The establishment of a new pest: Phenology, crop susceptibility, and impact of landscape on spotted wing drosophila

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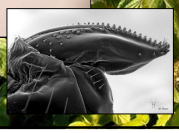
Spotted Wing Drosophila: SWD

- Diptera: Drosophilidae: *Drosophila suzukii*

- 1/8 to 1/5 inch long



Why is SWD such a problem?

Oviposit in ripening and ripe fruit

Photo Credit: E. Beers, WSU

World Distribution

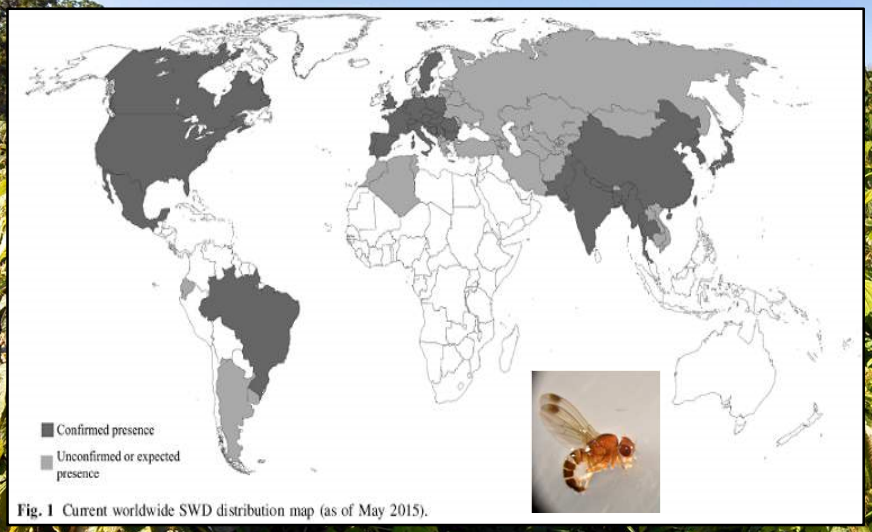
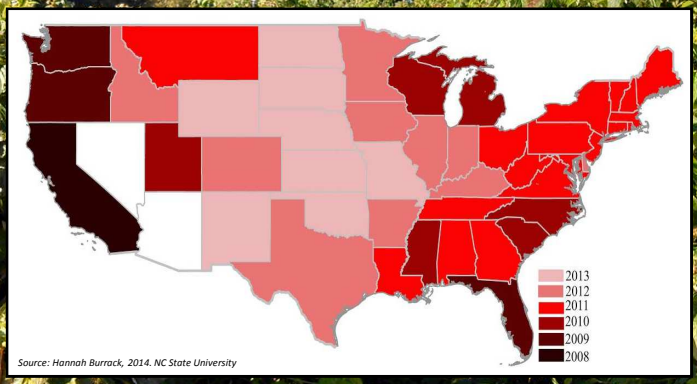


Fig. 1 Current worldwide SWD distribution map (as of May 2015).

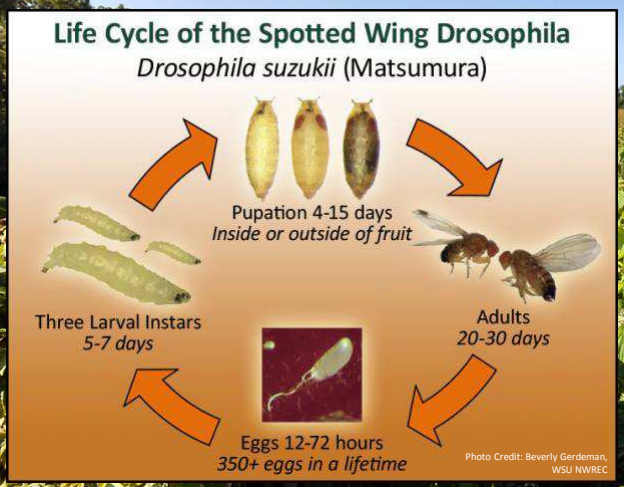
16, Journal of Pest Science

US Distribution and economics

- First detected in California in 2008
- Crop losses estimated at $720 million annually
- Costs of SWD management estimated at $130-170 million



Life cycle



- Female lay 1-3 eggs into ripening fruit
- Females can start laying eggs one day after adult emergence
- Multiple generations per year
- Optimal development at 65-79°F
- 12 day egg to adult
- Adults live 3-6 weeks

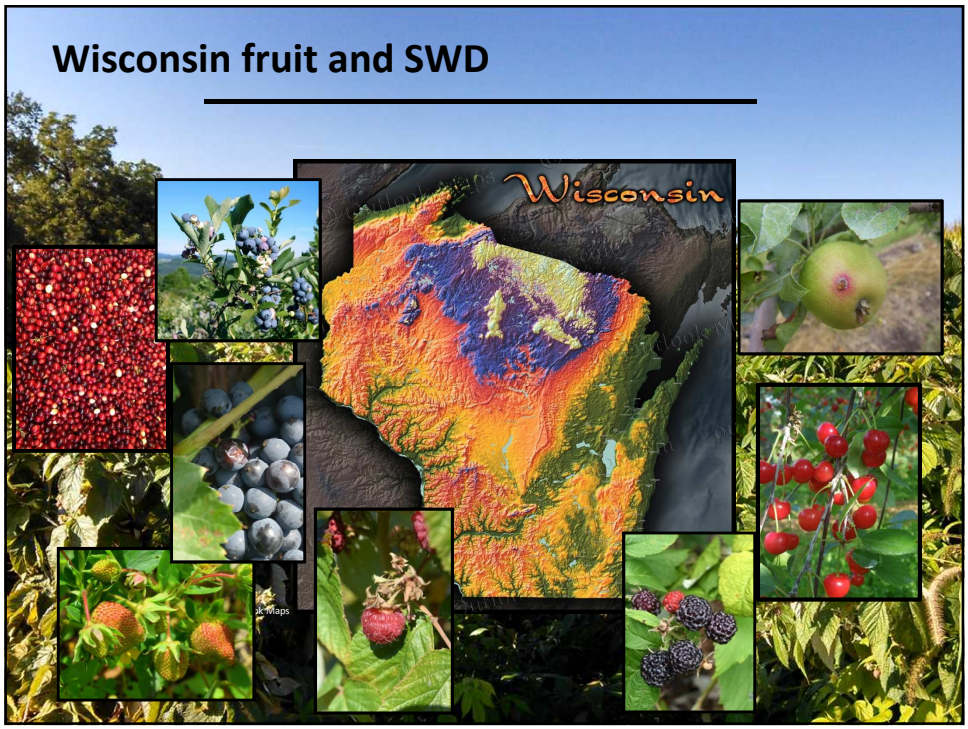
Susceptible fruits

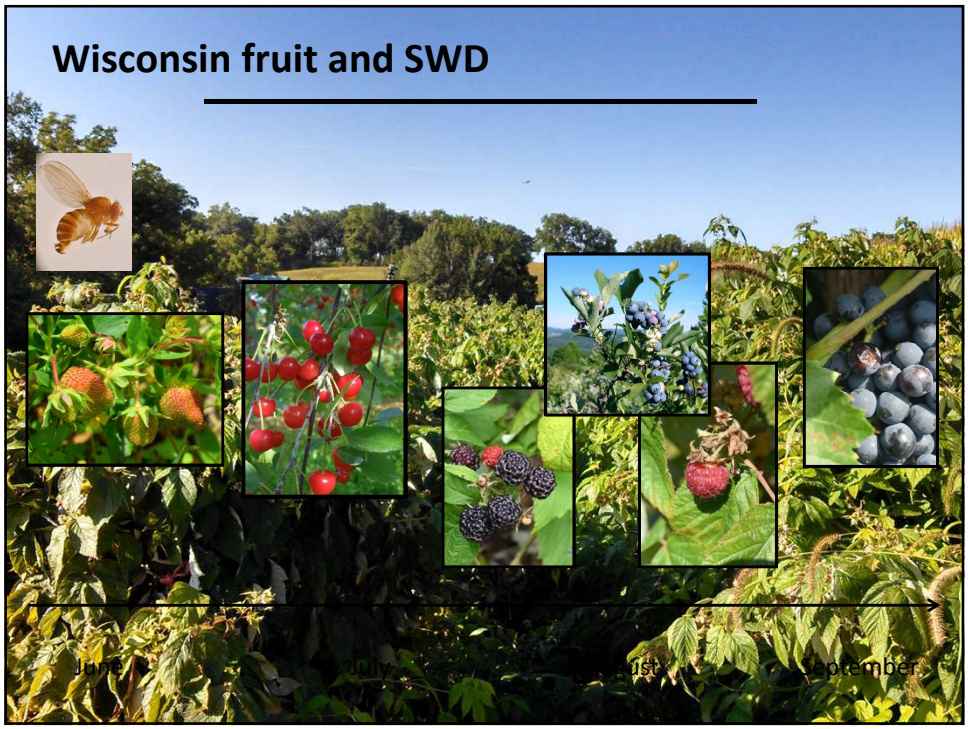
Highest risk	Moderate risk	Alternate hosts
Raspberries	Peaches	Snowberry
Blueberries	Grapes	Elderberry
Cherries	Pears	Pokeweed
Blackberries	Nectarines	Dogwood
Strawberries		Honeysuckle
		Bittersweet nightshade...



Damage from SWD and management

Management: cultural controls, sanitation, and chemical controls


Wisconsin fruit and SWD
Wisconsin


Wisconsin fruit and SWD
June
July
August
September

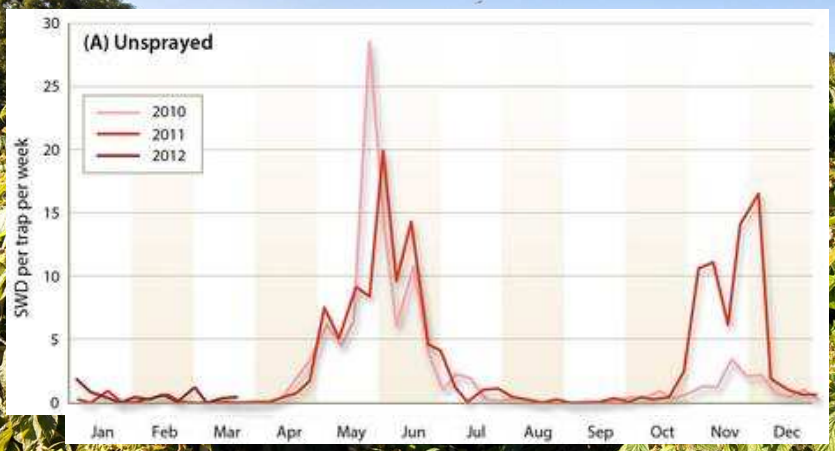
Outline

Phenology: First detection, abundance, peak, end of capture
Seasonal morphs and reproductive status of females

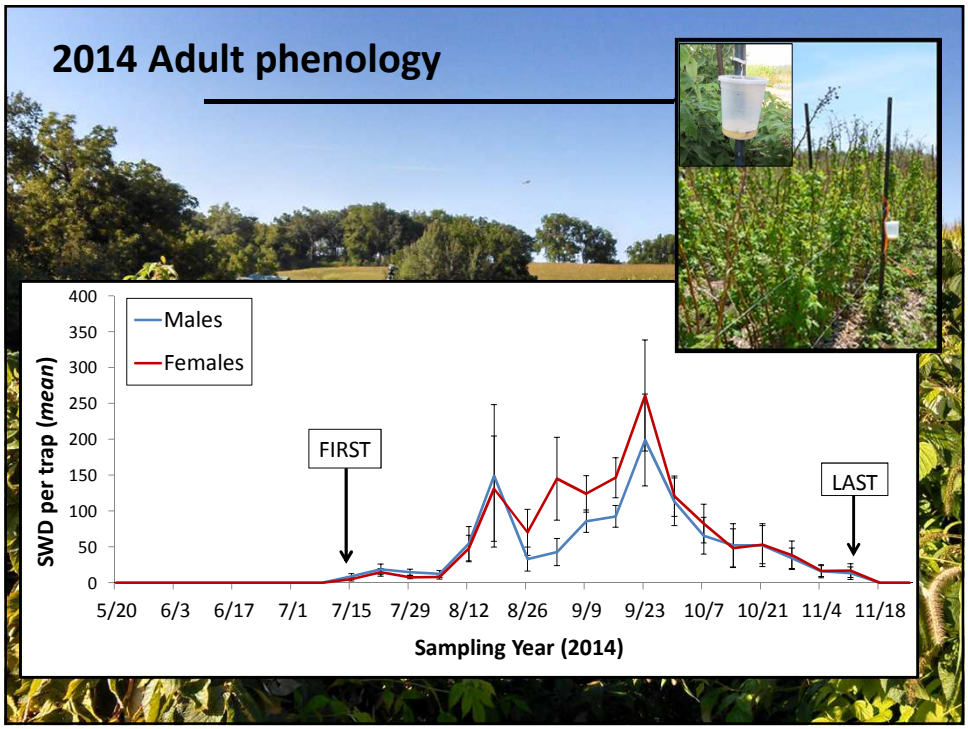
Effect of landscape

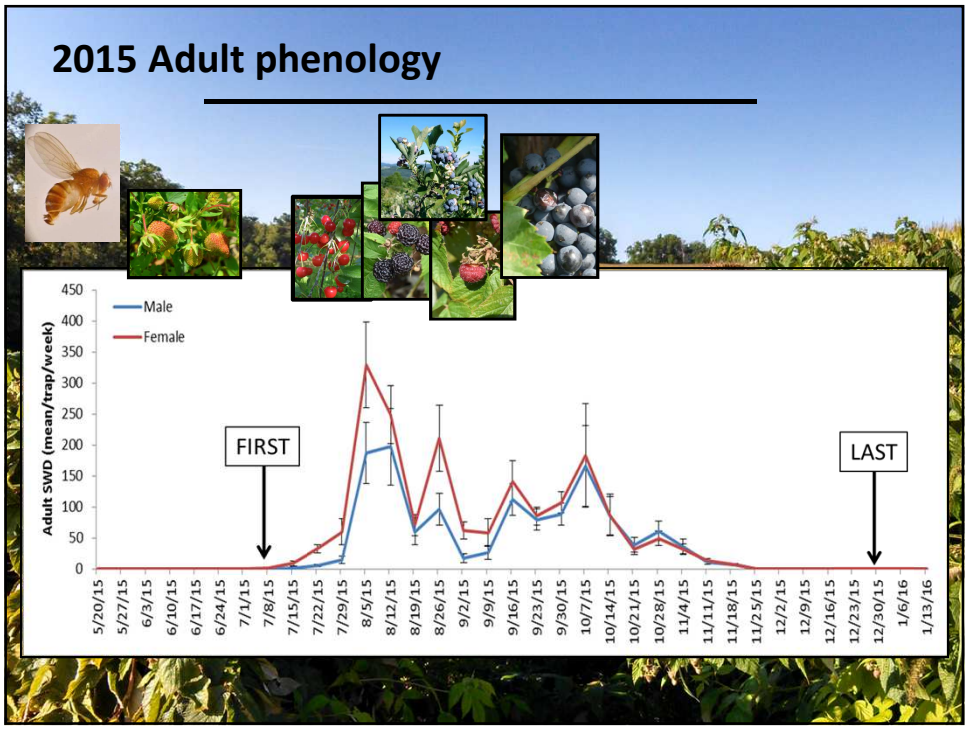
Susceptible crops: grape, aronia

Phenology in California

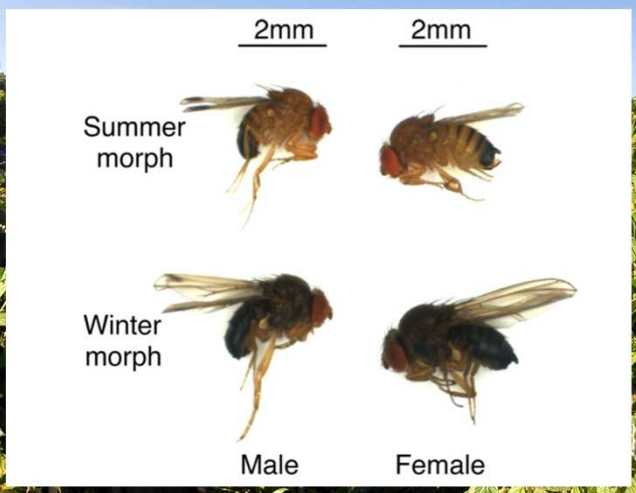


Cormier et al. 2016. *California Agriculture* 70(1): [illegible] DOI: 10.[illegible]


2014 Adult phenology
Males
Females
FIRST
LAST
SWD per trap (mean)
400
350
300
250
200
150
100
50
0
5/20
6/3
6/17
7/1
7/15
7/29
8/12
8/26
9/9
9/23
10/7
10/21
11/4
11/18
Sampling Year (2014)


2015 Adult phenology
Male
Female
FIRST
LAST
Adult SWD (mean/trap/week)
450
400
350
300
250
200
150
100
50
0
5/20/15
5/27/15
6/3/15
6/10/15
6/17/15
6/24/15
7/1/15
7/8/15
7/15/15
7/22/15
7/29/15
8/5/15
8/12/15
8/19/15
8/26/15
9/2/15
9/9/15
9/16/15
9/23/15
9/30/15
10/7/15
10/14/15
10/21/15
10/28/15
11/4/15
11/11/15
11/18/15
11/25/15
12/2/15
12/9/15
12/16/15
12/23/15
12/30/15
1/6/16
1/13/16

Seasonal adaptations to cold temperatures



Seasonal adaptations to cold temperatures

Can survive several months at 33.8 F

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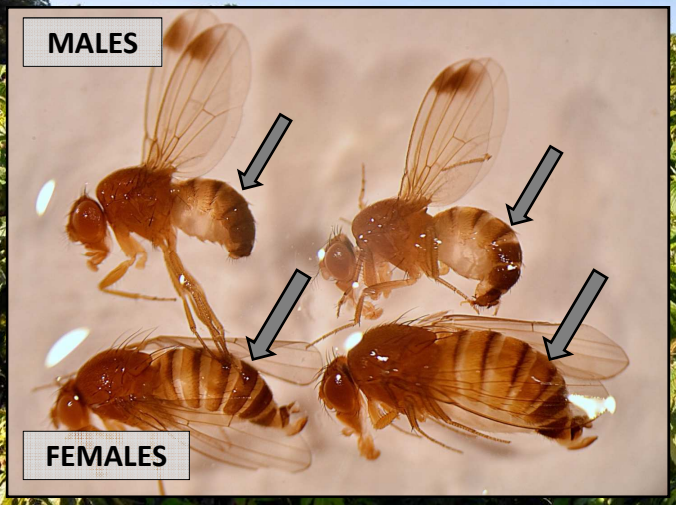
14 F <10% died

-4 F 90% died

Stephens et al. 2015

WINTER-MORPH

SUMMER-MORPH



Can't survive 3 months at 50 F

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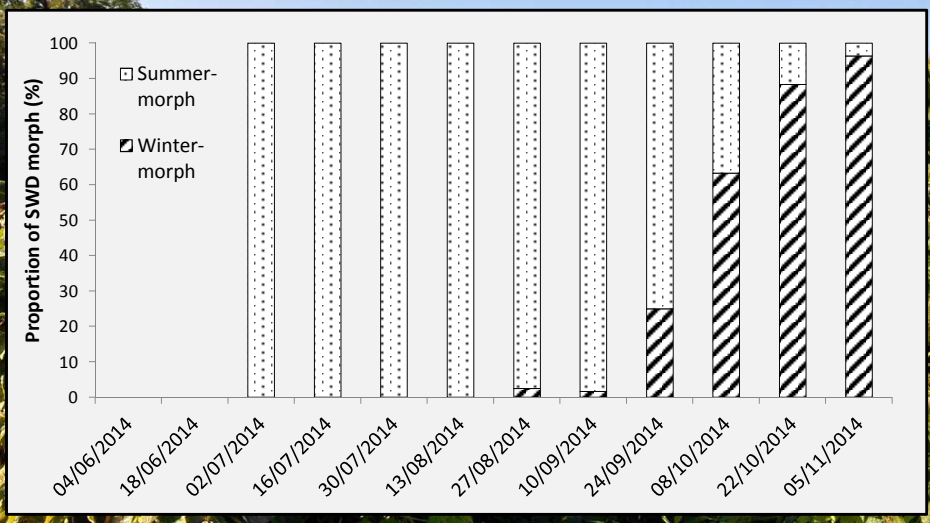
14 F 50% died

-4 F 100% died

Stephens et al. 2015

Seasonal morphs in WI



Seasonal morphs: reproductive status of females

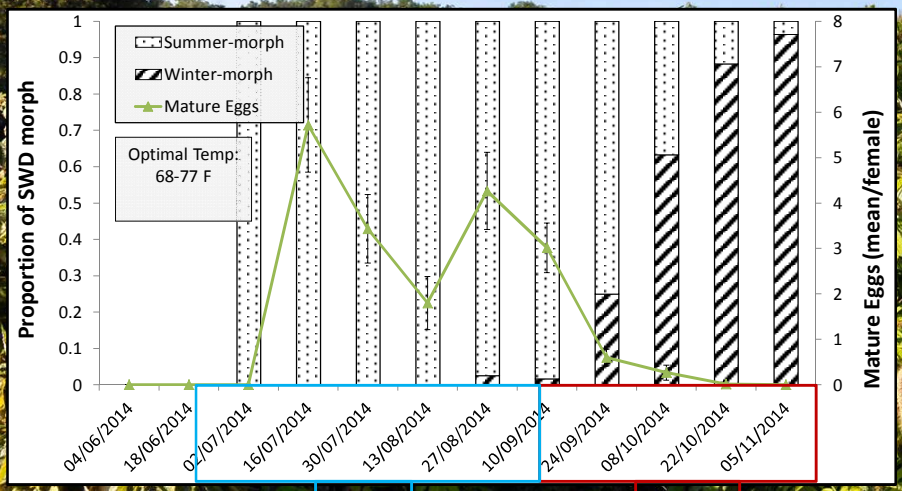
Presence of immature eggs

	Immature Eggs	
Morph	Absence	Presence
Summer	126	249
Winter	104	52

X^2 (1, N = 531) = 47.72, p < 0.001

Seasonal morphs: reproductive status of females

Number of mature eggs between morphs



Seasonal morphs: mature eggs

Number of mature eggs between morphs

Morph	*Mature Eggs (mean)*	*± SE*	*Count*
Summer	3.03	0.29	375
Winter	0.08	0.05	156

H = 84.918, d.f. = 1, $p < 0.001$

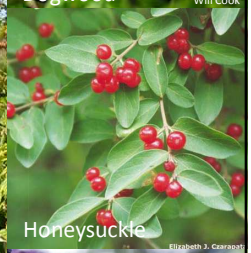
Outline

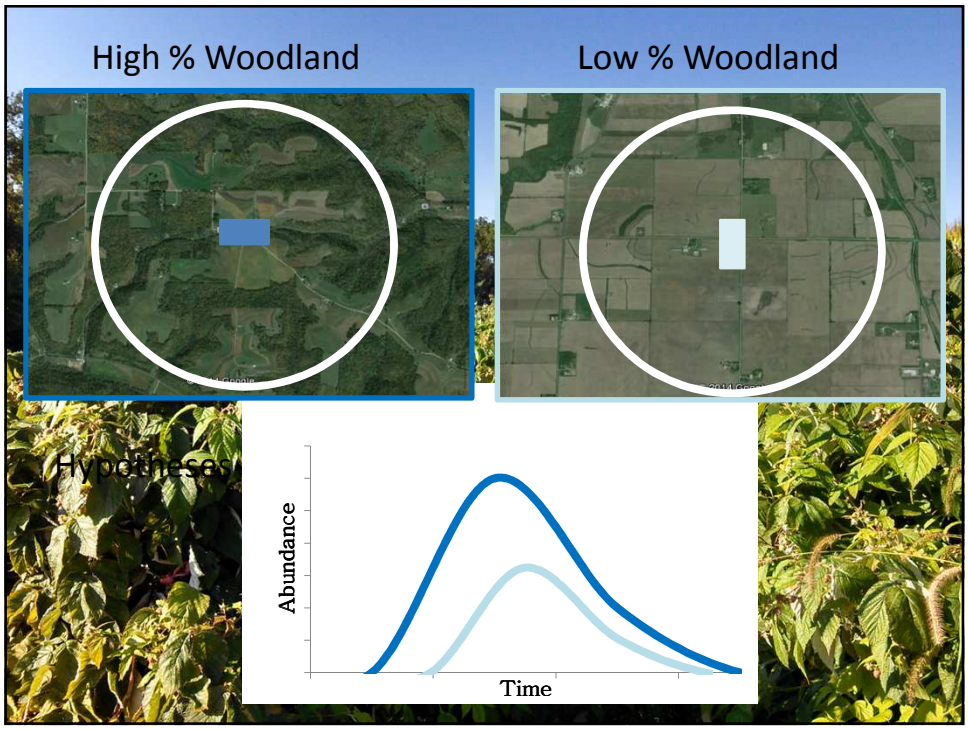
Phenology: First detection, abundance, peak, end of capture
Seasonal morphs and reproductive status of females

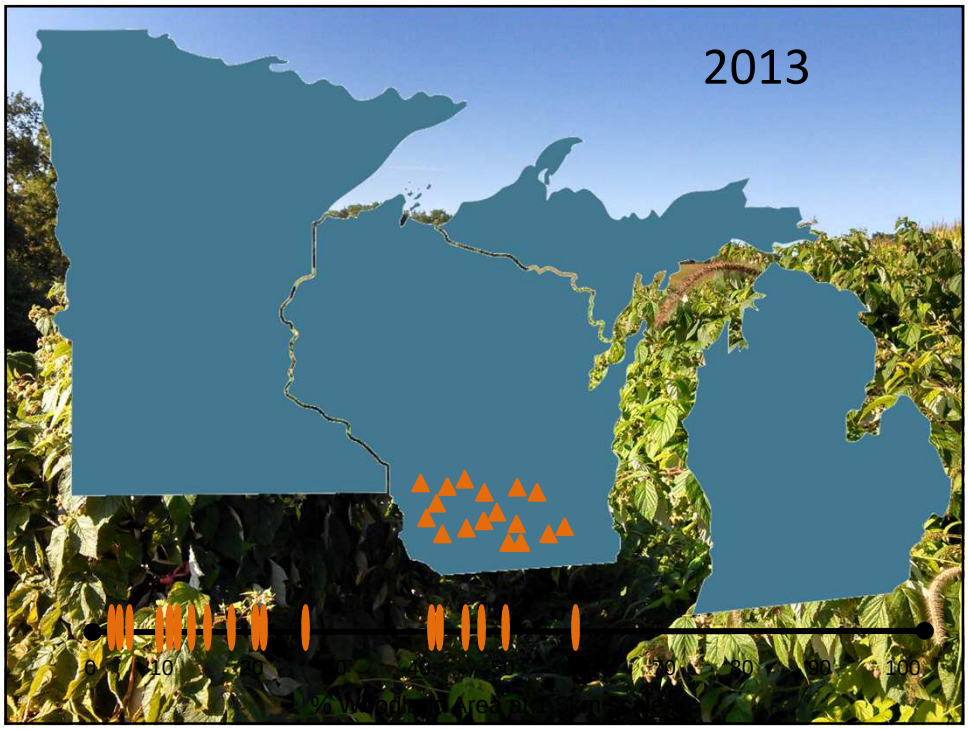
Effect of landscape

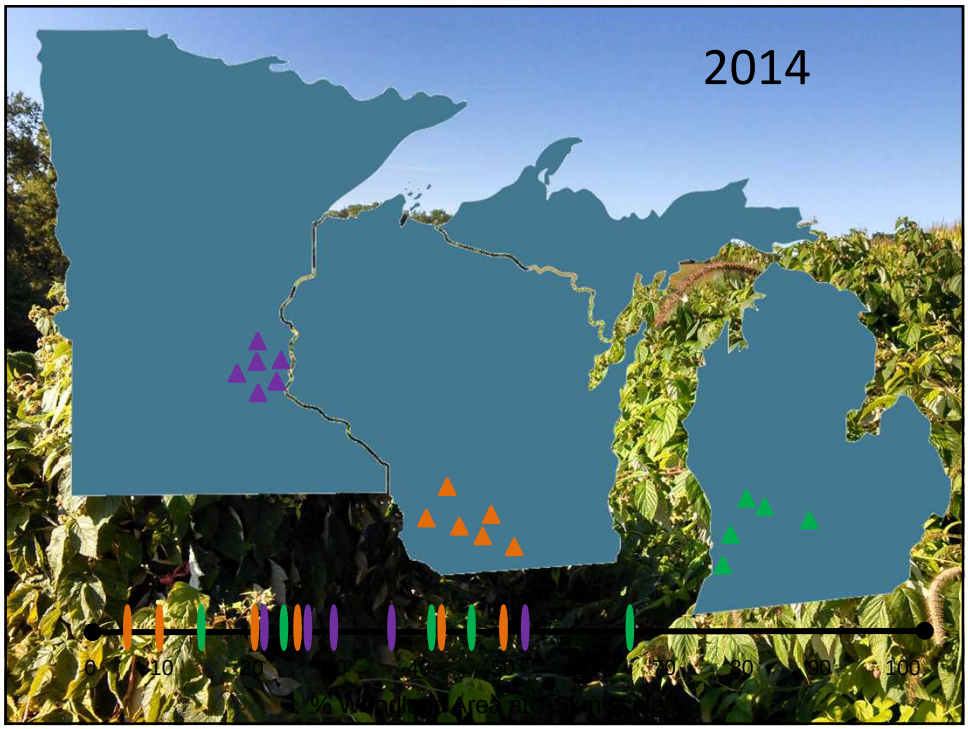
Susceptible crops: grape, aronia

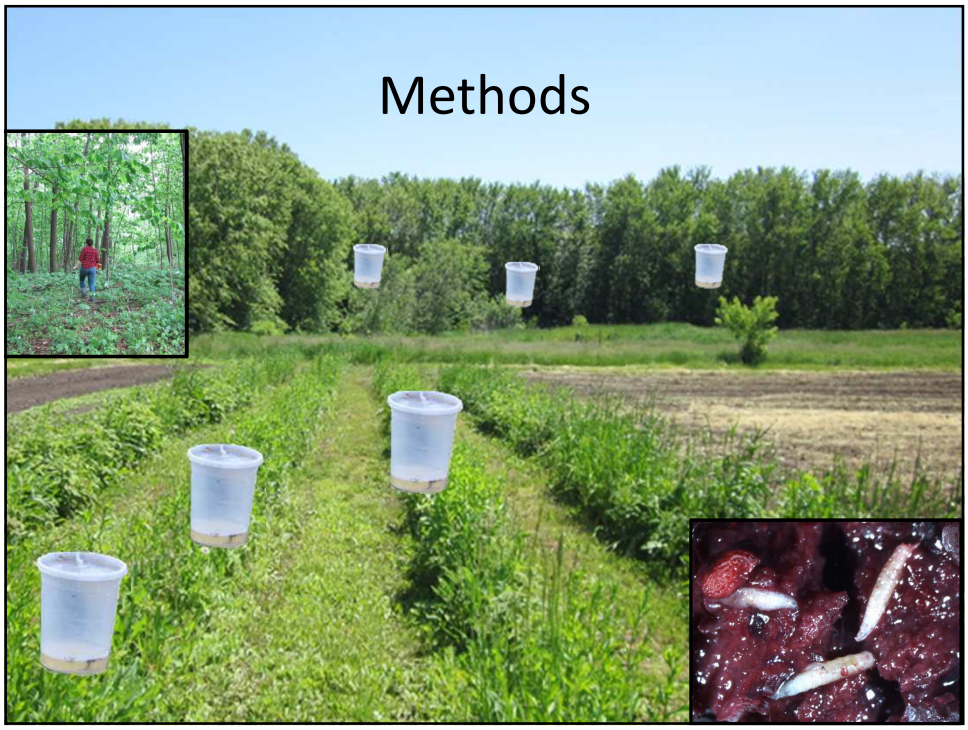
Does amount of woodland in surrounding landscape affect timing and population abundance of *D. suzukii*?




High % Woodland
Low % Woodland
Hypotheses
Abundance
Time

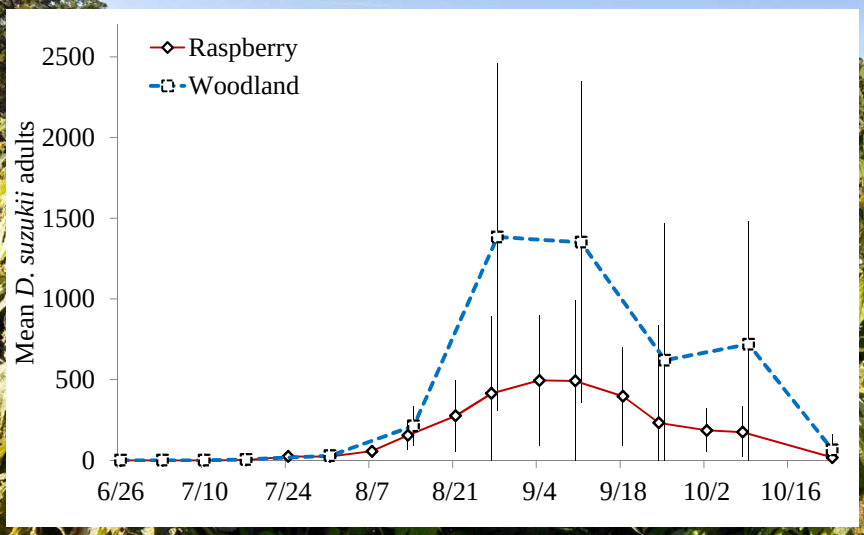

2013
0
10
70
80
90
100


2014
0
10
70
80
90
100


Methods

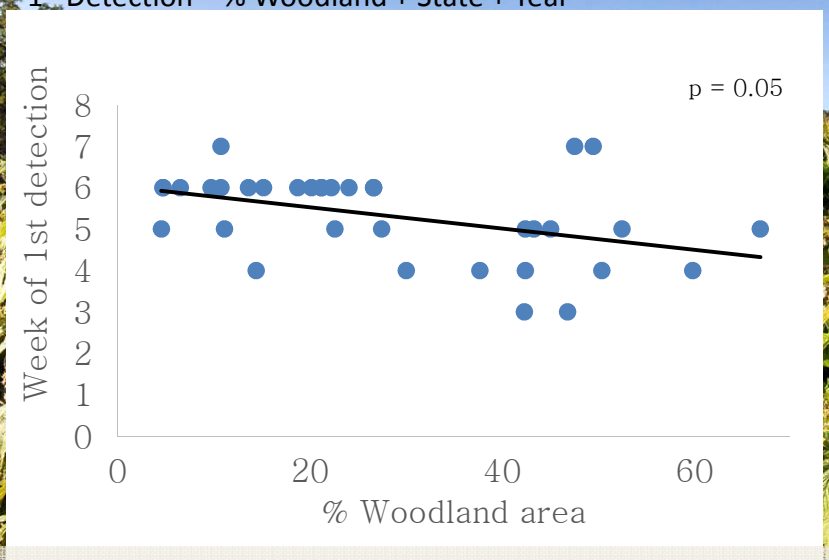
Phenology per habitat

2013

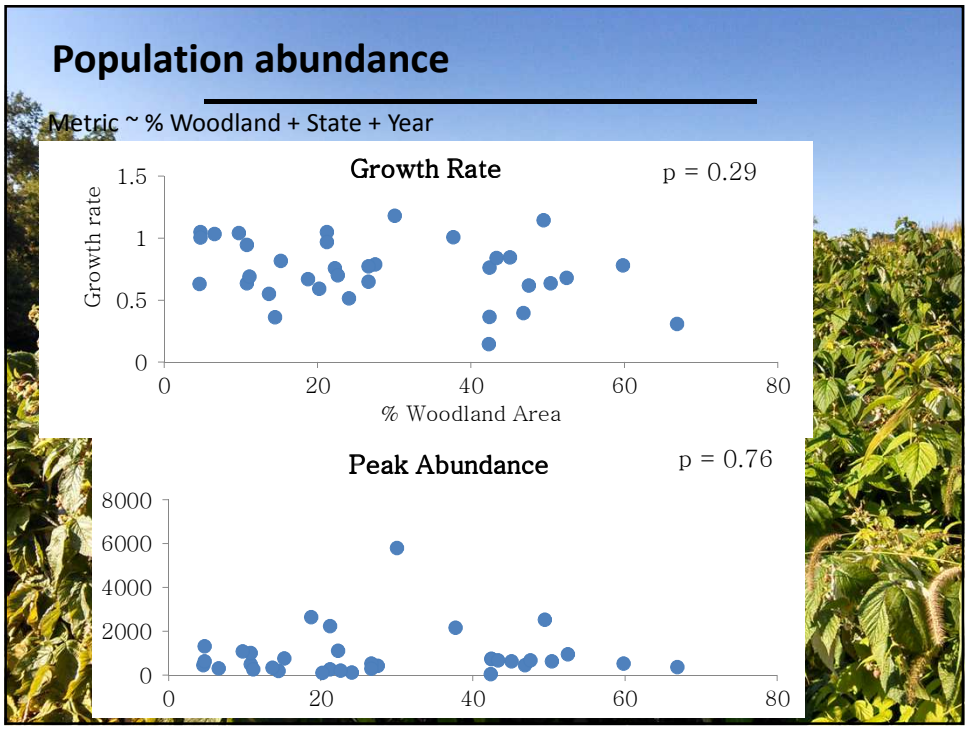


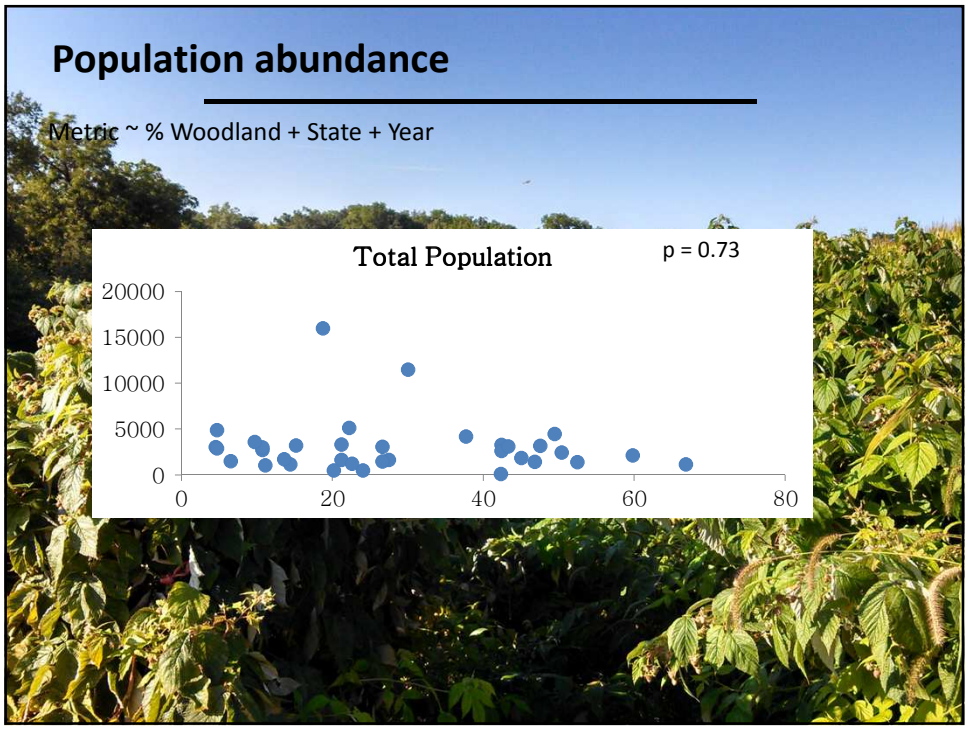
1st Detection

1st Detection ~ % Woodland + State + Year



Flies appear 1-2 weeks earlier in highly wooded areas


Population abundance
Metric ~ % Woodland + State + Year
Growth Rate
p = 0.29
Growth rate
1.5
1
0.5
0
0
20
40
60
80
% Woodland Area
Peak Abundance
p = 0.76
8000
6000
4000
2000
0
0
20
40
60
80


Population abundance
Metric ~ % Woodland + State + Year
Total Population
p = 0.73
20000
15000
10000
5000
0
0
20
40
60
80

Larval infestation

- Larval infestation not correlated to % woodland
  (Larvae ~ Woodland + Adults, p = 0.1)
- Positively correlated to adult trap catches of concurrent week
  (Larvae ~ Adults, p = 0.048)
- 79% of 65 fruit samples
- 99% larvae were *D. suzukii*
- mean 200 larvae/pound

Outline

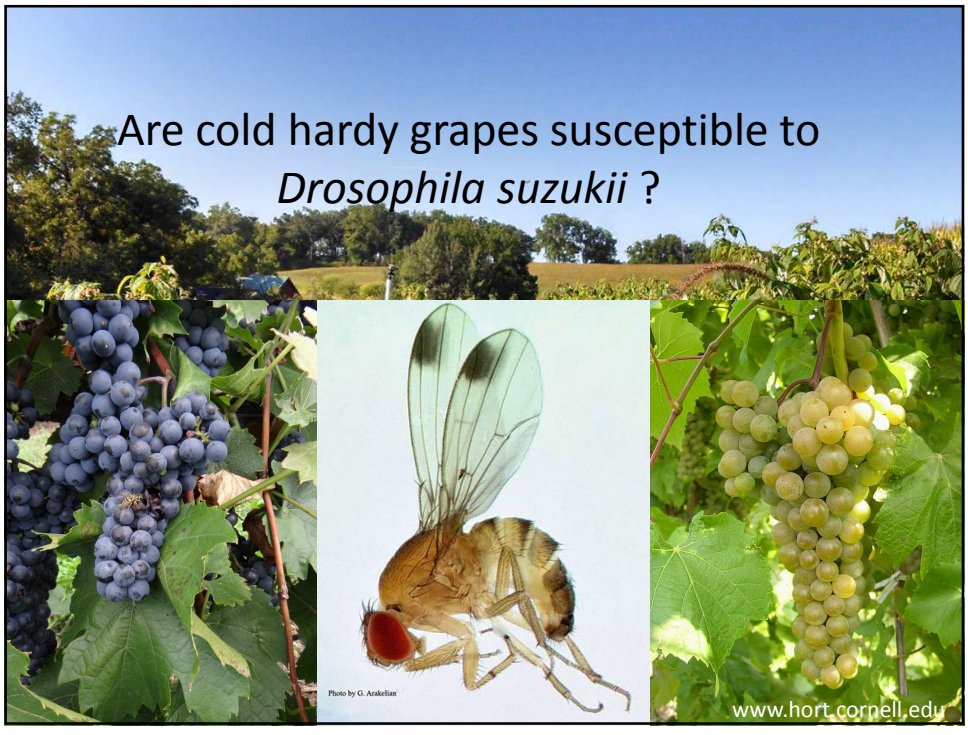
Phenology: First detection, abundance, peak, end of capture
Seasonal morphs and reproductive status of females

Effect of landscape

Susceptible crops: grape, aronia

Vitis vinifera *V. labrusca* *V. riparia* *V. vinifera*

- Field infestation in parts of the US, Europe, Japan
- Status as a pest unclear, but management is occurring
- Low susceptibility shown in lab experiments (Lee et al. 2011)



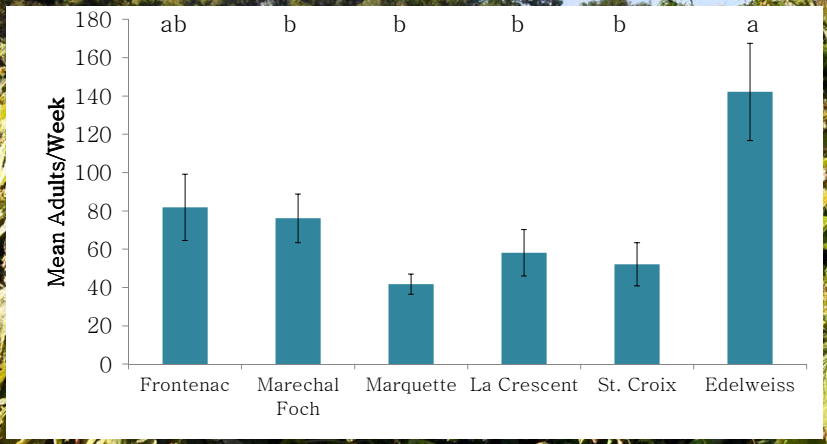
Field assessment

Are there susceptibility differences in varieties?
Does adult presence = infestation?

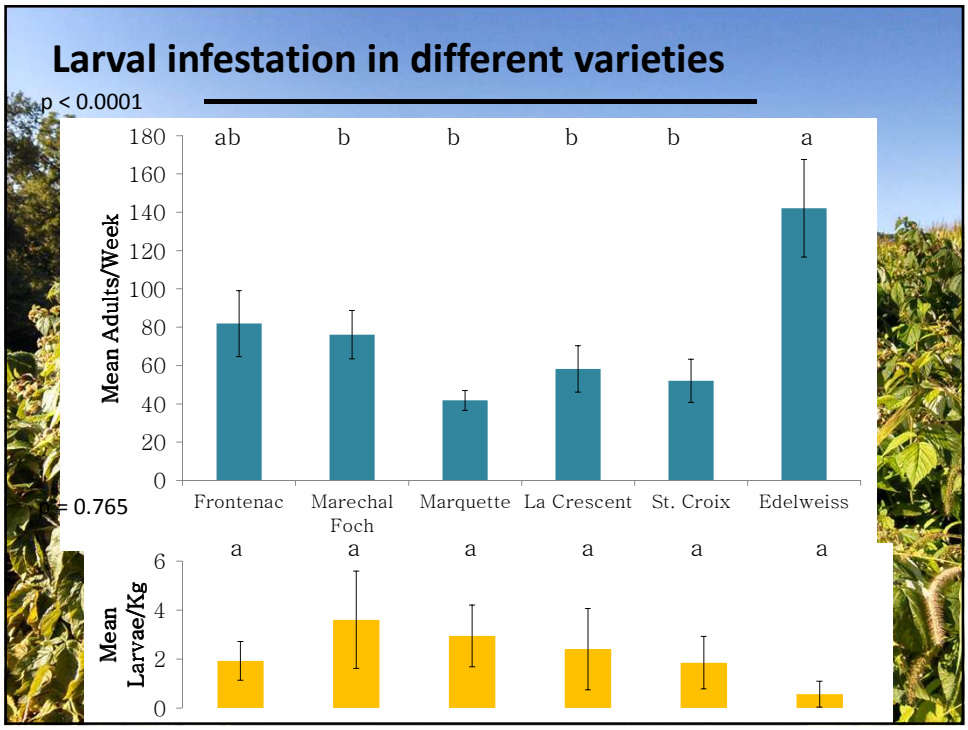
Methods: Adult & larval monitoring
in six commonly grown wine grape varieties

Adult trap catches in different varieties

$p \leq 0.0001$



Larval infestation in different varieties



Larval infestation

- 15% of 151 samples
- 100% *D. suzukii*
- Low abundance
  - 4 larvae/lb grapes
  - 200 larvae/lb raspberry
- Not correlated to adult trap catch or variety
- Larval infestation more prevalent near harvest

Field assessment

- No consistent varietal differences
- Adult presence ≠ larval infestation
- Field larval infestations possible, but at low levels

What cause low levels of infestation in cold-hardy wine grapes?

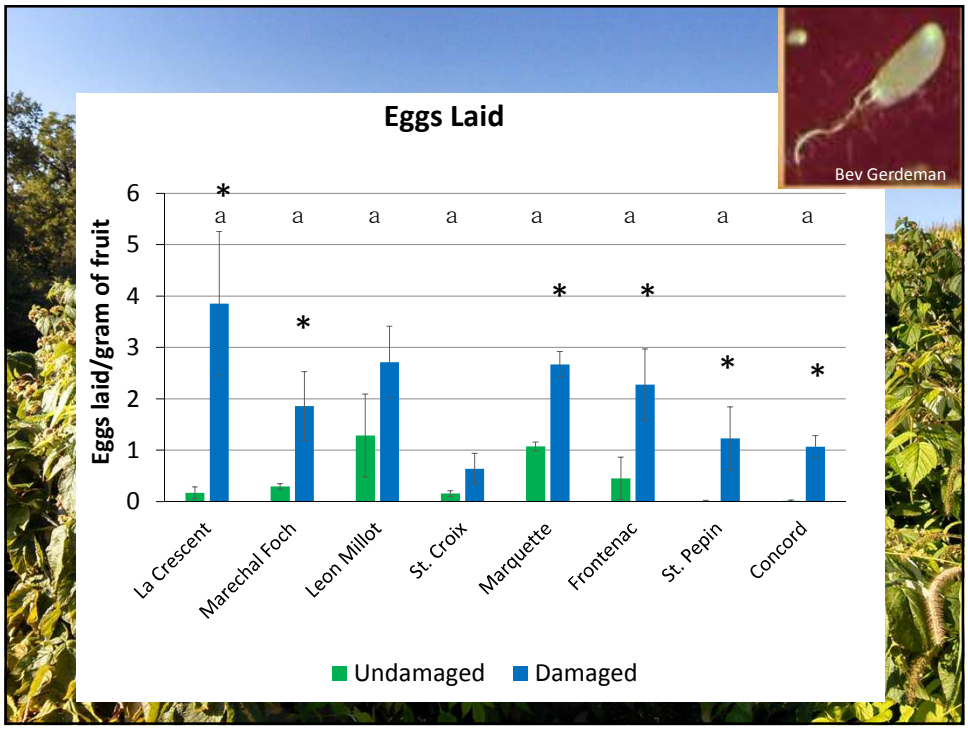
No-choice tests in lab

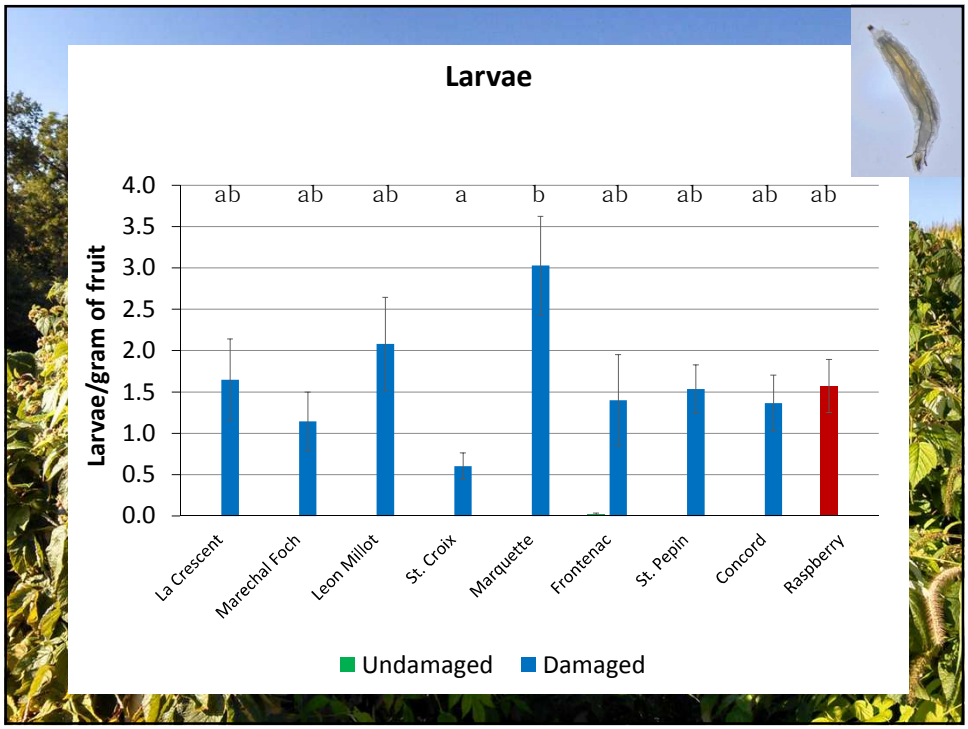
- How does damage affect susceptibility?
- Are there differences in varieties?
- How do grapes compare to raspberry?

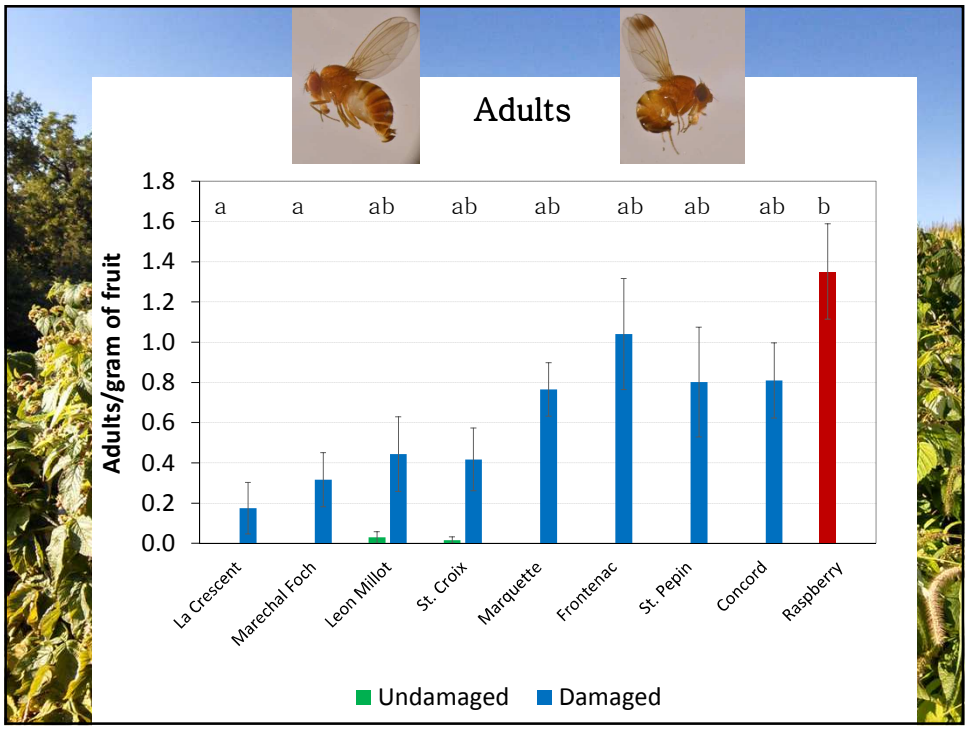
8 grape varieties

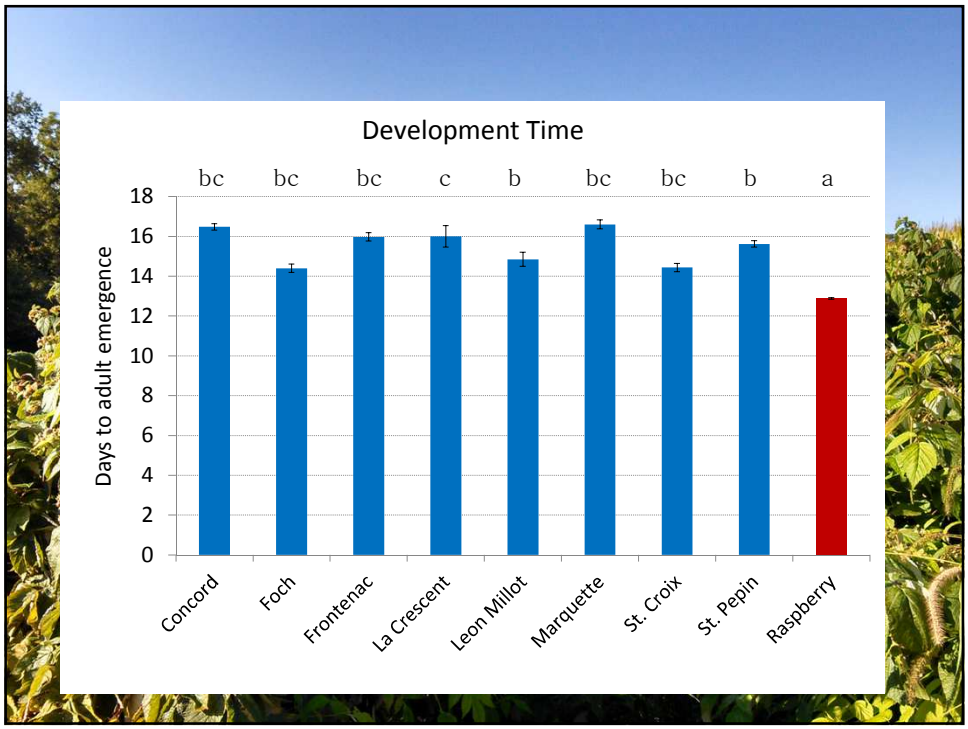
Raspberry control

Fruit characteristics


Eggs Laid
Bev Gerdeman
Eggs laid/gram of fruit
6
5
4
3
2
1
0
a a a a a a a a
* * * * *
La Crescent
Marechal Foch
Leon Millot
St. Croix
Marquette
Frontenac
St. Pepin
Concord
Undamaged
Damaged

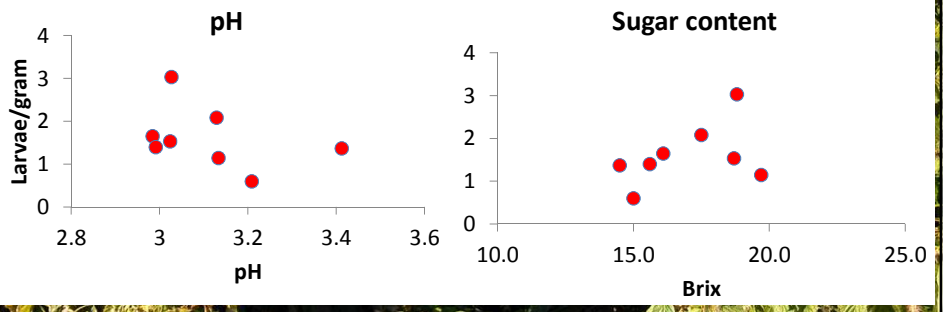

Larvae
Larvae/gram of fruit
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ab ab ab a b ab ab ab ab
La Crescent
Marechal Foch
Leon Millot
St. Croix
Marquette
Frontenac
St. Pepin
Concord
Raspberry
Undamaged
Damaged


Adults
Adults/gram of fruit
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
a a ab ab ab ab ab ab b
La Crescent
Marechal Foch
Leon Millot
St. Croix
Marquette
Frontenac
St. Pepin
Concord
Raspberry
Undamaged
Damaged


Development Time
Days to adult emergence
18
16
14
12
10
8
6
4
2
0
bc bc bc c b bc bc b a
Concord
Foch
Frontenac
La Crescent
Leon Millot
Marquette
St. Croix
St. Pepin
Raspberry

Fruit characteristics

- pH and Brix not correlated to number of larvae



Conclusions

- Phenology of SWD variable and needs to be correlated to degree days
- Wintermorph present in Wisconsin and undergoes reproductive diapause
- *D. suzukii* arrives earlier at farms in woodland landscapes but raspberry population abundance is unaffected
- Cold hardy wine grapes are largely resistant to *D. suzukii* if intact, but [illegible] susceptible if damaged

Future directions

- Determine if populations are overwintering in Wisconsin
- Describe spatial and temporal distribution of SWD inside crop
- Assess presence and impact of parasitoids
- Identify optimal lure for monitoring and trapping
- Assess cultural control methods

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