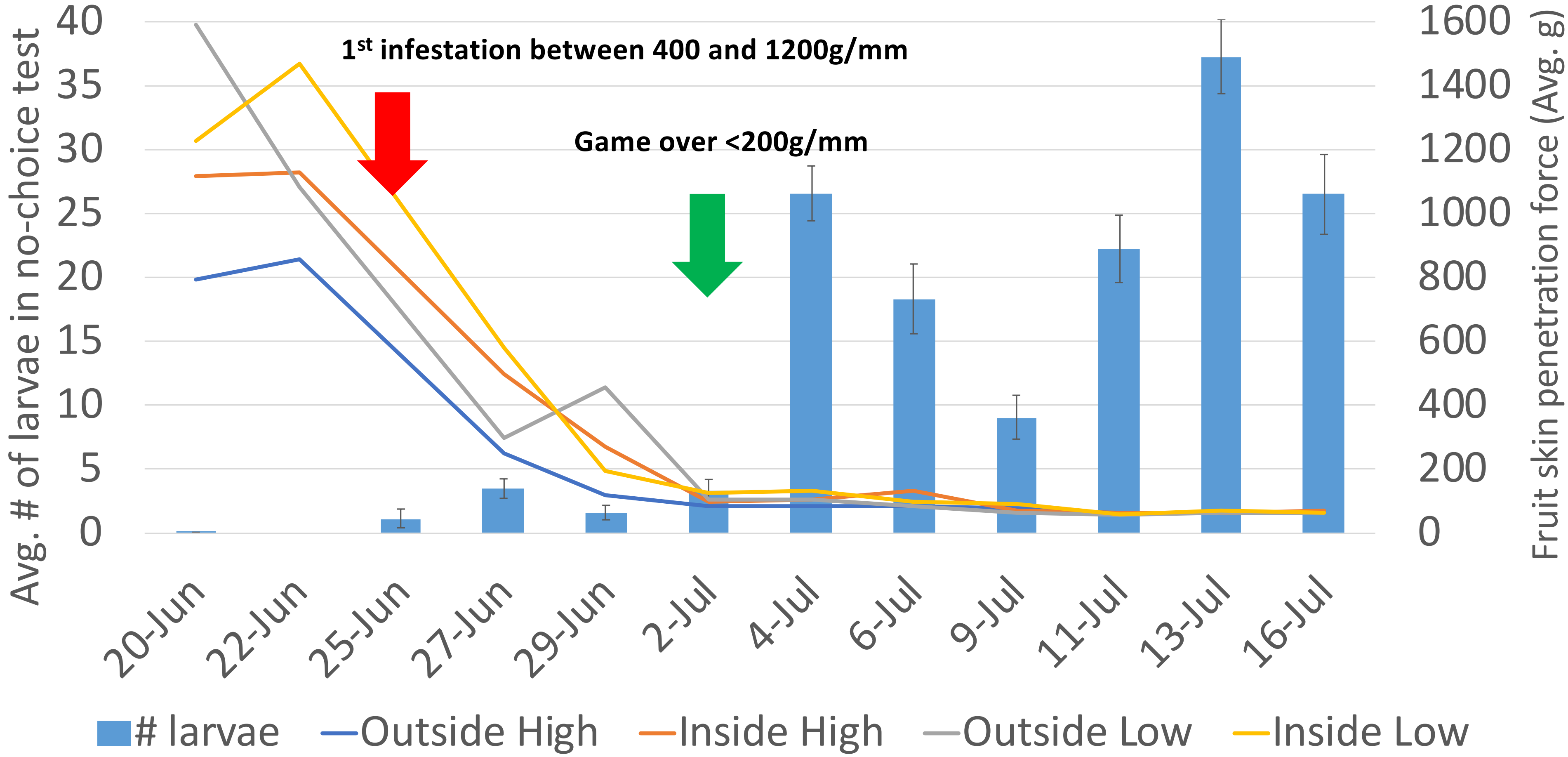
Fruit Firmness (g/mm) and SWD Infestation
1st infestation @ 800g/mm
Avg. # SWD Larvae
Firmtech Firmness (gms/mm)
40
35
30
25
20
15
10
5
0
1200
1000
800
600
400
200
0
20-Jun
22-Jun
25-Jun
27-Jun
29-Jun
2-Jul
4-Jul
6-Jul
9-Jul
11-Jul
13-Jul
16-Jul
Larvae
Outside High
Inside High
Outside Low
Inside Low


Fruit Firmness (g/mm) and SWD Infestation
Avg. # SWD Larvae
Firmtech Firmness (gms/mm)
1st infestation @ 800g/mm
Higher infestation
@ <500g/mm
0
5
10
15
20
25
30
35
40
0
200
400
600
800
1000
1200
20-Jun
22-Jun
25-Jun
27-Jun
29-Jun
2-Jul
4-Jul
6-Jul
9-Jul
11-Jul
13-Jul
16-Jul
Larvae
Outside High
Inside High
Outside Low
Inside Low


Fruit Firmness (g/mm) and SWD Infestation
Avg. # SWD Larvae
Firmtech Firmness (gms/mm)
1st infestation @ 800g/mm
Higher infestation
@ <500g/mm
Game over @ <200g/mm
0
5
10
15
20
25
30
35
40
0
200
400
600
800
1000
1200
20-Jun
22-Jun
25-Jun
27-Jun
29-Jun
2-Jul
4-Jul
6-Jul
9-Jul
11-Jul
13-Jul
16-Jul
Larvae
Outside High
Inside High
Outside Low
Inside Low


Fruit Penetration Force (g/mm) and SWD Infestation
Avg. # of larvae in no-choice test
Fruit skin penetration force (Avg. g)
0
5
10
15
20
25
30
35
40
0
200
400
600
800
1000
1200
1400
1600
20-Jun
22-Jun
25-Jun
27-Jun
29-Jun
2-Jul
4-Jul
6-Jul
9-Jul
11-Jul
13-Jul
16-Jul
larvae
Outside High
Inside High
Outside Low
Inside Low

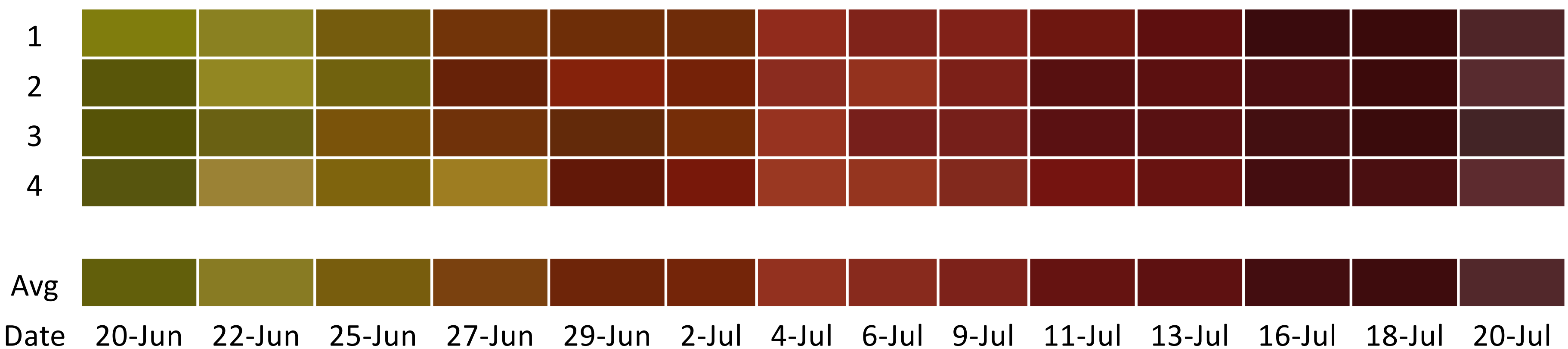
Fruit Penetration Force (g/mm) and SWD Infestation



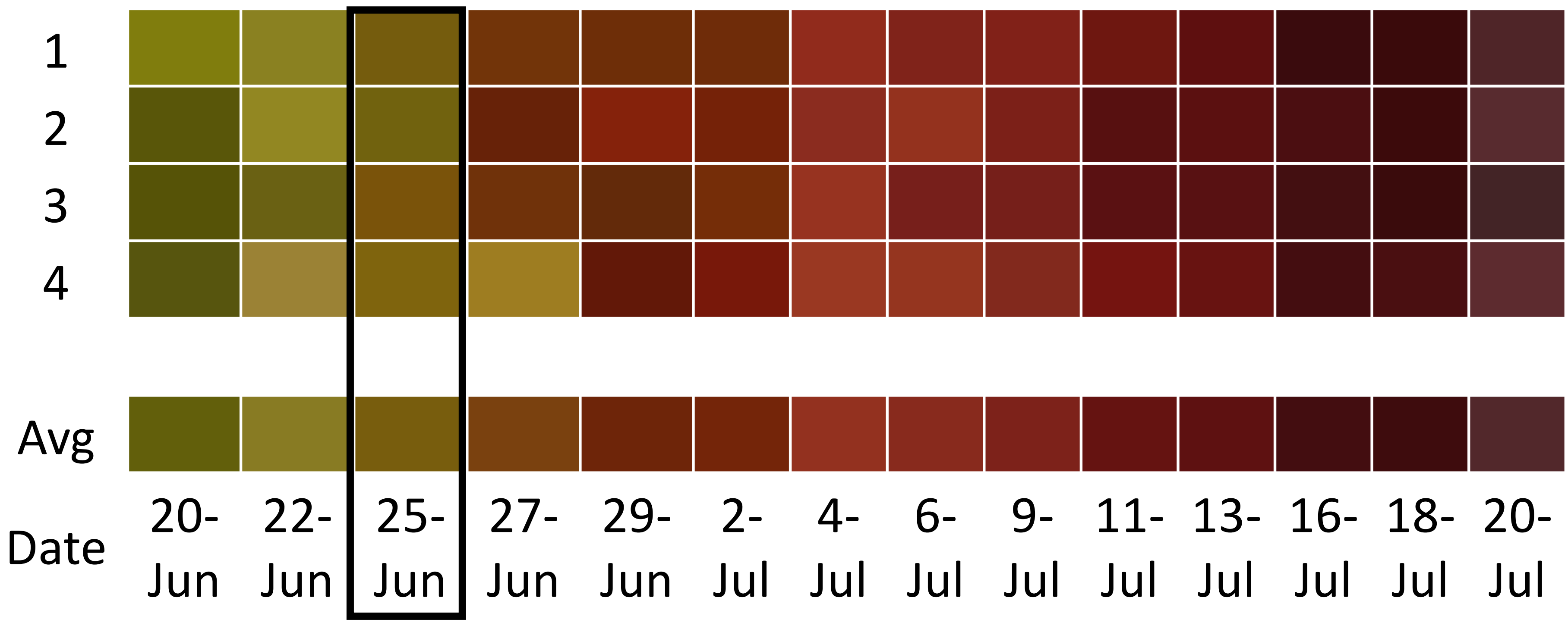
Color

- Are SWD females attracted to red fruit?
  - Is color an indicator when to begin spray program?
- Collected 25 random from four regions of tree
  - Snapped a picture of fruit in a light box
  - Analyzed individual fruit for RGB

Average Fruit Color by Date



Average Fruit Color by Date



J. Amer. Soc. Hort. Sci. 131(5):601–607. 2006.

Phenological Models of Flower Bud Stages and Fruit Growth of 'Montmorency' Sour Cherry Based on Growing Degree-day Accumulation

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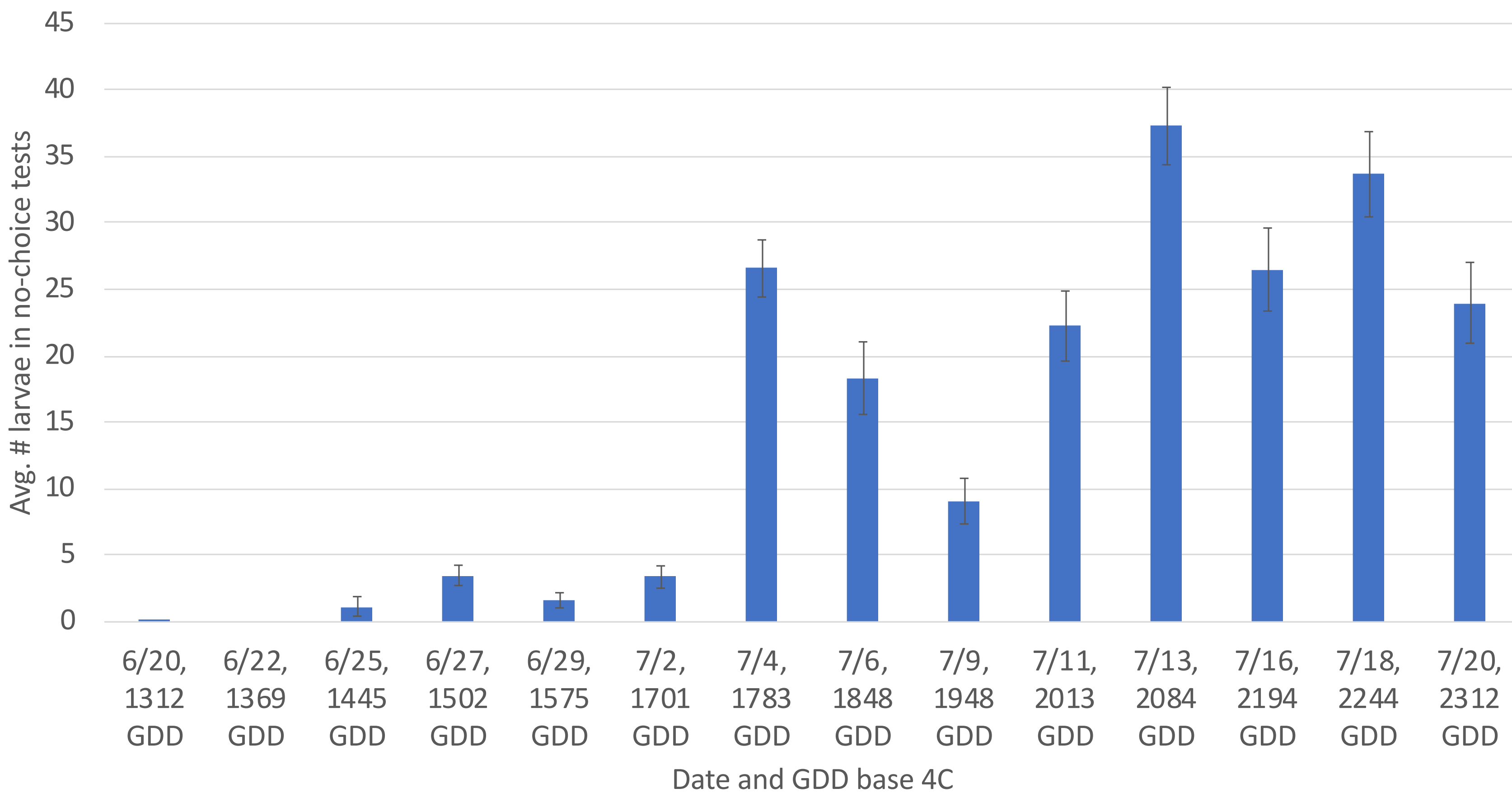
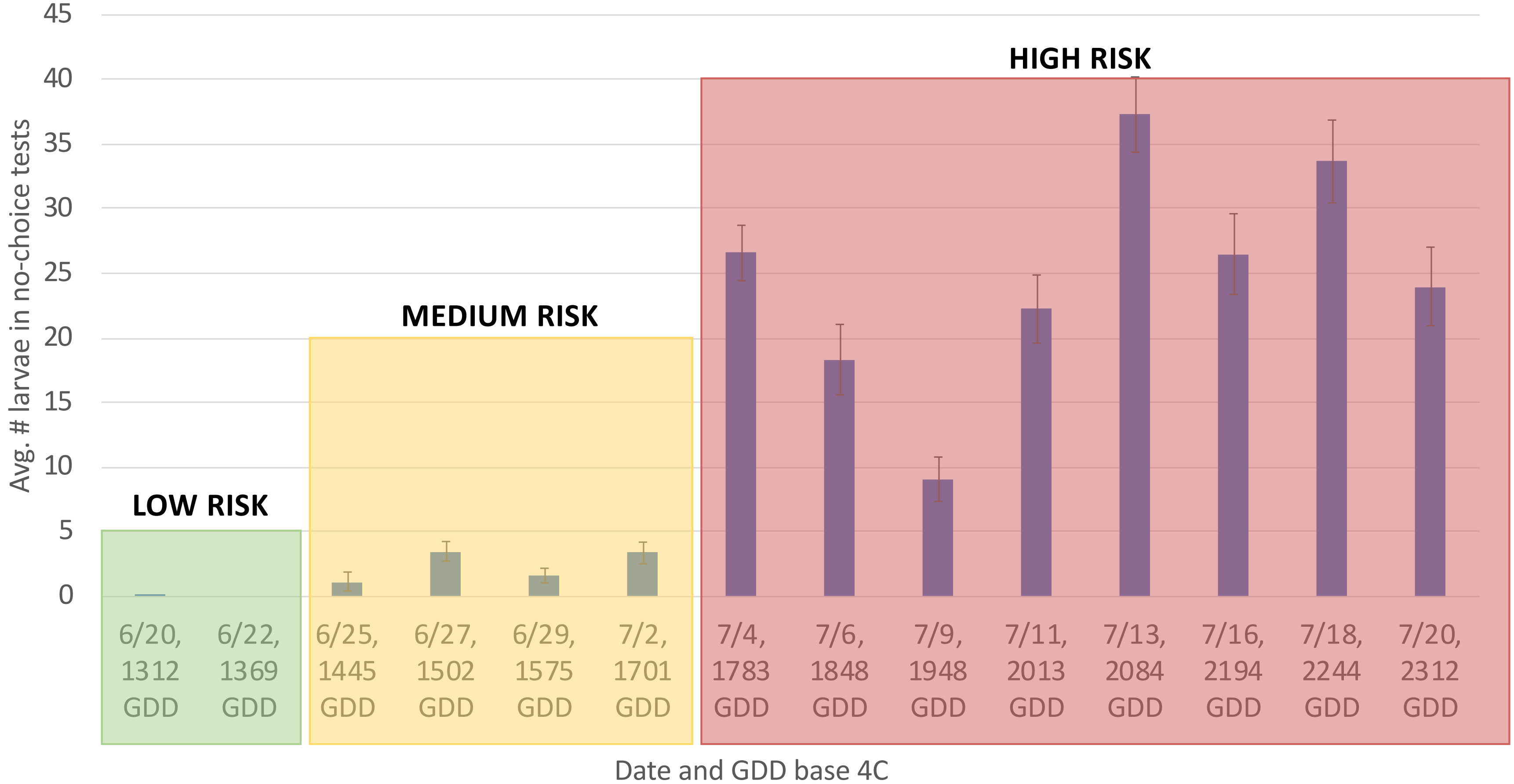
Additional index words. growth model, *Prunus cerasus*, phenology, fruit diameter, tart cherry

Abstract. A simulation model for determining flower bud phenological stages and fruit growth as a function of daily maximum and minimum temperatures was developed for 'Montmorency' sour cherry (*Prunus cerasus* L.). The models were developed and tested with observations collected in the three major sour cherry production areas in Michigan located in northwestern, western central, and southwestern sections of the lower peninsula. Observations of flower bud phenology and fruit diameter were collected at 3- to 7-day intervals, in spurs and terminal shoots across multiple years. Nonlinear equations using accumulation of growing degree-days (base 4 °C) as an independent variable were fitted to observed flower bud phenological stages and fruit diameter, expressed as percentage of final fruit diameter. Simulated bud phenology stages were in agreement with observed data. Mean differences of simulated vs. observed dates of early phenological stages in the three production areas were between 4 and 1 days for side green and near 0 days for tight cluster, while during later stages (e.g., first bloom and full bloom) mean differences ranged from –2 to 0 days. Means differences of predicted fruit diameter were in the range of 0 to –3 days. Needing only daily temperature data, these simulation models have potential applicability in improving the timing and efficiency of management decisions related to crop phenology, such as pest control, fertilization, and irrigation.

Michigan is the leading producer of sour cherry in the United States, accounting for approximately 70% (90,400 Mg) of the U.S. sour cherry production in the period 1995–2004 (National Agricultural Statistic Service, 2005). The main sour cherry 2003). The timing of specific flower bud phenological stages can be used as a climatological indicator at the regional level and contribute to the evaluation of possible impacts of climate change and variability.



GDD based on 1 March start date; coincides with phenological development model


HIGH RISK
MEDIUM RISK
LOW RISK
Avg. # larvae in no-choice tests
45
40
35
30
25
20
15
10
5
0
6/20, 1312 GDD
6/22, 1369 GDD
6/25, 1445 GDD
6/27, 1502 GDD
6/29, 1575 GDD
7/2, 1701 GDD
7/4, 1783 GDD
7/6, 1848 GDD
7/9, 1948 GDD
7/11, 2013 GDD
7/13, 2084 GDD
7/16, 2194 GDD
7/18, 2244 GDD
7/20, 2312 GDD
Date and GDD base 4C

When Should Growers Initiate Management Programs to Beat SWD?

- **First adult fly catch?**

Not a great gauge but an initial indicator

- **Adult fly trap count?**

Helpful to know when populations rise,

but initiating programs based on adult catch is risky

Regional trap catch may be better indicator than single traps on a farm

- **Fruit physiology?**

Future research is needed in this area

2019 Research Goals

- Test individual fruits:
  - Brix, weight, color, penetration force, and firmness
  - Place those fruits into choice bioassays
    - Direct timing ‘when’ fruit becomes infested by SWD
  - Goal is to link fruit physiological parameters to GDD and SWD infestation
  - Refine risk model to help growers initiate SWD management programs

Acknowledgments

- Growers
- NWHMRC Team:
  - E. Pochubay, K. Powers, J. Zelinski, B. Klein, M. Anderson
  - NWMHRC Foundation
- L. Gut and R. Isaacs labs

Project GREEEN

MONTMORENCY TART CHERRIES

Michigan State HORTICULTURAL Society

AgBio Research

MSU EXTENSION