Western Region Update

Nik Wiman, Peter Shearer*, Vaughn Walton, Jana Lee, Silvia Rondon, Jeffrey Miller, Chris Hedstrom, Richard Hilton, Shannon Davis, Preston Brown

Jay Brunner, Todd Murray

USDA

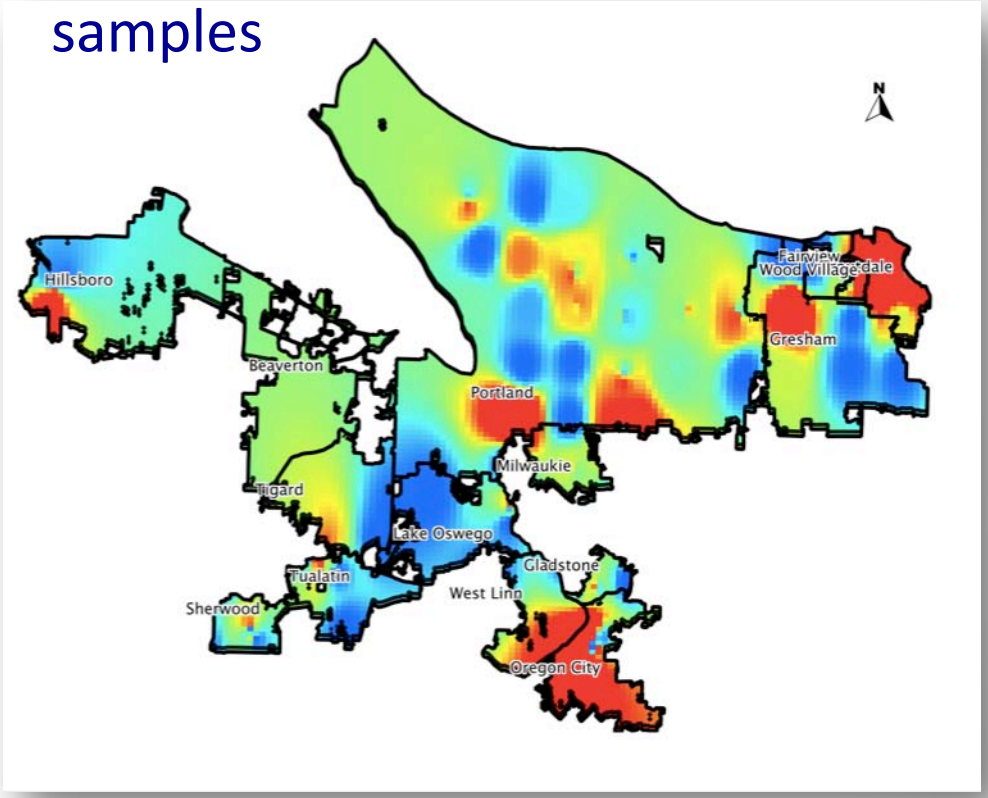
Washington State University
World Class. Face to Face.

Oregon State University

Background

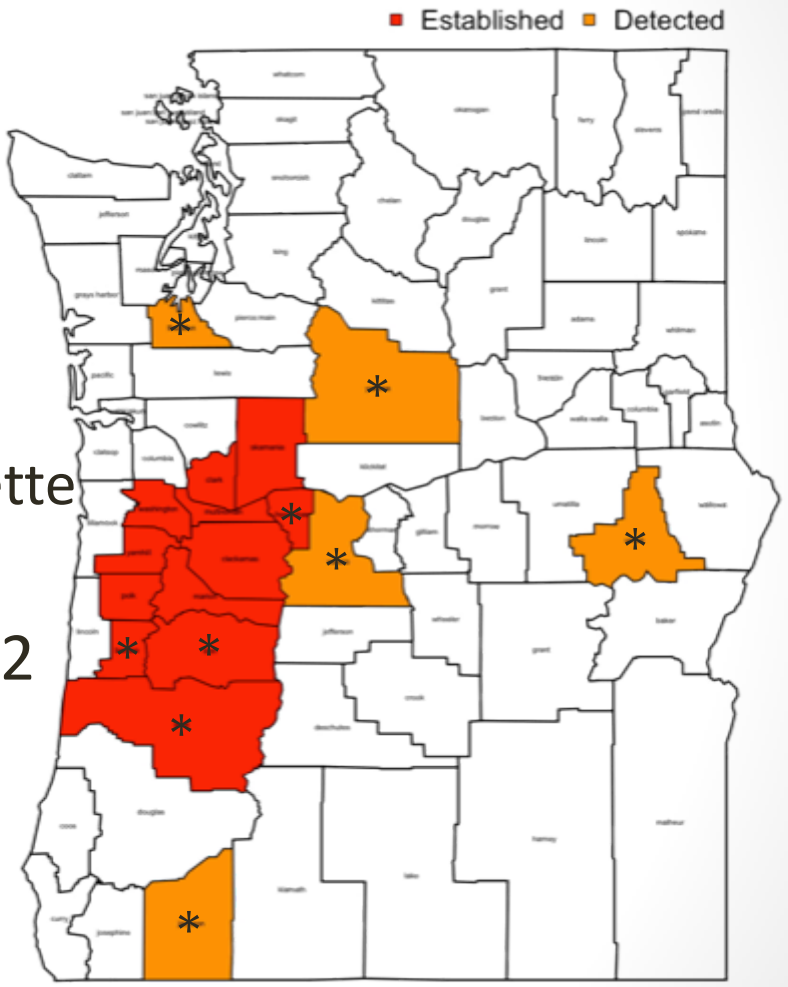
- 2004: BMSB identified from Portland by ODA
- 2004-2011: Urban nuisance problems increasing
- 2012: First finds of BMSB in commercial agriculture
- 2012: OSU survey finds BMSB are widely distributed
- 2013: More finds in commercial agricuture

Greater Portland, OR gridded beat samples



Current PNW distribution

- OSU/WSU/WSDA data
- Major range expansion
- Major new established populations found in 2012
  - Hood River, Southern Willamette valley counties
- Several new detections in 2012
  - Yakima, Jackson, Wasco
- Focus for 2013: The Dalles, Southern OR
- WA will be focused on Yakima



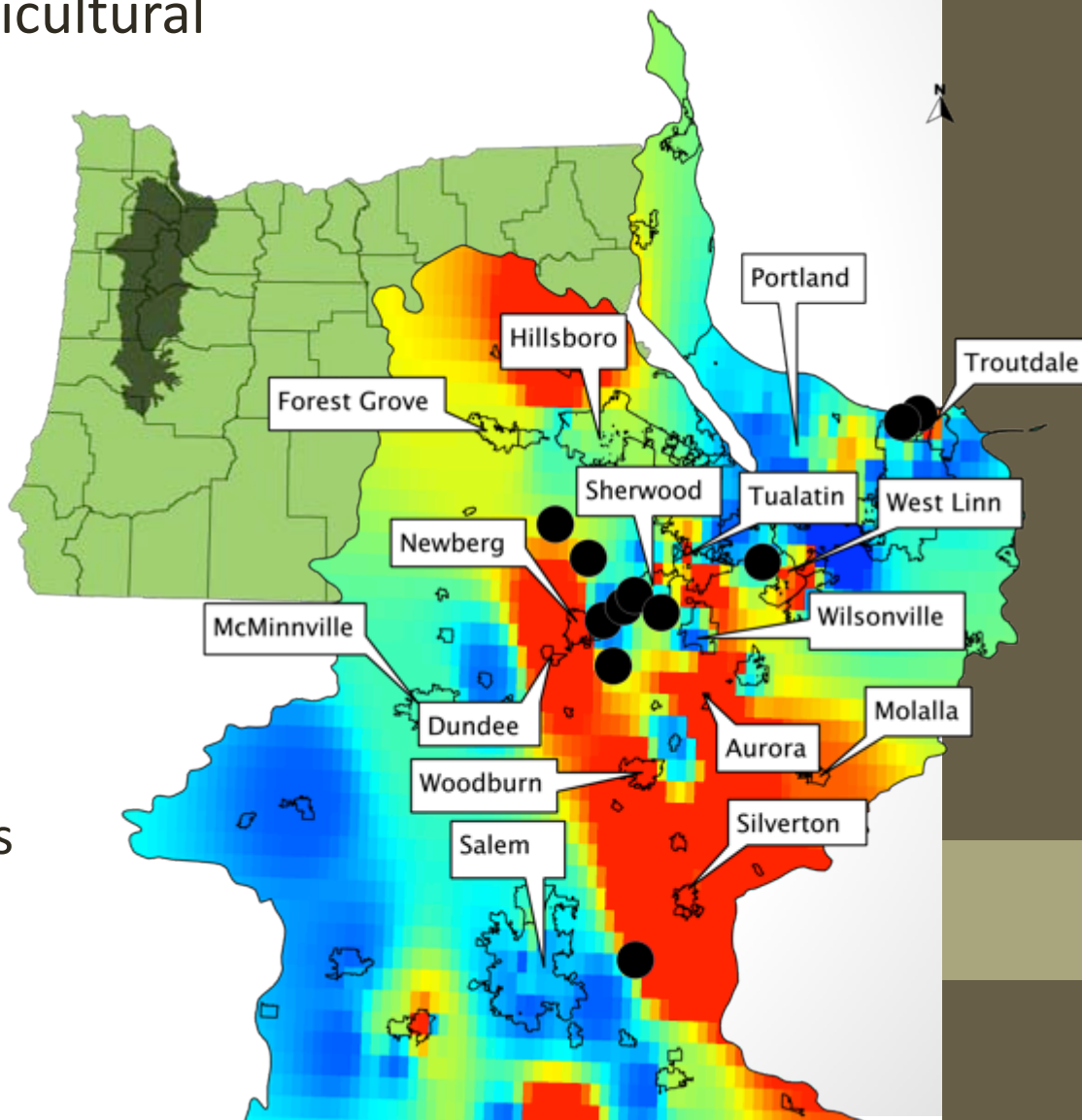
CA=?

BMSB in OREGON

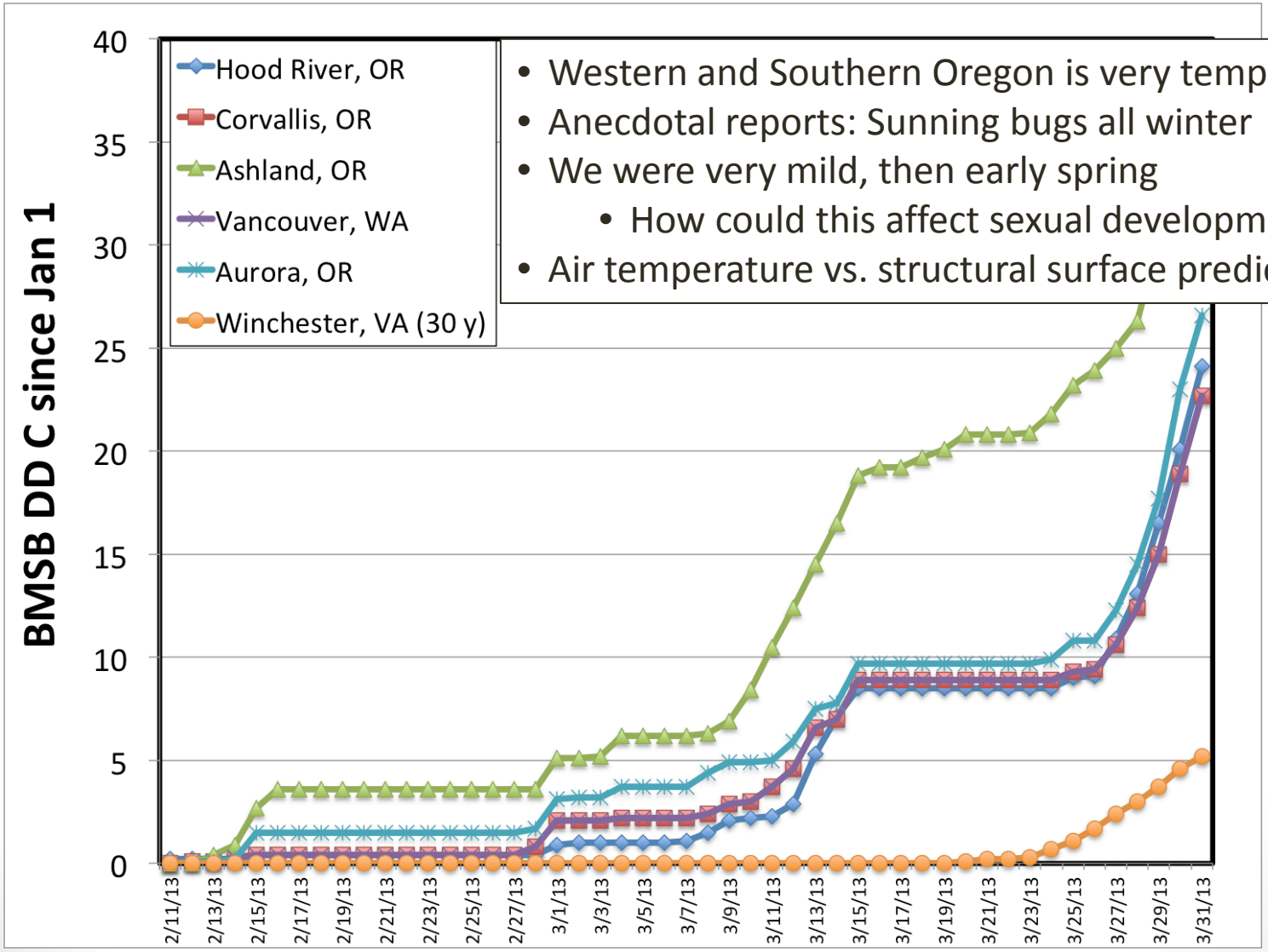
BMSB is becoming more agricultural

- Hazelnut
- Tree Fruit
- Vineyard
- Caneberry
- Nurseries
- Blueberry

- Suspected damage but unverified
- Infestation stigma
- Potential for severe problems
  - Habitat, human population, and mild environment



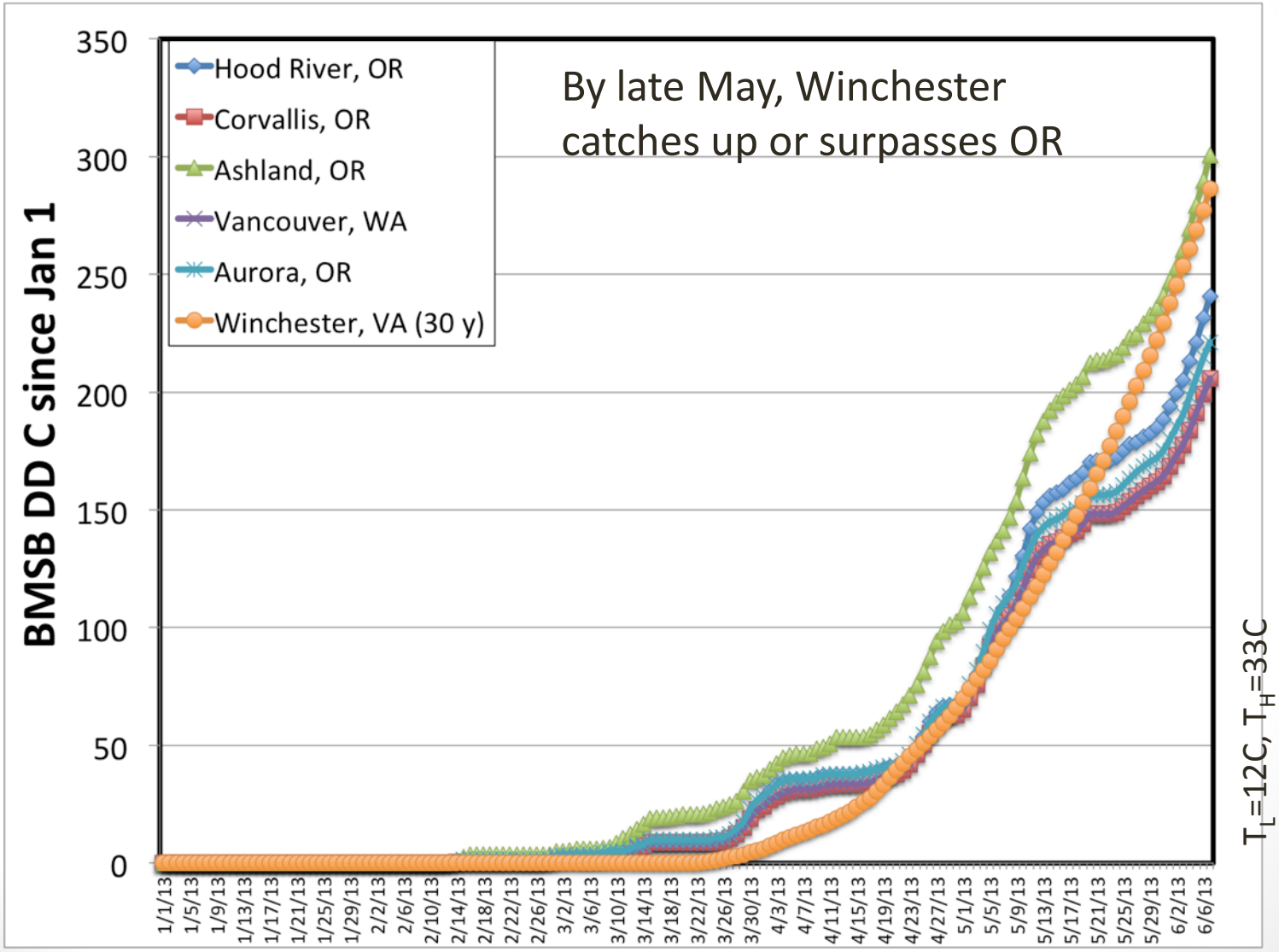
Early DD Accumulation in OR



- Western and Southern Oregon is very temperate
- Anecdotal reports: Sunning bugs all winter
- We were very mild, then early spring
  - How could this affect sexual development?
- Air temperature vs. structural surface predictions

T_L=12C, T_H=33C
single sine IPPC

Early DD Accumulation in OR

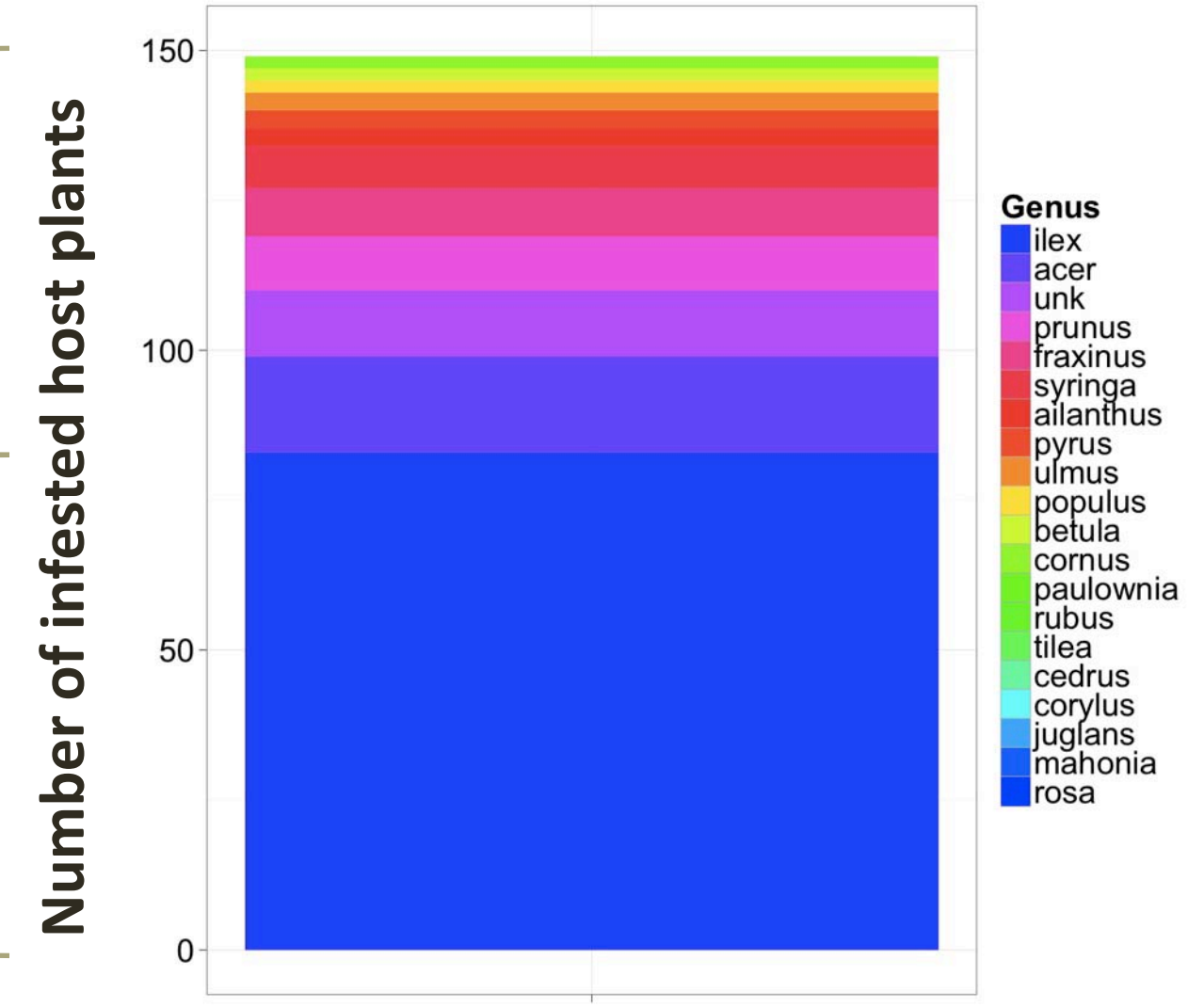


T_L=12C, T_H=33C
single sine IPPC

Host use patterns – Frequency

More maples, Lilac, etc.

Approx. 90 discrete, infested holly



Important host plants in OR

- High density food source allows massive aggregations of BMSB (proteinacous)

- **2013**: examining volatiles from holly berries and other hosts as potential attractants
- Funded Cherry Technology Grant, PI Jay Brunner, WSU
- How important are food odors?
- Other monitoring tools

Important host plants in OR

Important host plants in OR

Important host plants in OR

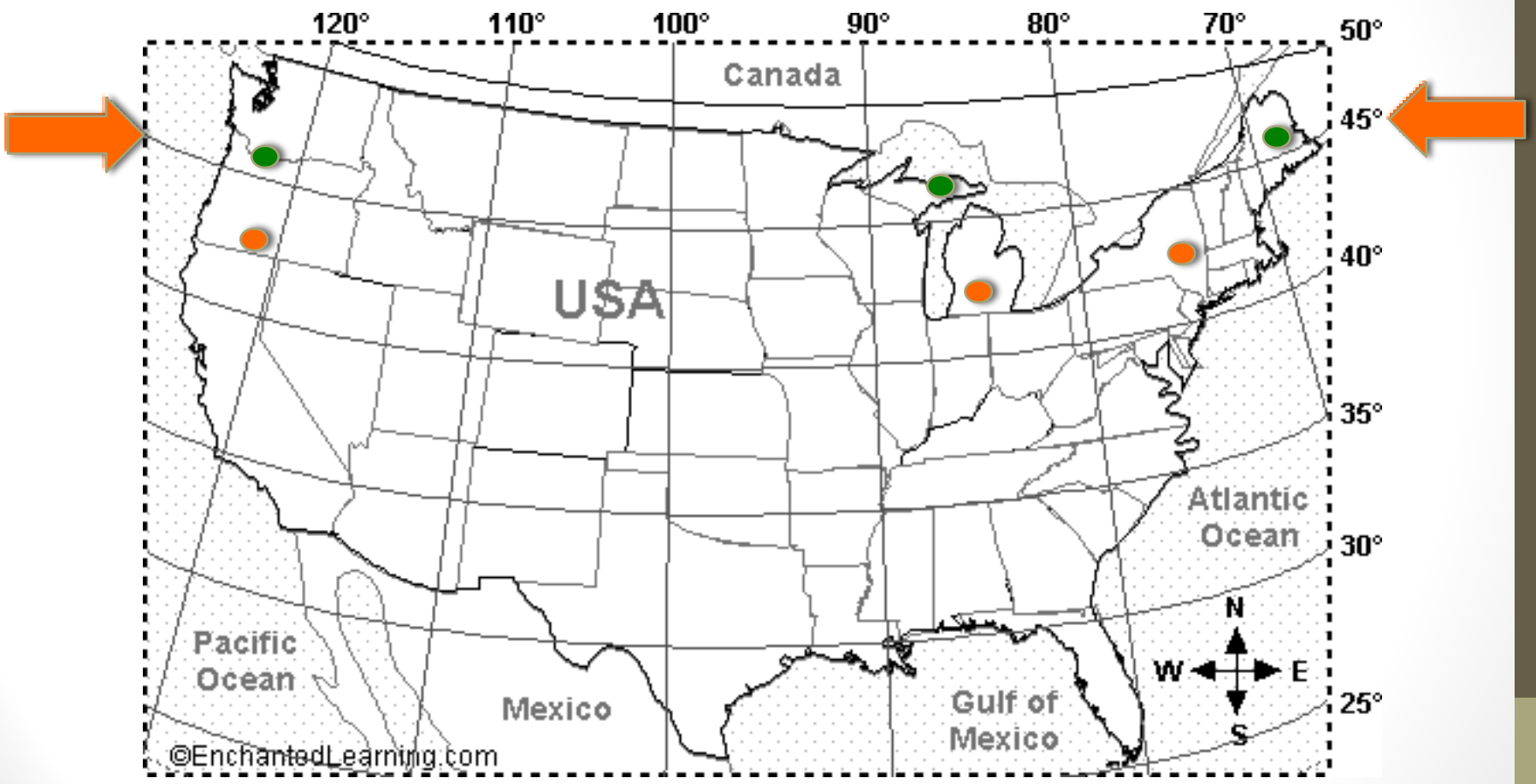
Important crop plants in OR

Phenology & Voltinism: Cages

- Briefly: follow life history events in a controlled outdoor environment
  - Stage-specific phenology
  - Voltinism: how many generations??
  - Currently: thought to be 1 in OR
- 7 cages in 5 locations (6x6x6)
- Brent's protocol *except* free ranging not allowed
- Supplemental food provided in sleeve cages if necessary
- Established 4/15-4/19

Sleeve cages in Hood River

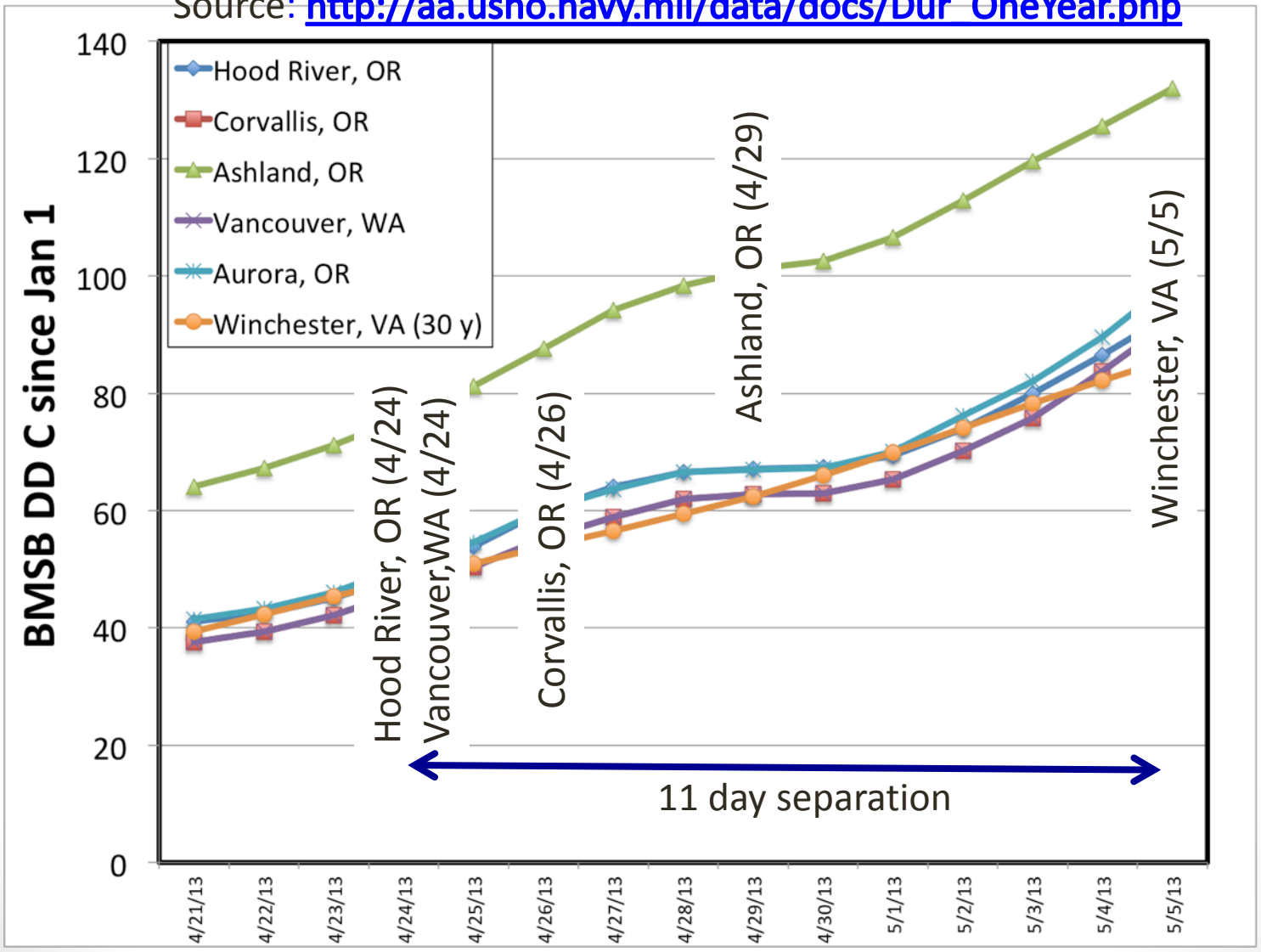
Daylight: Date of 14h of light



Phenology & Voltinism: Cages

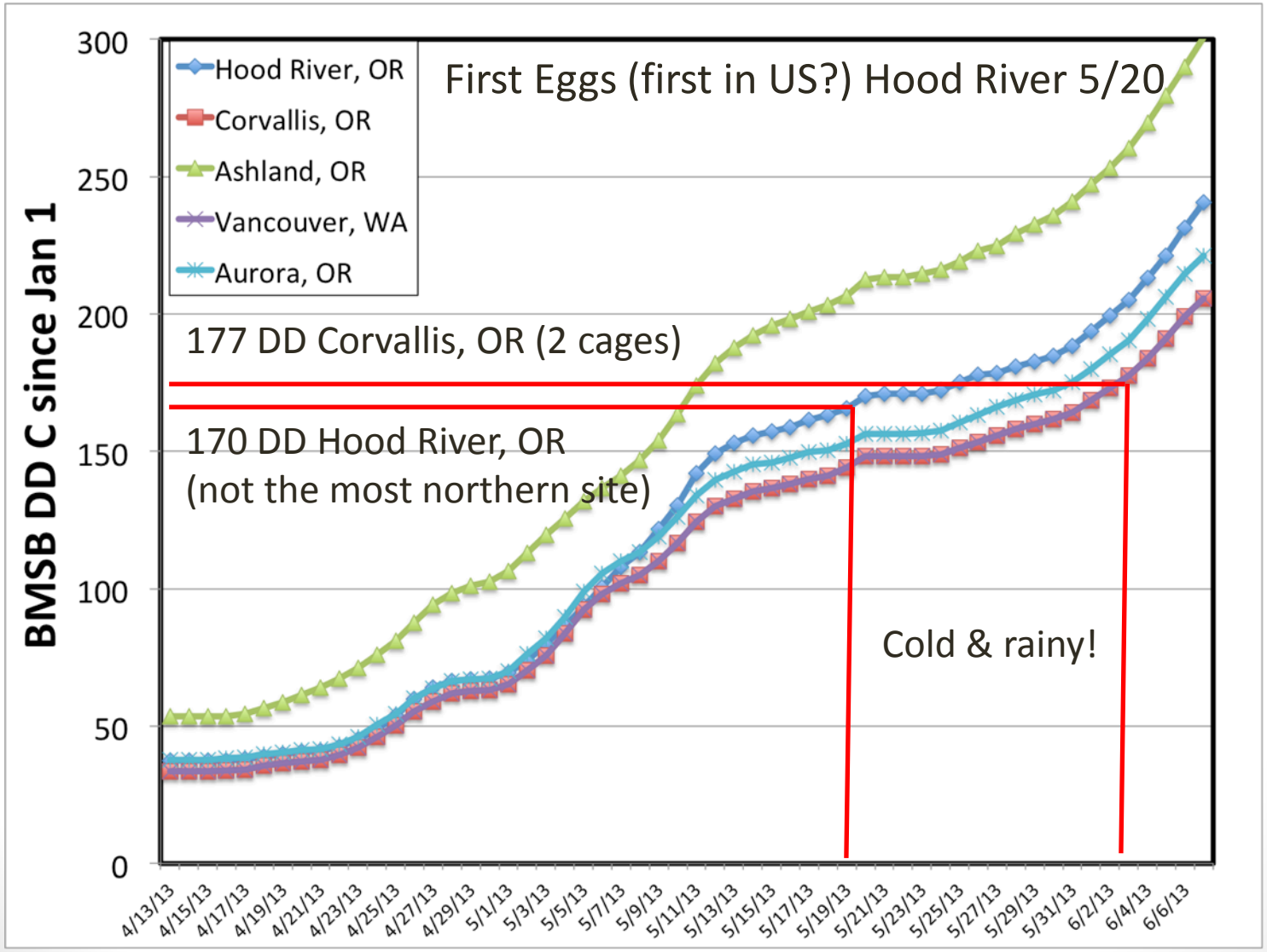
Daylight: Date of 14h of light

Source: http://aa.usno.navy.mil/data/docs/Dur_OneYear.php



T_L=12C, T_H=33C
single sine IPPC

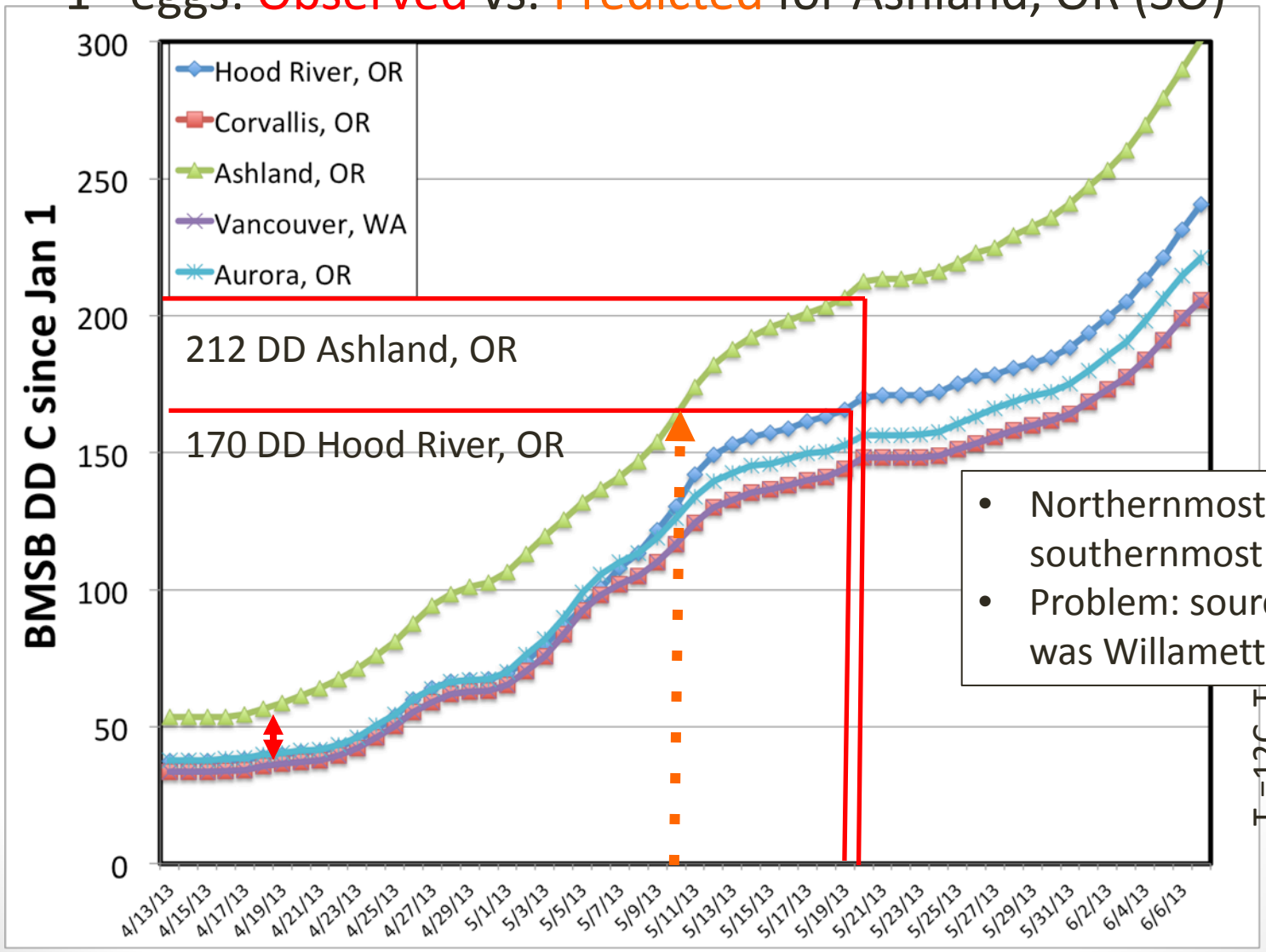
Phenology & Voltinism: Cages



T_L=12C, T_H=33C
single sine IPPC

Phenology & Voltinism: Cages

1st eggs: Observed vs. Predicted for Ashland, OR (SO)



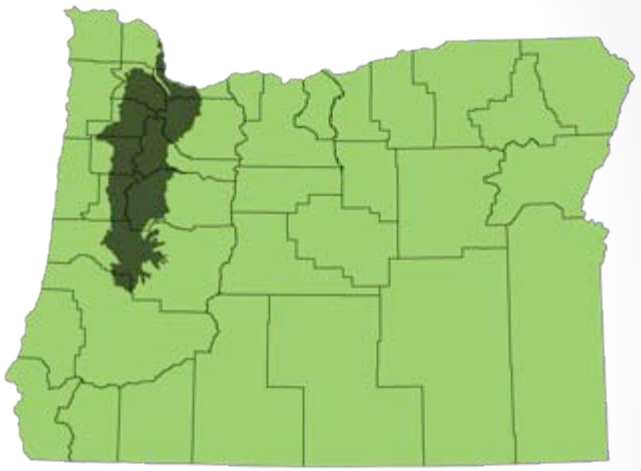
- Northernmost and southernmost 1 day apart
- Problem: source of BMSB was Willamette

T_L=12C, T
single sin

Phenology & Voltinism: Rearing

METHODS:

- BMSB collected from Willamette Valley 2-3 times per week (beats)
- Placed into individual 74ml cups along with food, water
- Growth Room (16:8 L:D, 26° C)
- Follow life history



GOALS:

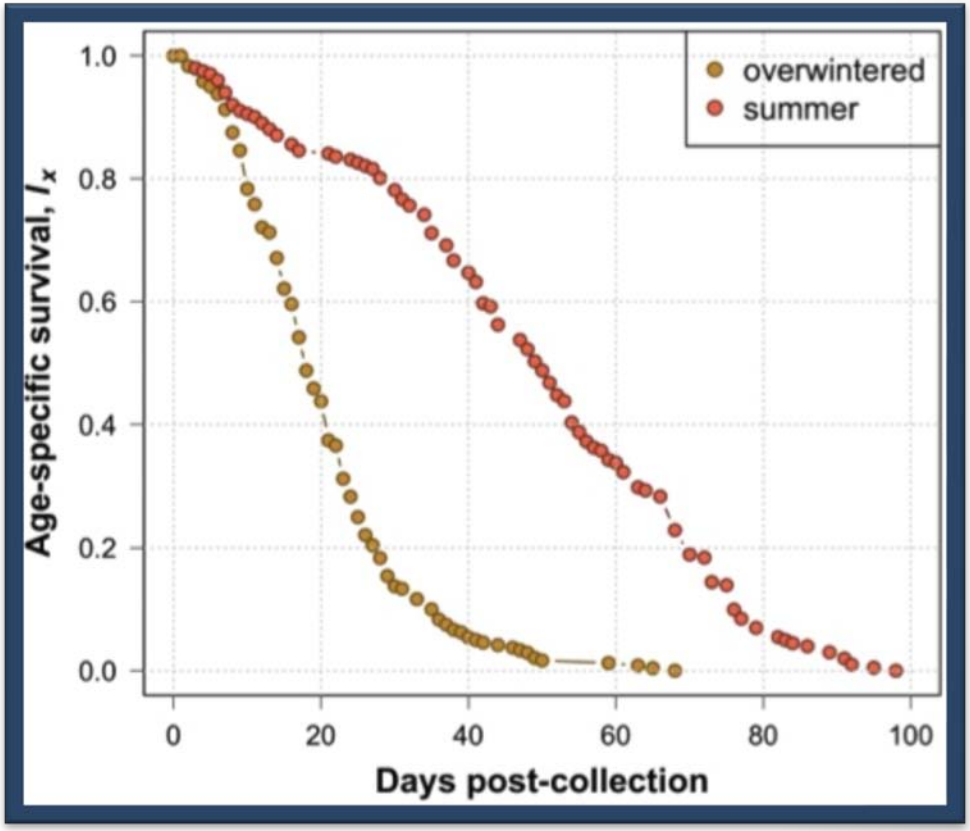
- Translate: calendar time to DD to predict life history events in the field
  - Every day lived in a growth chamber at 26 C = 13.8 DD
  - Lab life table data on DD scale = predictive model for field?
    - Nonconventional DD model testing
    - More informative than development alone, reproductive periods, voltinsim?

Classifying Generations

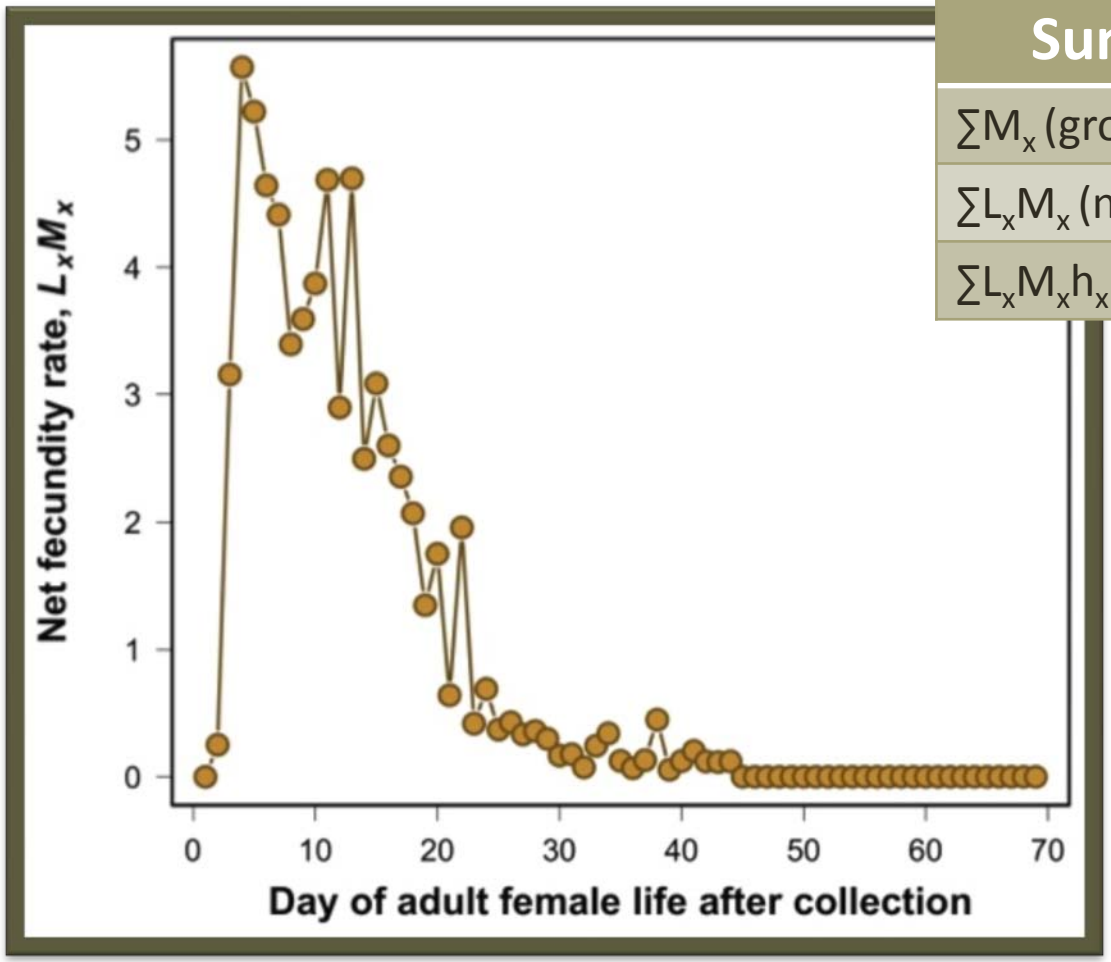
- Adults becoming sparse 8/3-8/20
- Increasing 5th
- Increasing cadavers
- First new adult 8/21
  - Melanization & hardness

Calendar Day Survival

- Long lived adults
- Difference in overwintered and summer adults reflects missing diapause period
- Adult life for overwintered is already about half over at collection in spring



Calendar Day Fecundity



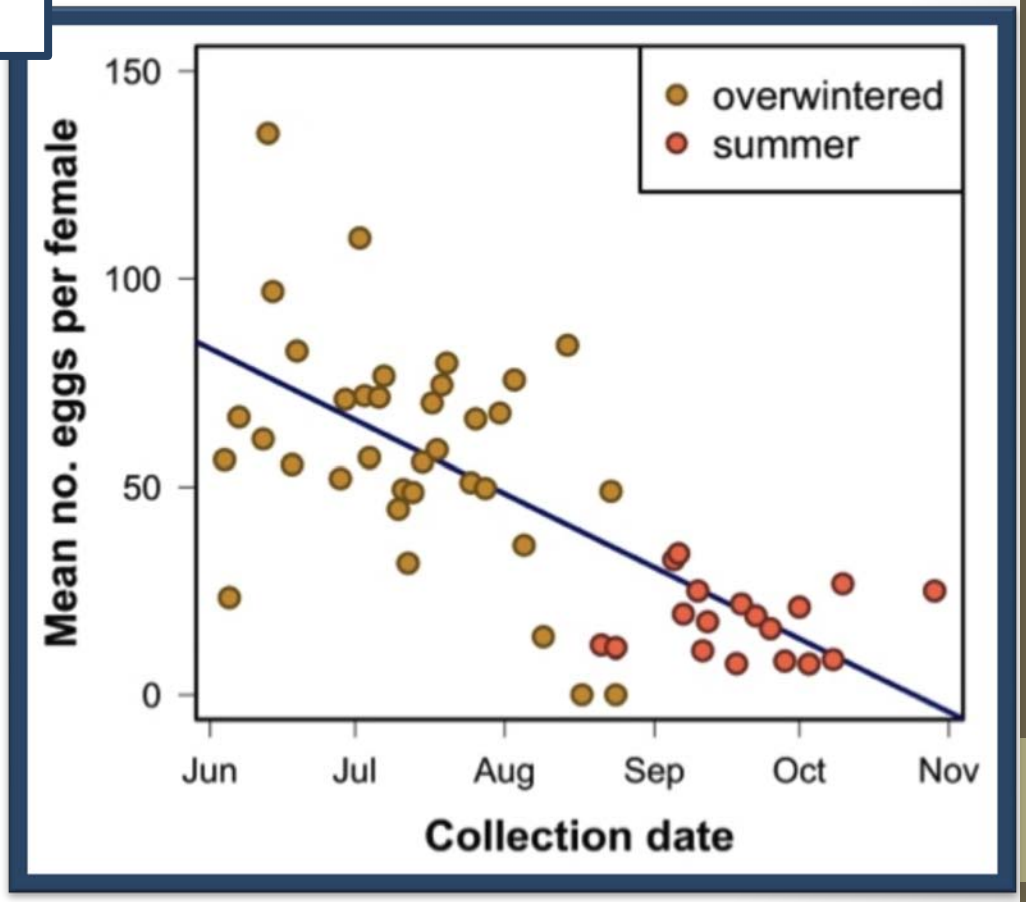
Summary statistics	
$\sum M_x$ (gross fecundity)	129
$\sum L_x M_x$ (net fecundity)	70
$\sum L_x M_x h_x$ (net fertility)	56

- Most reproduction occurred soon after collection
- Calendar day basis doesn't really make sense (bugs are different ages at collection)
- However, summary stats are stable

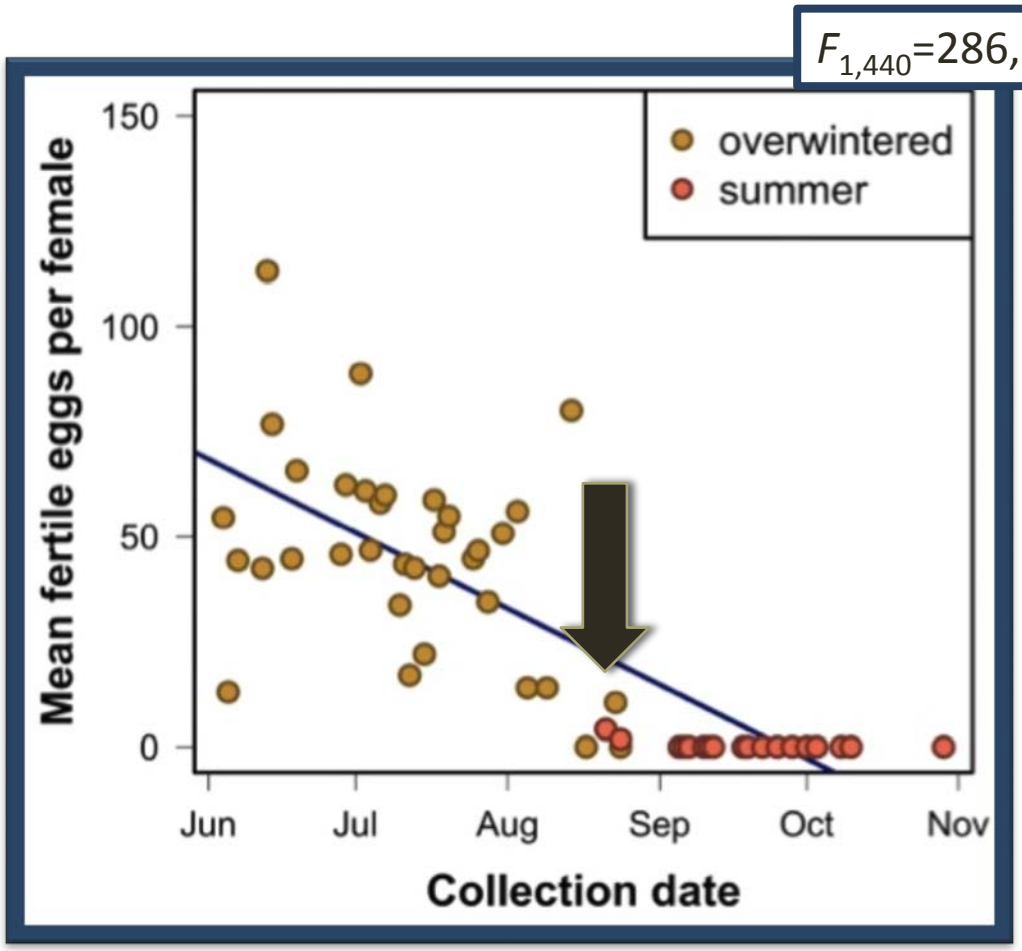
Fecundity Regression

$F_{1,440}$=190, P < 0.01

- The time of collection had an effect on the fecundity of females (age effect)
- Fecundity of summer females was low and uniform
- Were summer females unfertilized?



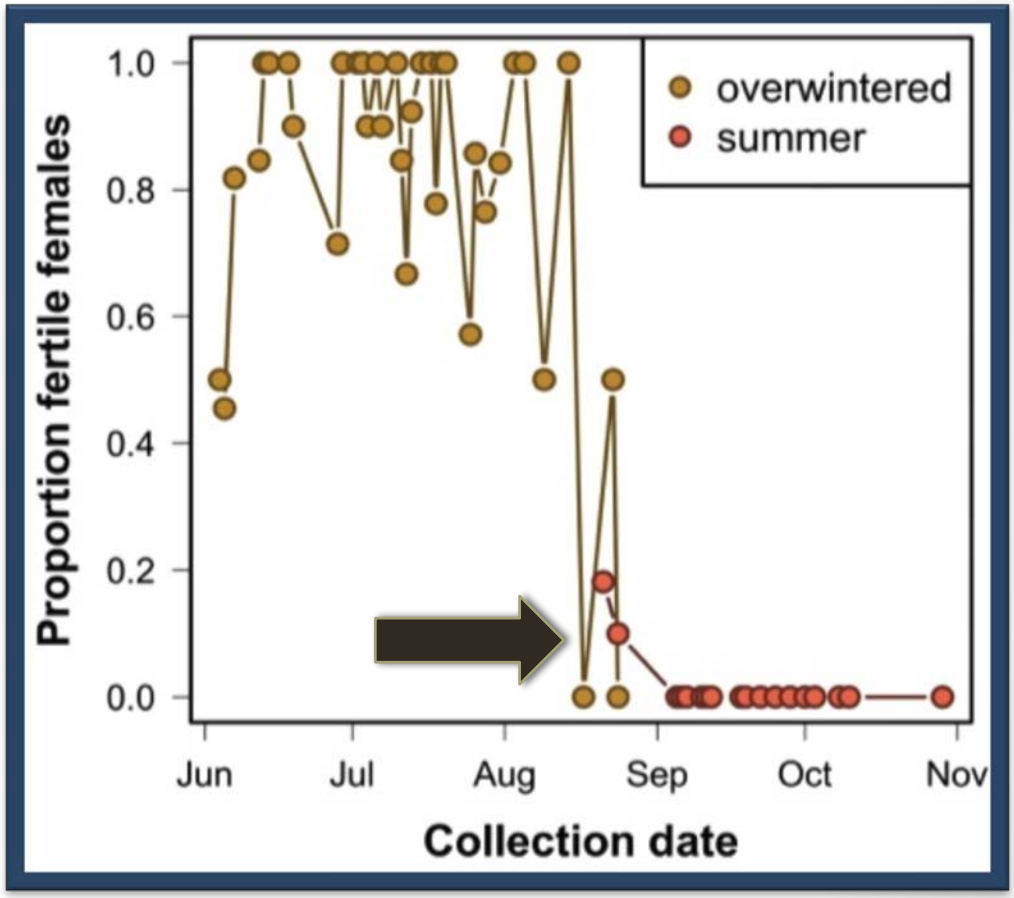
Fertility Regression



- The time of collection affected fertility of females (age effect)
- Very little fertility in fems classified as summer gen
  - Misclassified?
  - Small partial second generation?

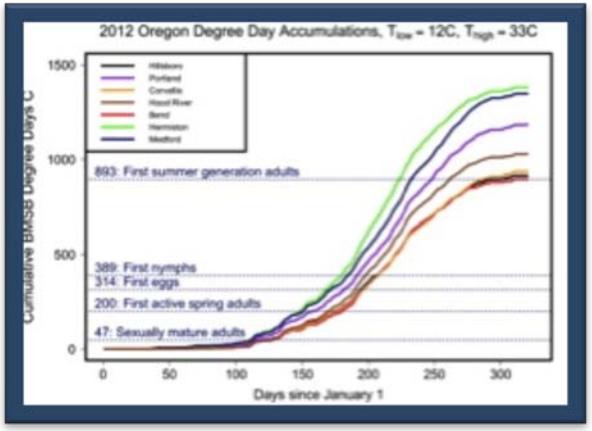
Proportion fertile females

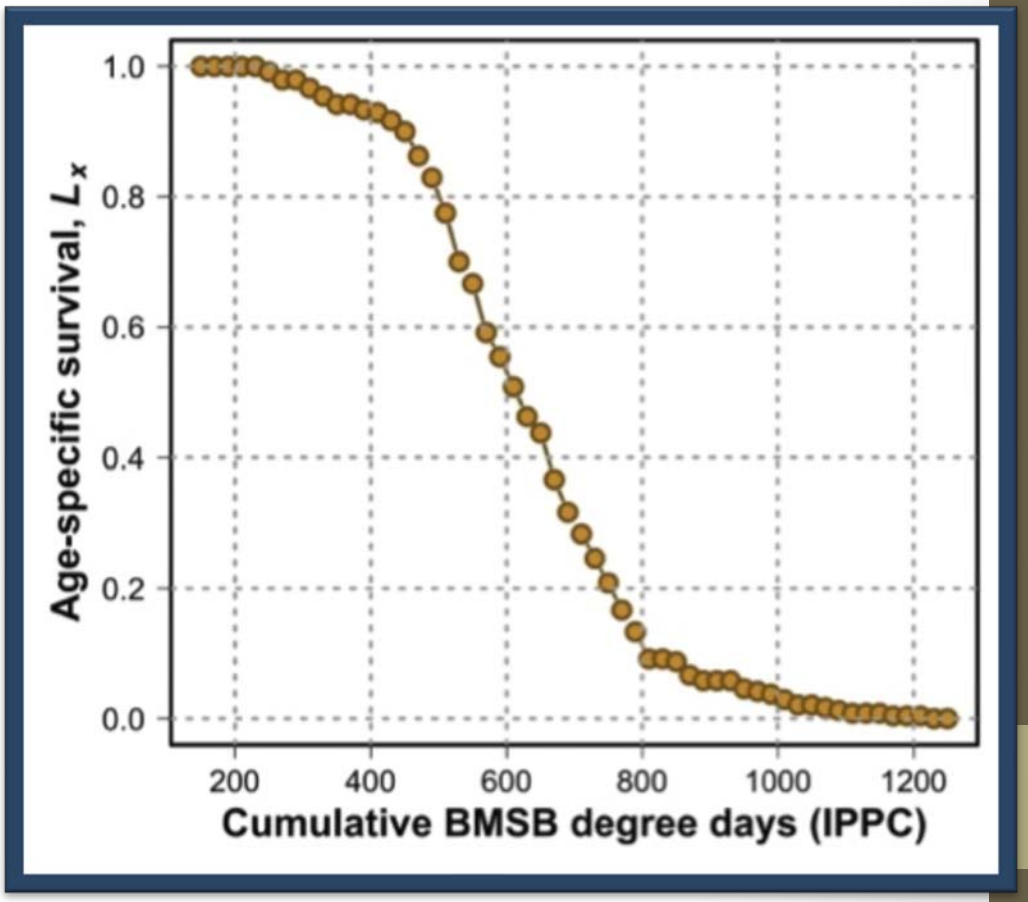
- The fertile proportion of cohorts increased initially, then averaged around 80%
- Misclassification may have occurred during the brief period of generational overlap of adults



Degree Day Scale Survival

- Predicts survival up to and past the first summer adults (893 DD)
- Last 5% or so suspect because of possible misclassification





Degree Day Scale Fecundity

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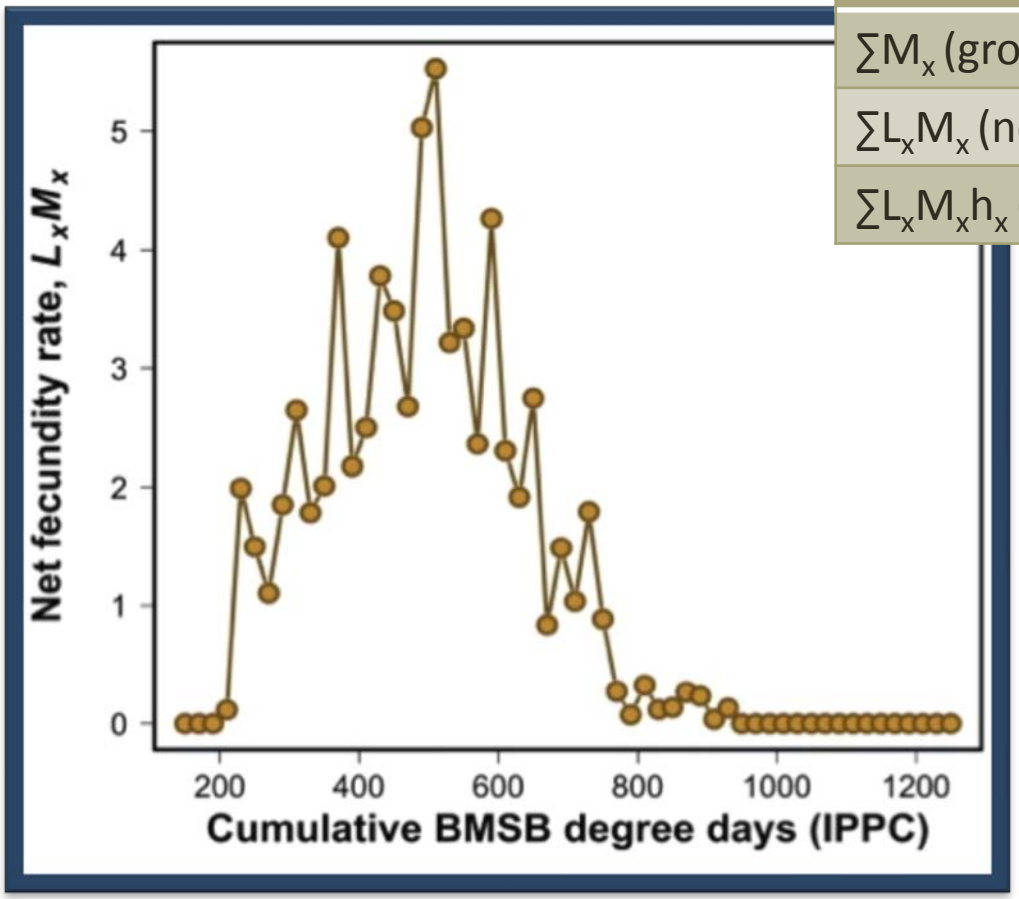
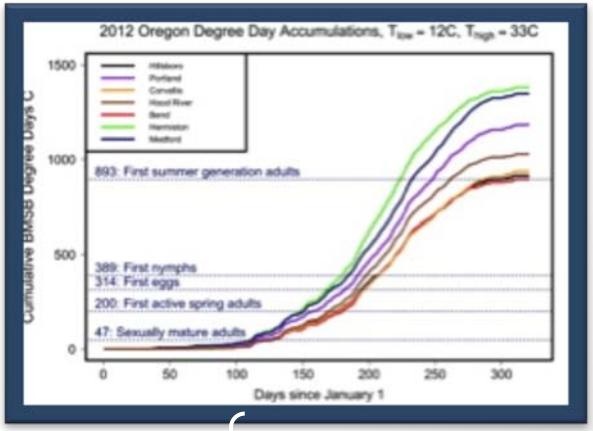
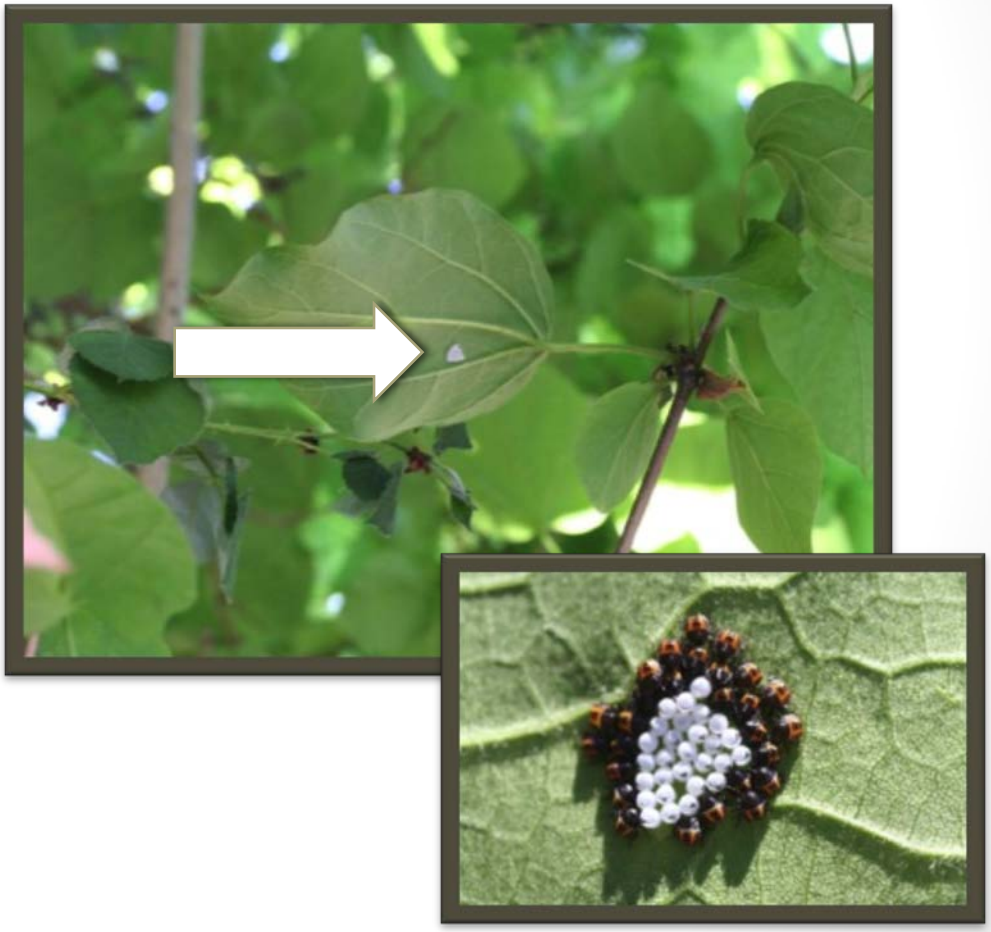


- Predicts reproduction up to and past the first summer adults (893 DD)



Predicted vs. Observed

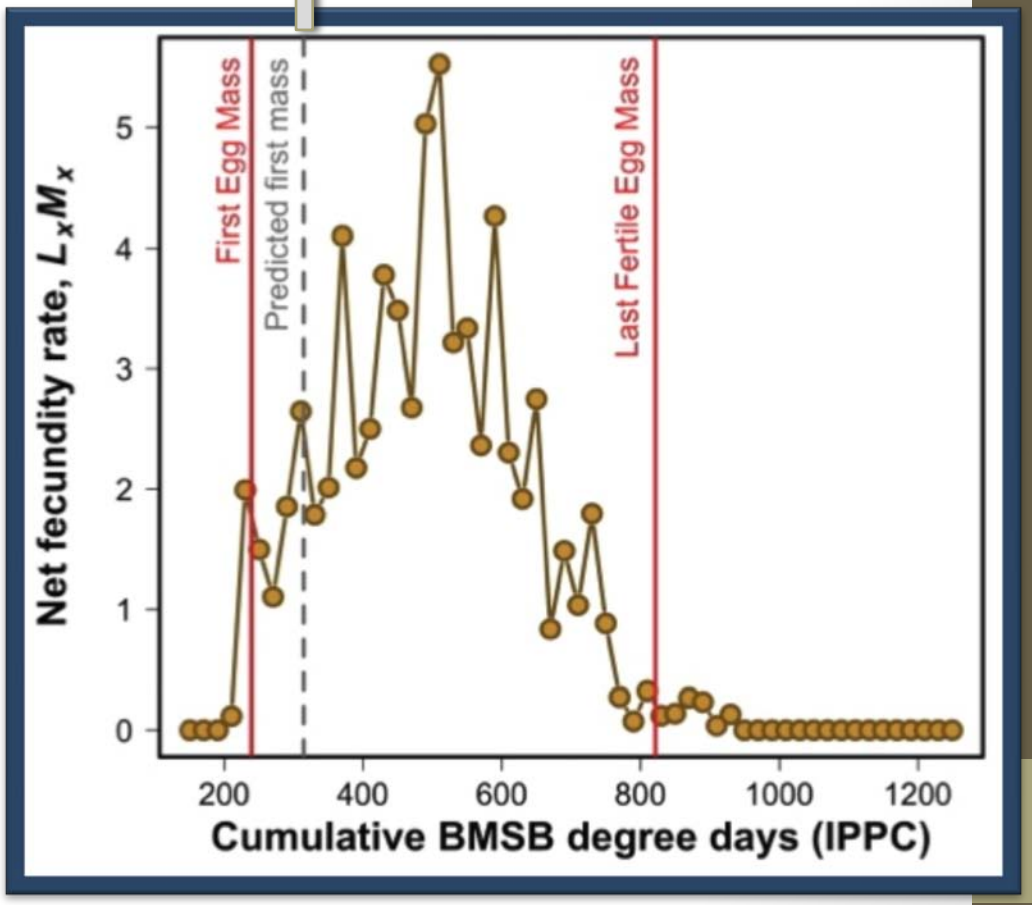
- Field egg collections
- Searches 2-3 times per week
- 2 crews
  - Willamette
  - Hood River



Predicted vs. Observed: 2012

- ✓ First egg mass found near the start of the predicted reproductive period
- ✓ The IPPC model predicted eggs a little late (314 vs. 225 DD)
- ✓ The last fertile egg mass was found at the very end of the reproductive period
- ✓ Egg masses were (rarely) found into October, but were infertile

(IPPC/Nielsen)



Conclusions

- ✓ Methodology appears to have predictive potential: reproductive periods agreed with observed, better than development model
  - ✓ Potentially more informative model than that based solely on development thresholds
    - ✓ Beginning, peak, and end of reproduction
    - ✓ Management potential
- ✓ Model predicts survival and reproduction of overwintered females for most of the season
  - Stranded nymphs can result from long OW generation
    - Does not require an additional generation
- ✓ Almost no females classified as summer generation were fertile
  - If there was a second generation in 2012, it is very small and partial

Electronic SB feeding monitor

Shearer, P.W., and V.P. Jones 1996. Diel feeding pattern of adult female southern green stink bug (Hemiptera:Pentatomidae. Environ. Entomol. 25:599-602.

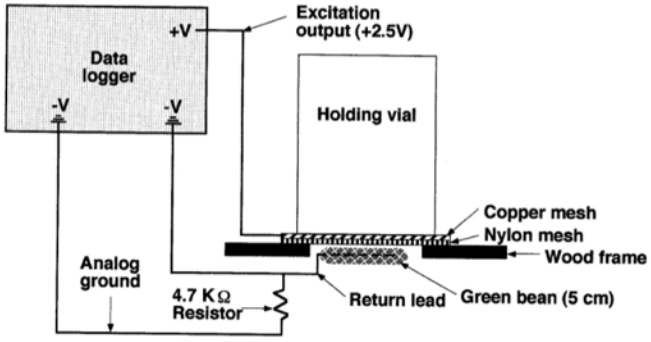


Fig. 1. Schematic of 1 feeding station for activity recorder (not drawn to scale).

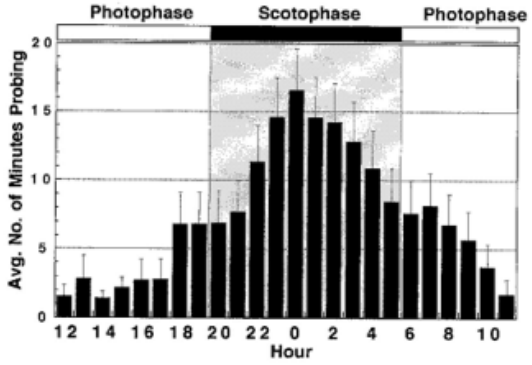
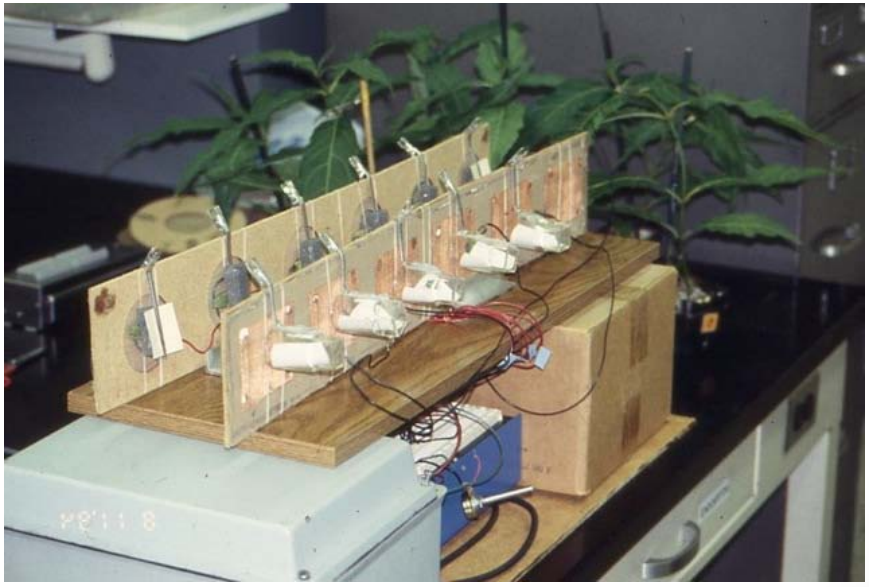
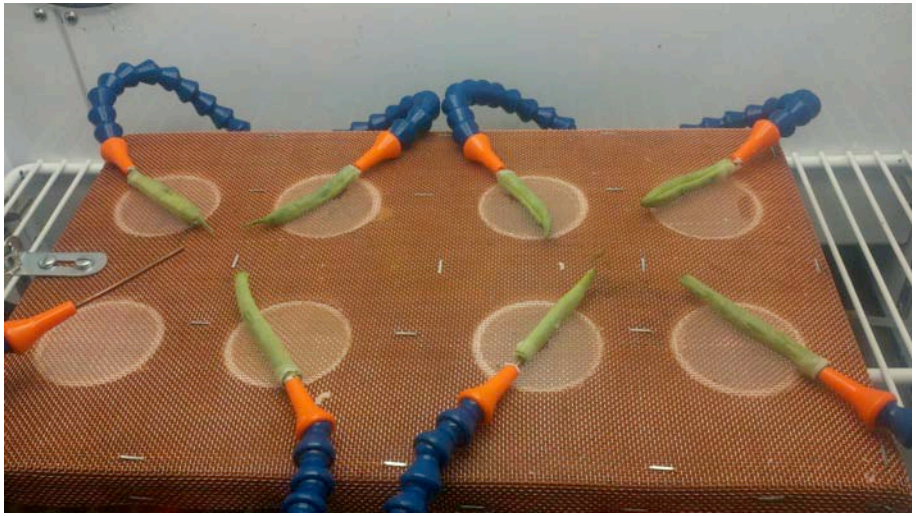


Fig. 2. Average (±SEM) number of minutes per hour that N. *viridula* were recorded probing food in a photoperiod of 14:10 (L:D) h.



Cool, but clunky!

Electronic SB feeding monitor



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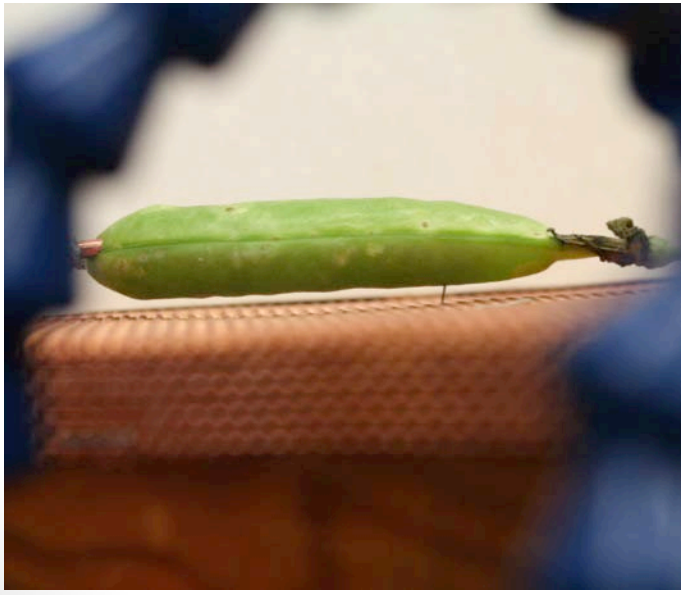

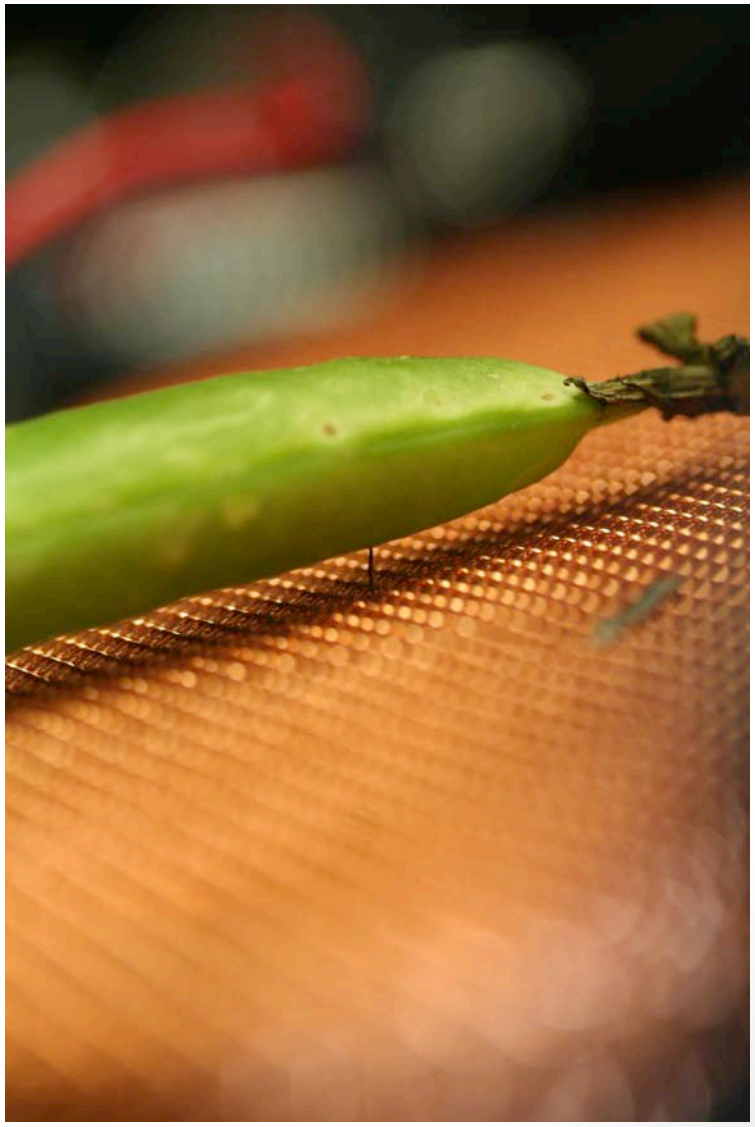

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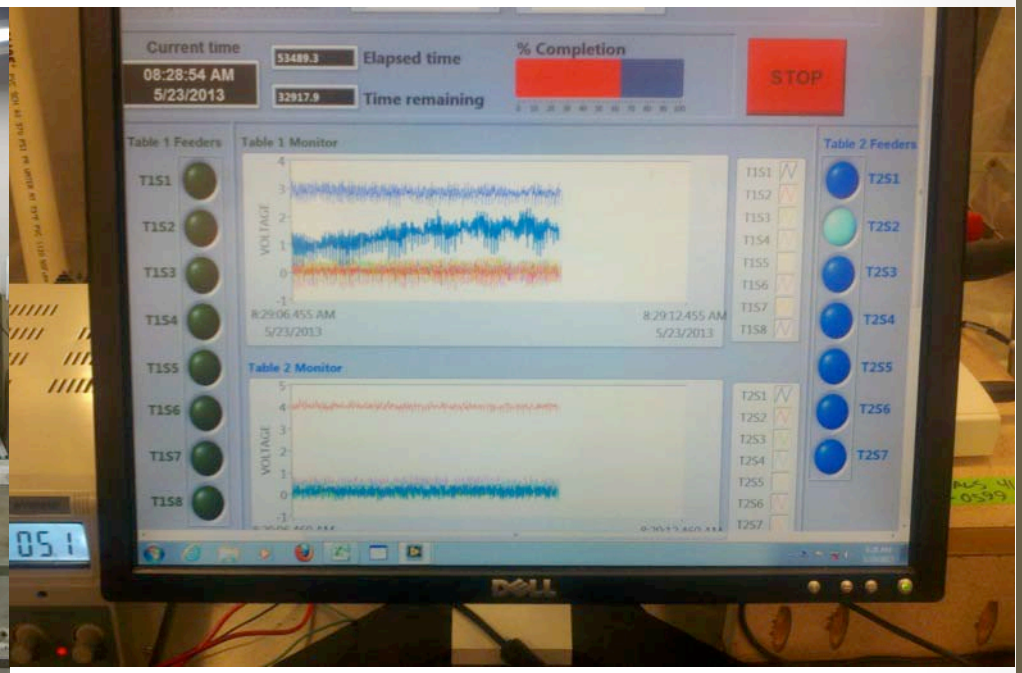
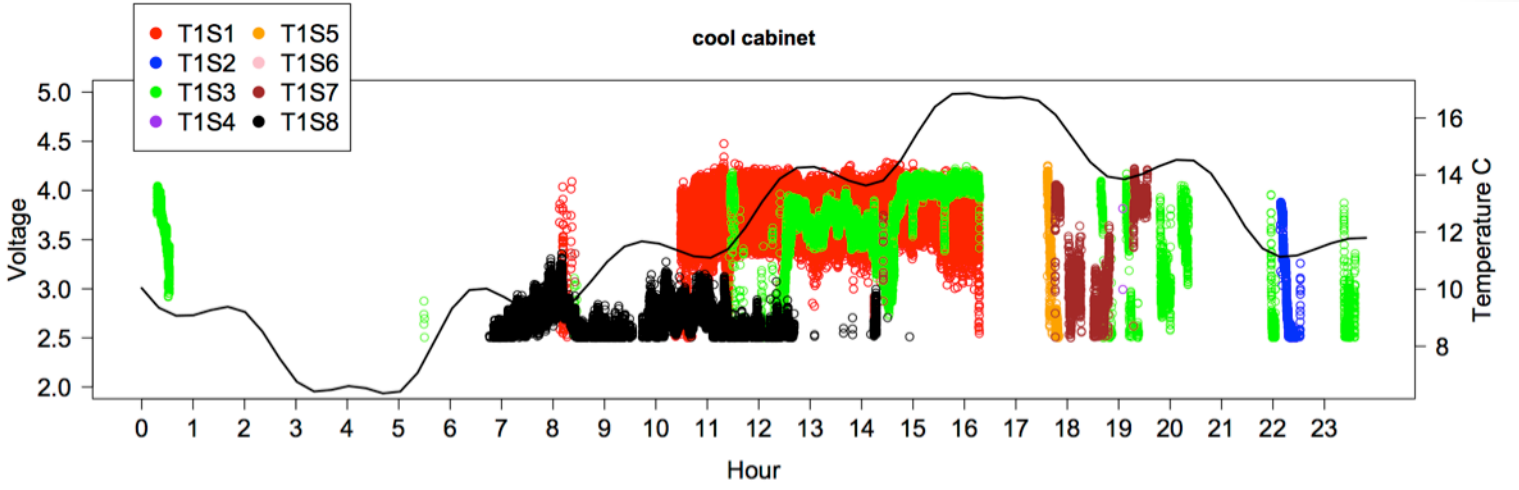
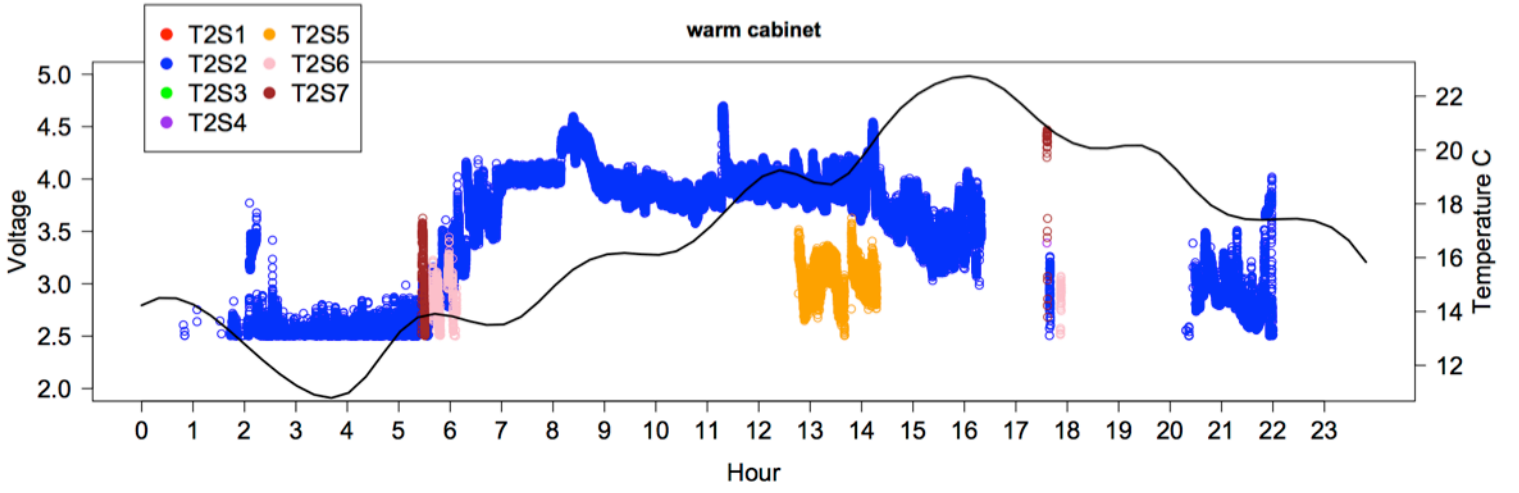


Set it and forget it

- USB data acquisition with Lab View
- Timer set to X length of time (48 h)
- Will log 1 point per sec
- LEDs and waveform graphs

Electronic SB feeding monitor





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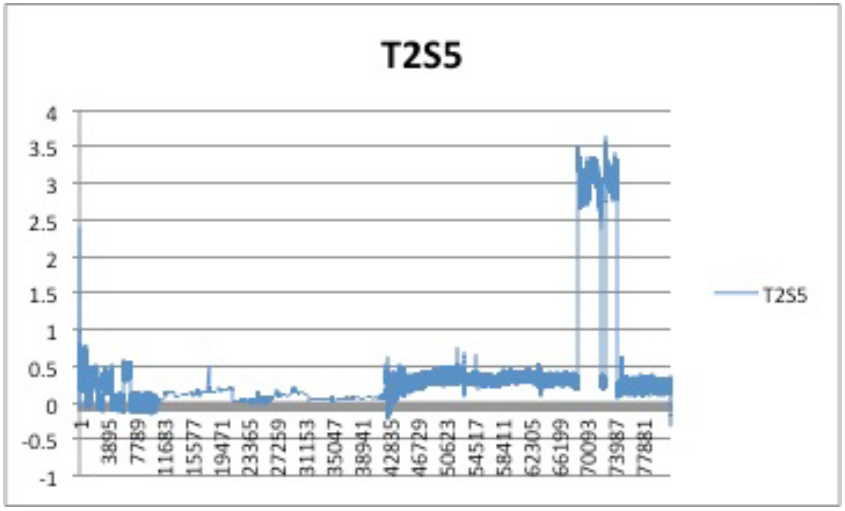
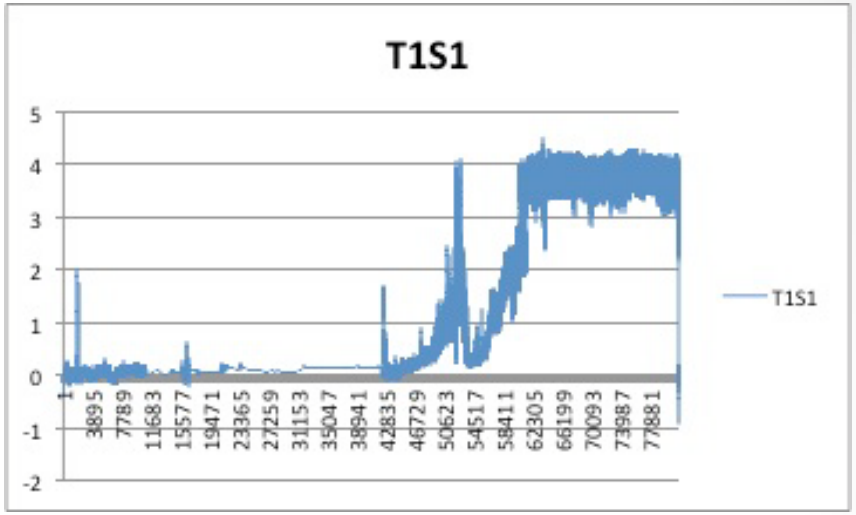
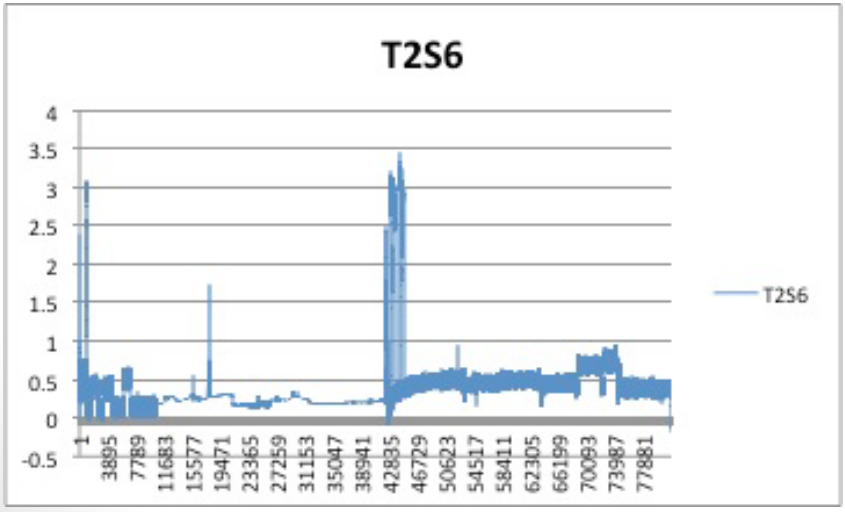
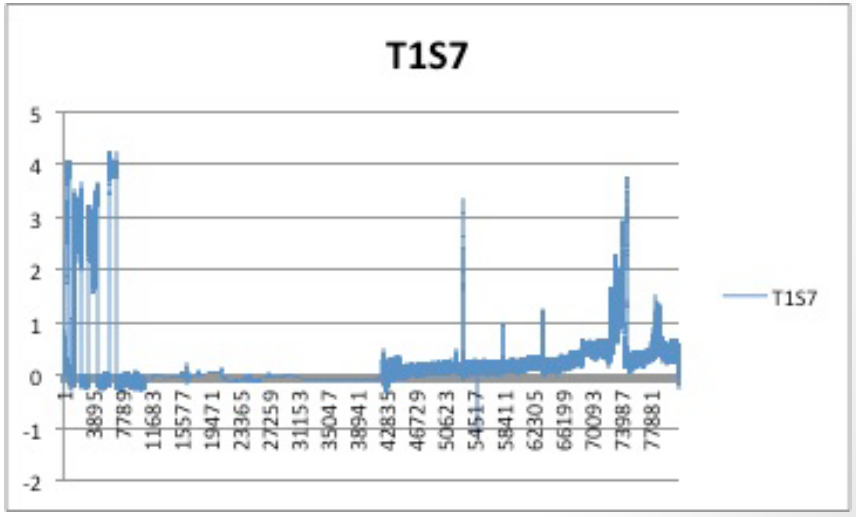








Electronic SB feeding monitor

- Current objectives:
  - Determine feeding patterns of M,F, and nymphs
  - Determine seasonal patterns
  - Examine how environment shapes feeding behavior
- Possible future uses of this technology:
  - Insecticide bioassays
  - Feeding stimulants
  - Feeding deterrents
- Adapt probes to accept different food items
- Adapt to other insects (honeybees)

Biological control

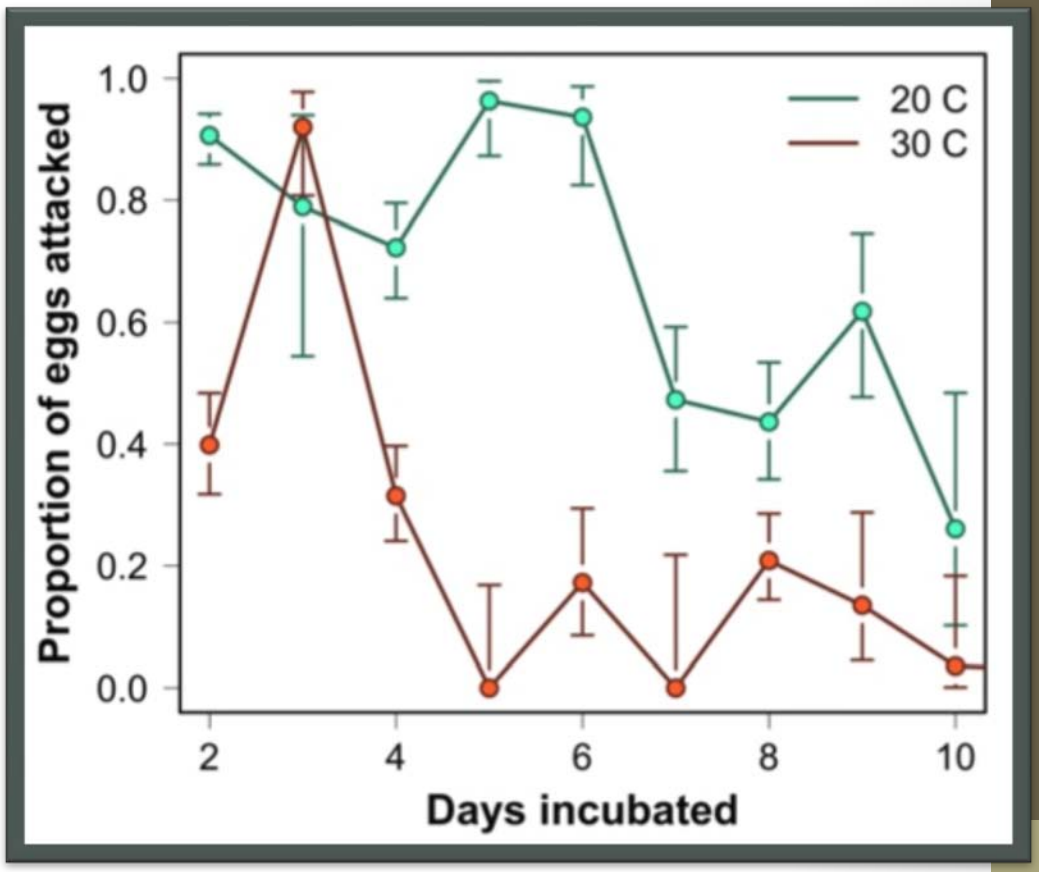
Crabronid wasps

Sentinel Egg Masses

- Objective: determine parasitoid diversity and rank
  - Different crops, natural areas (ornamental and wild plants)
- Problem for us in Oregon: Grower will not allow fresh viable egg masses in the field
- Solution: freeze the EM making them sterile
  - Well-tested technique for *Nezara* parasitioids
  - Frozen EM (-80C) are acceptable to parasitoids
  - Frozen EM can be banked
  - Frozen EM may in fact be more acceptable than fresh
    - Two *Trissolcus* spp. in colony reared better on frozen vs. fresh EM
    - Suggests biological defense prevents successful parasitism by native parasitoids

Frozen egg masses – lab Testing

- **Fresh** BMSB eggs are only acceptable to *T. halyomorphae* for ~24 hrs
- **Frozen** egg masses are parasitized at a high rate out to 6 d, when kept cool
- **Incubated frozen** egg masses degrade faster but still are still attacked



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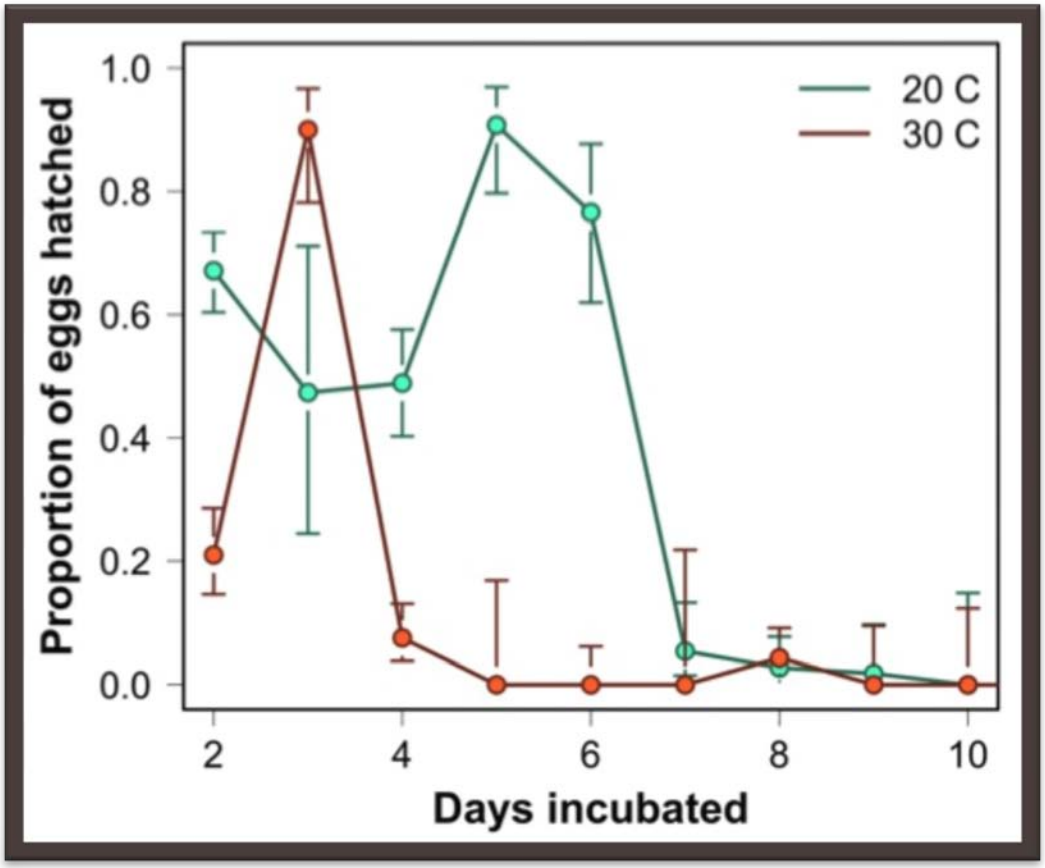
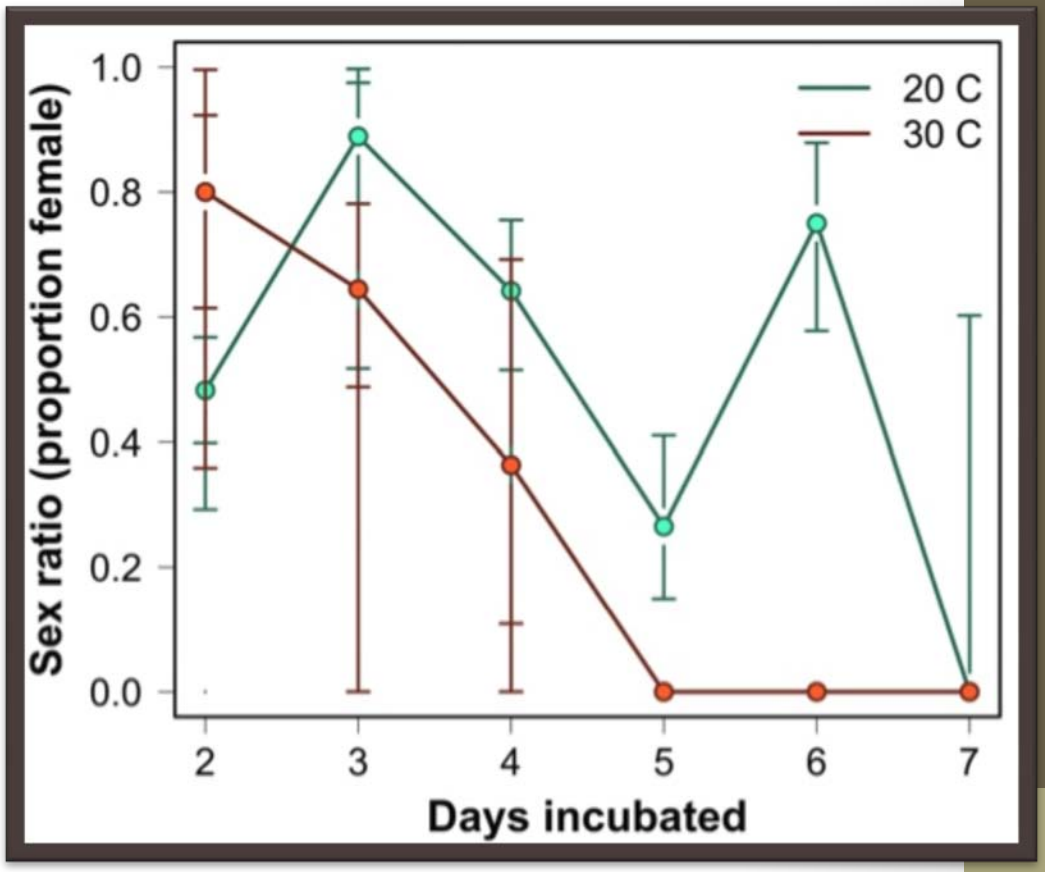


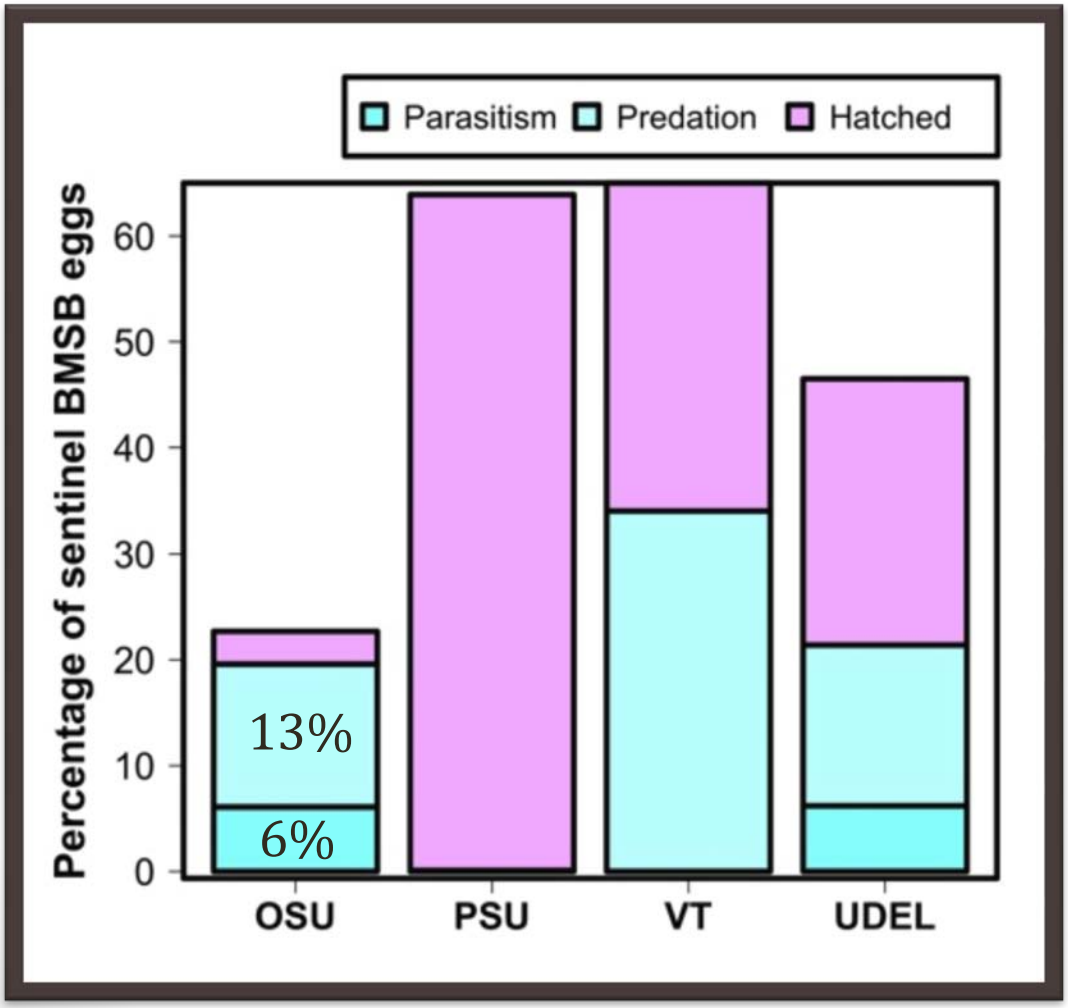
- Emergence from **Frozen** egg masses is high out to 6d, when kept cool
- Poor emergence out to 3d when eggs are heated
- This is good, we drive a lot to get to field sites

Frozen egg masses – lab Testing

- Sex ratios may remain female biased for ~ 3d when eggs kept cool
  - Low emergence after day 5 is messing up data, more reps needed
- Emergence out to 3d was female biased at warm incubation temperatures



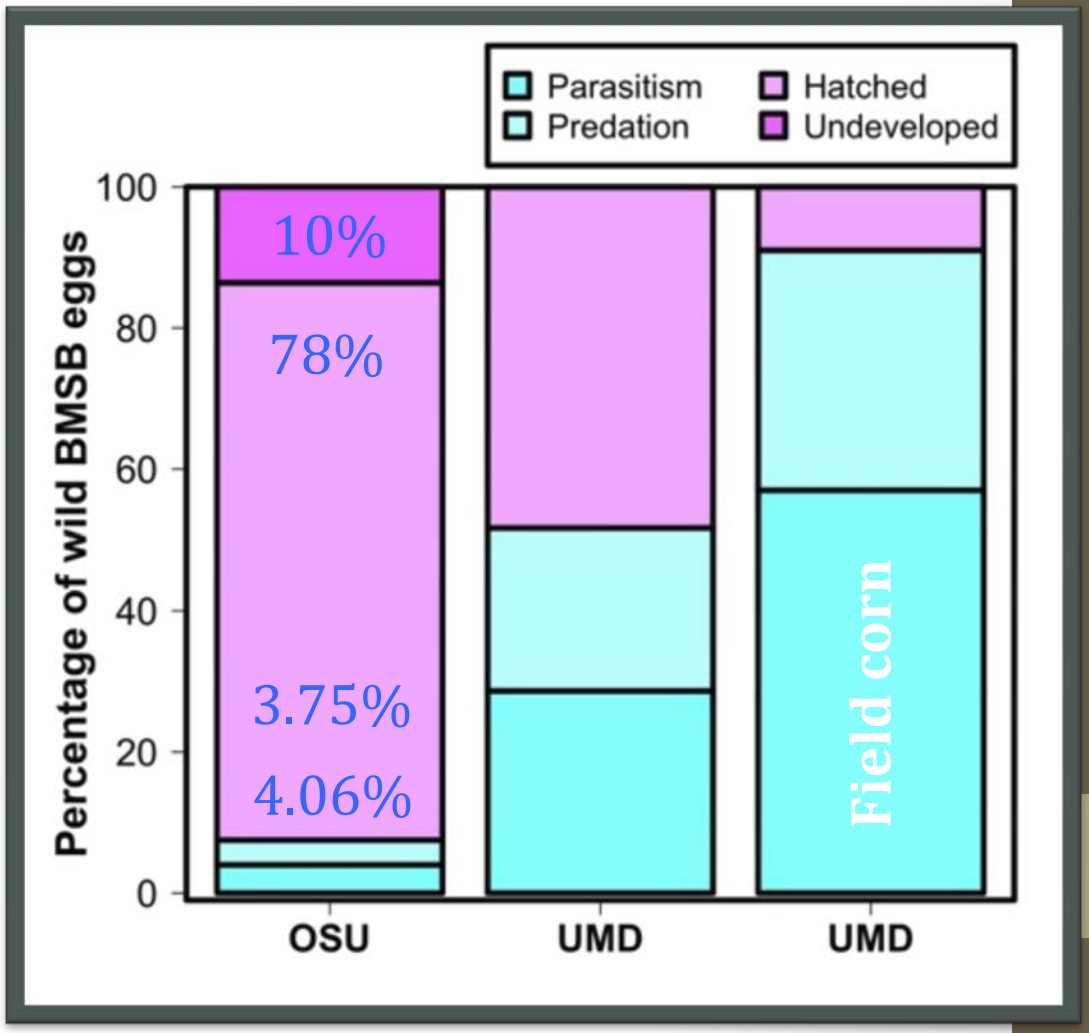
Parasitism of sentinel EM



- OSU: blackberry, hazelnut, blueberry, holly
  - Left for a week
- PSU:apple
- VT: ailanthus
- UDEL: sweet corn

Parasitism of Wild EM

- Comparing E. and W. Coast
- Ornamentals
  - OR: holly, paulownia, catalpa, maple, ailanthus
  - UMD: Maples, Cherry, elm
- UMD:Field corn



Predation issues on sentinels

Wiped out again!

- Pesky predators
  - Predation data for wild masses is important
  - Predation of sentinels is annoying and expensive
  - Really trying to examine parasitoid species
  - Predation data on sentinel masses not informative
  - Human placement bias
    - Temporal bias for frozen masses (1 week)

Predator cages for sentinel EM

- **Goal**: exclude ants and other mandibulate predators
- **Plan**: test on 50% of 2013 sentinels

Oregon parasitoid diversity

Trissolcus cosmopeplae

- Not reared from BMSB eggs in Mid-Atlantic
- The genus cosmopepla contains some of the smallest pentatomids
- More research needed on host records, may hit bigger SB eggs too

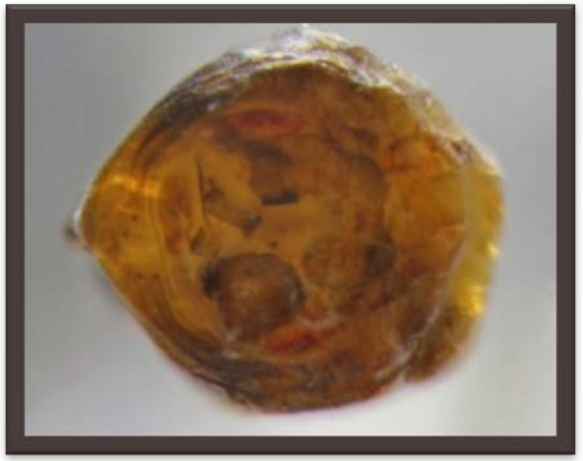
Cosmopepla intergressa

Trissolcus euschisti

Wild and sentinel egg dissections

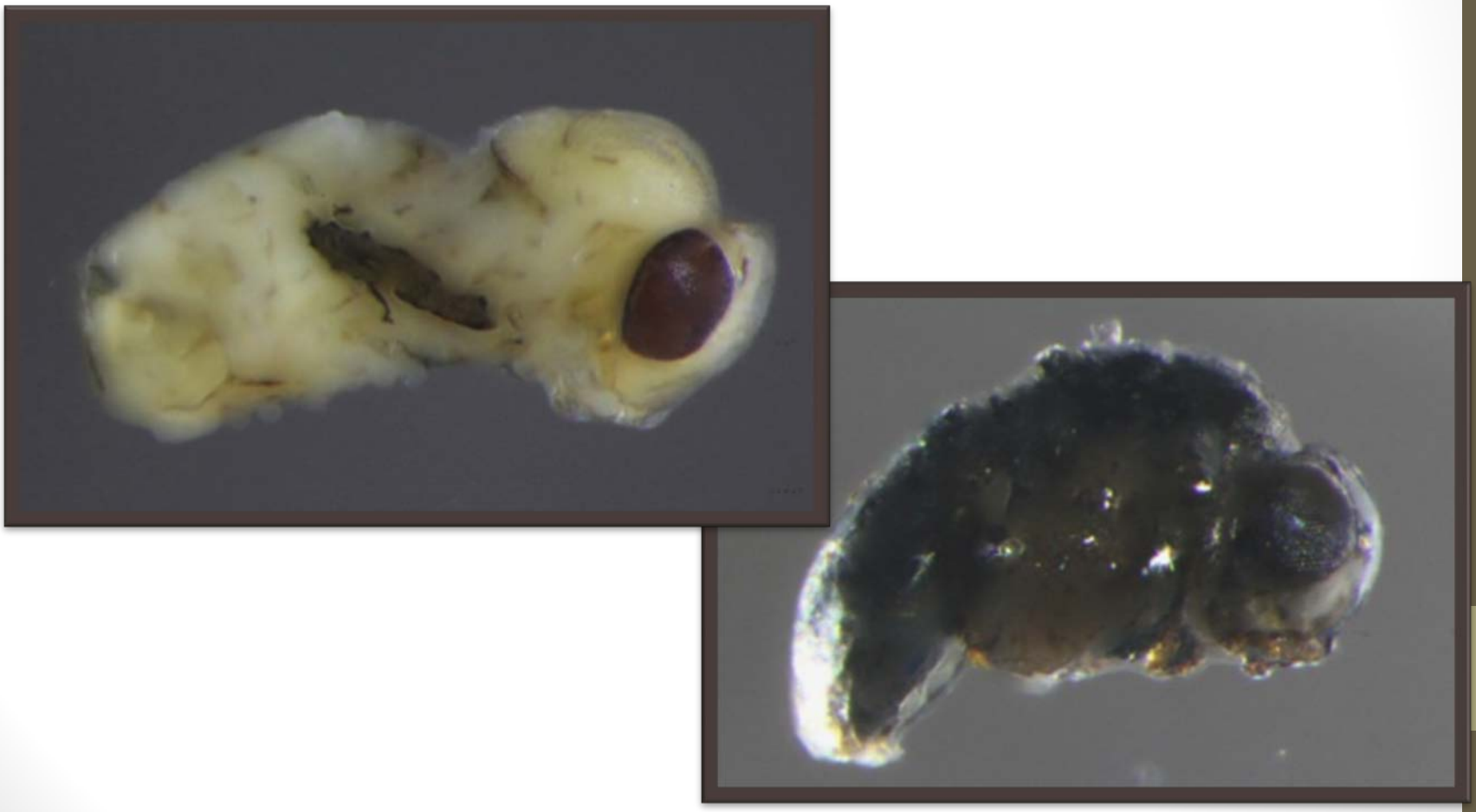
Trissolcus early development

Wild and sentinel egg dissections



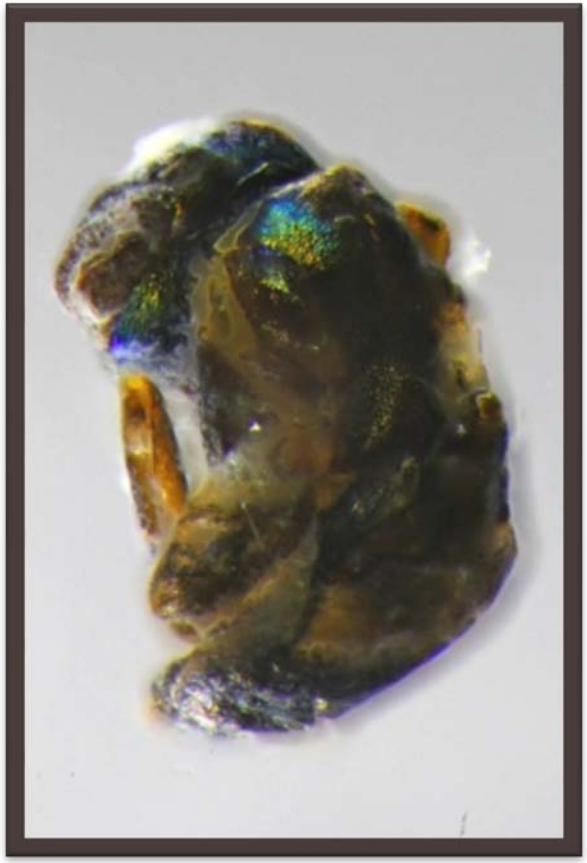
Wild and sentinel egg dissections

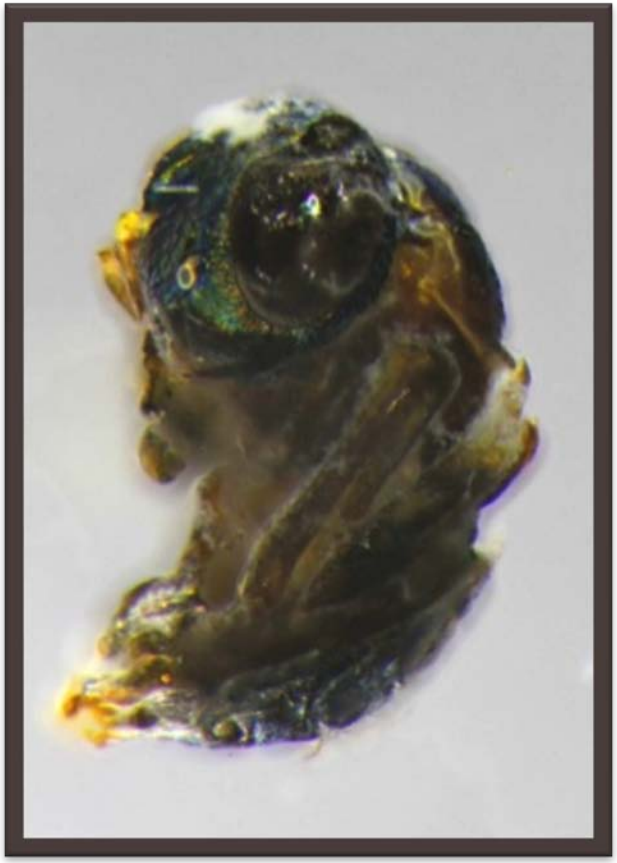
Trissolcus late development



Wild and sentinel egg dissections

Anastatus spp. ONLY ONE!!





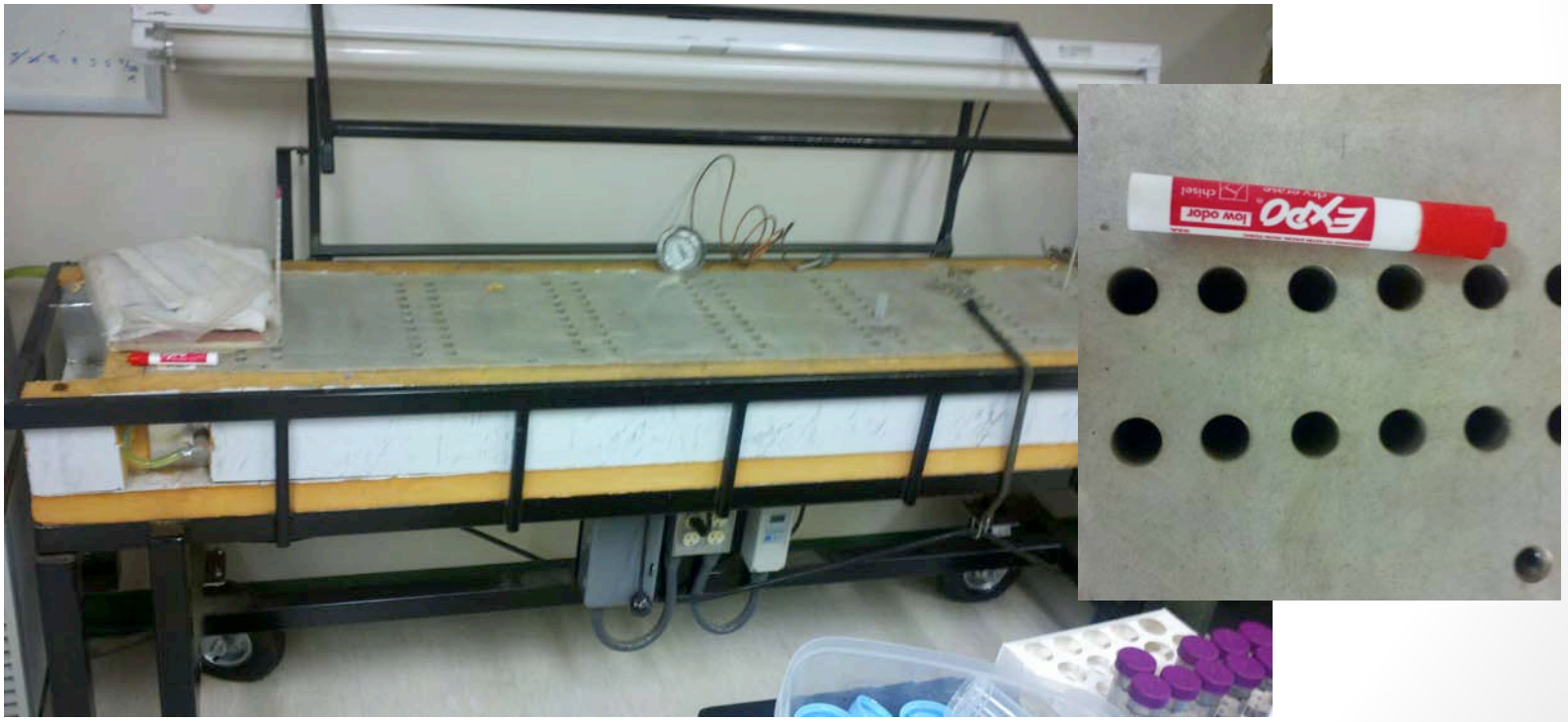
Kairomones and parasitoids

- We performed a kairomone trial in 2012 at 3 sites in OR
  - With Dave Biddinger, Penn State
- 3 treatments: UTC, *Euschistus conspersus* pheromone and USDA-ARS #10 x 3 reps/site
- Cards were collected and rotated weekly
- Potential *Trissolcus* were lifted, washed, and pickled
  - Lots of scope work ahead!
  - Will be repeated 2013
    - Maybe clear or white cards
    - Fewer nontargets

Temp-dependent parasitism

soon!

- How efficiently do BMSB egg parasitoids compete at different temperatures?
- Funded by Oregon Ag Research Foundation (ARF)



Temperature gradient table

2012 Hazelnut feeding damage trials

Chris Hedstrom & Vaughn Walton

- USDA Hazelnut Germplasm Repository, Corvallis, OR
- 9 trees representing three cultivars
- 25 bags placed in each tree in May (225 bags total)
- Insect exposure from June to October 2012 – 16 weeks total
- Three adult males or late instar nymph per bag, exposed for one week
- Nuts examined for damage after harvest

Healthy

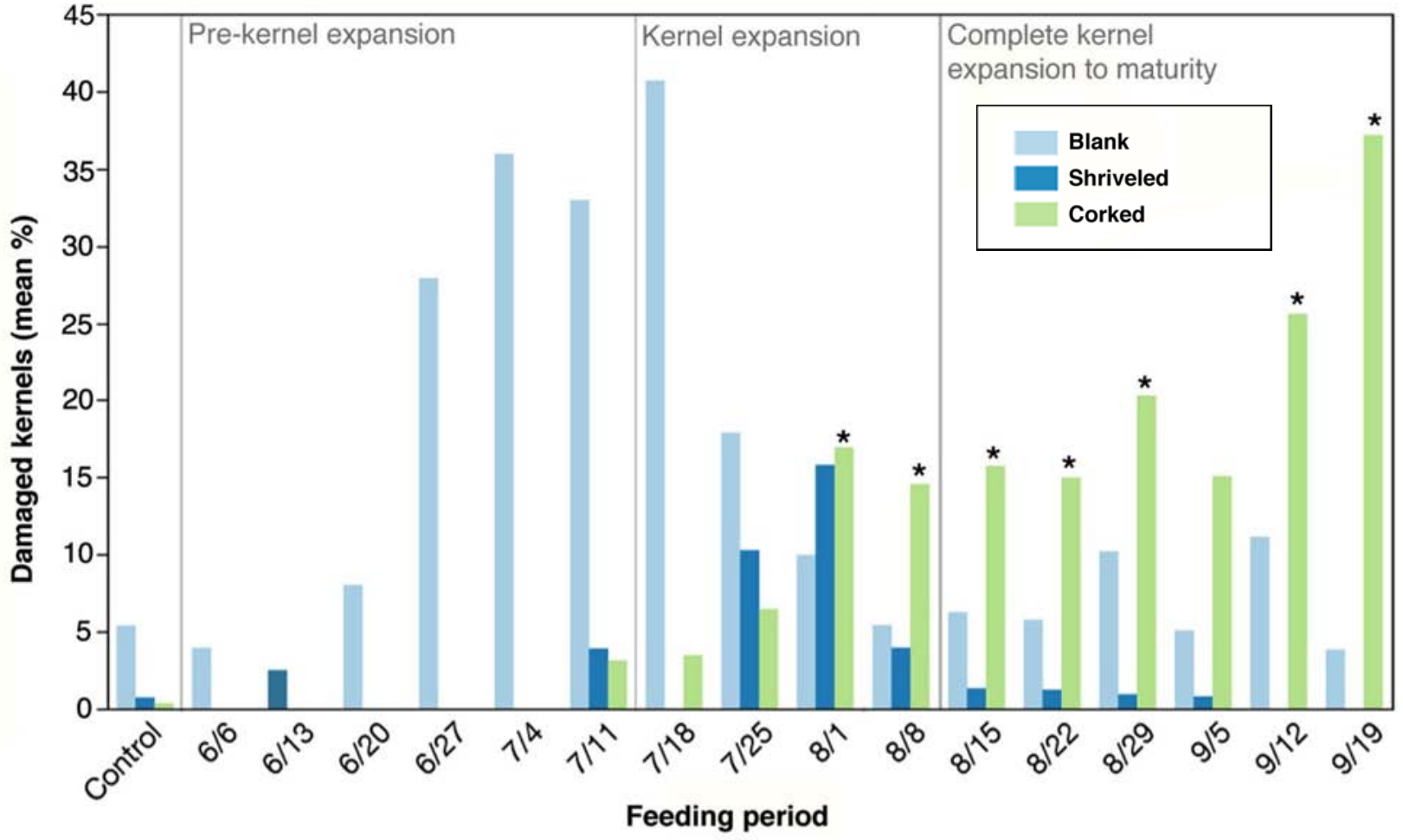
Blanks

Shriveled

Corking

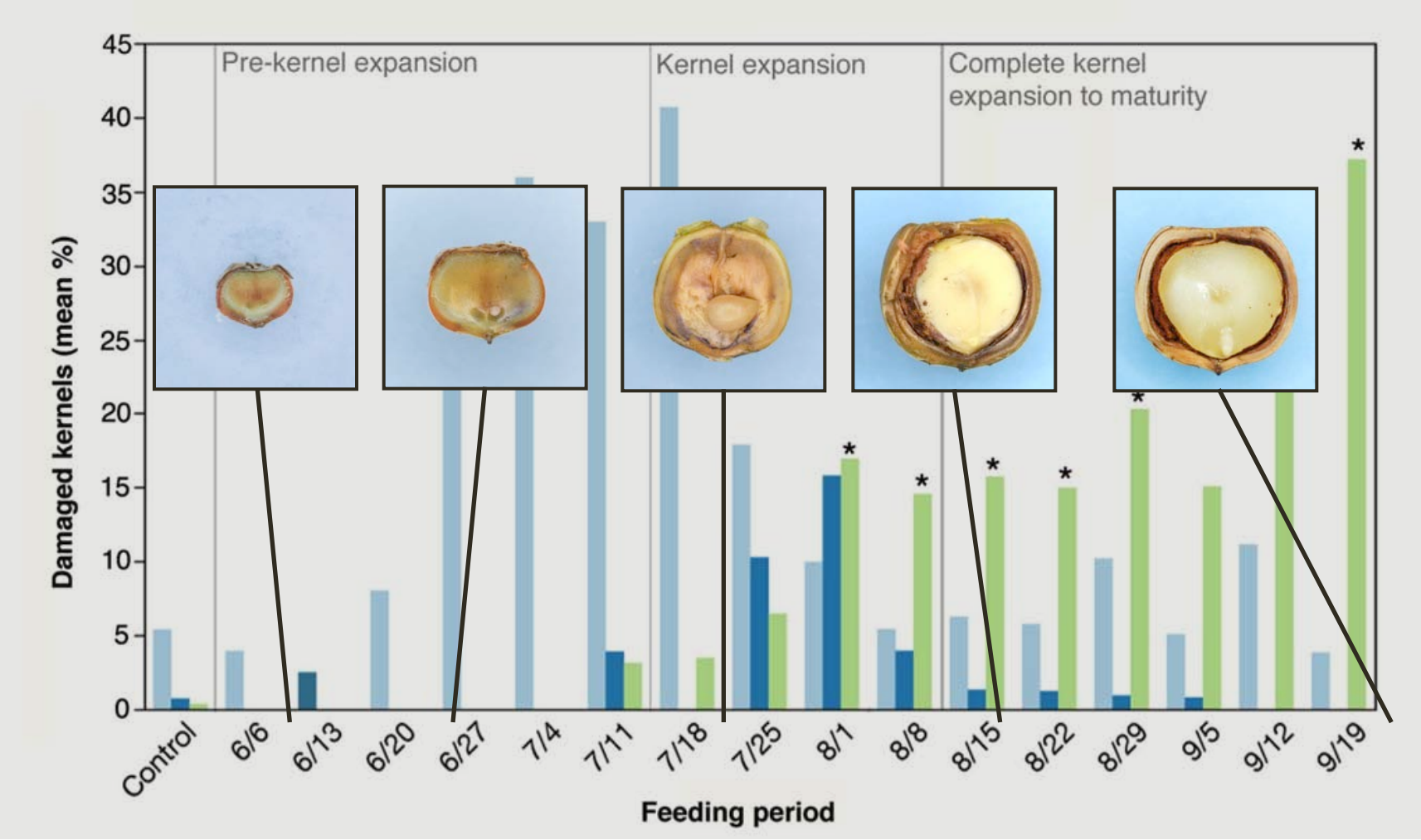
Oily

2012 Hazelnut feeding damage results



Asterisks indicate significant difference of mean % damage type when compared to the control group (Kruskal-Wallis non-parametric ANOVA)

2012 Hazelnut feeding damage results



Summary

All stages of hazelnuts tested appear to be susceptible to feeding damage

Damage appears to be very similar to that of other tree nuts by other members of Pentatomidae

Trends observed suggest that early season feeding can result in blank nuts and late season feeding can result in corking and necrosis

Trial being repeated in 2013

Controlled damage: Blueberries

new!

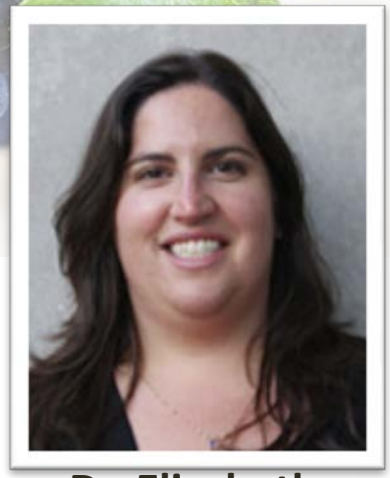
- Coordinated with Joyce Parker (Rutgers)
- Sleeve cage trials
- Early and late variety
- 0,2,5,10 BMSB per cluster x 10 reps
- Week-long exposures

Controlled damage: Blueberries

Controlled damage: Blackberry

BMSB taint in wine

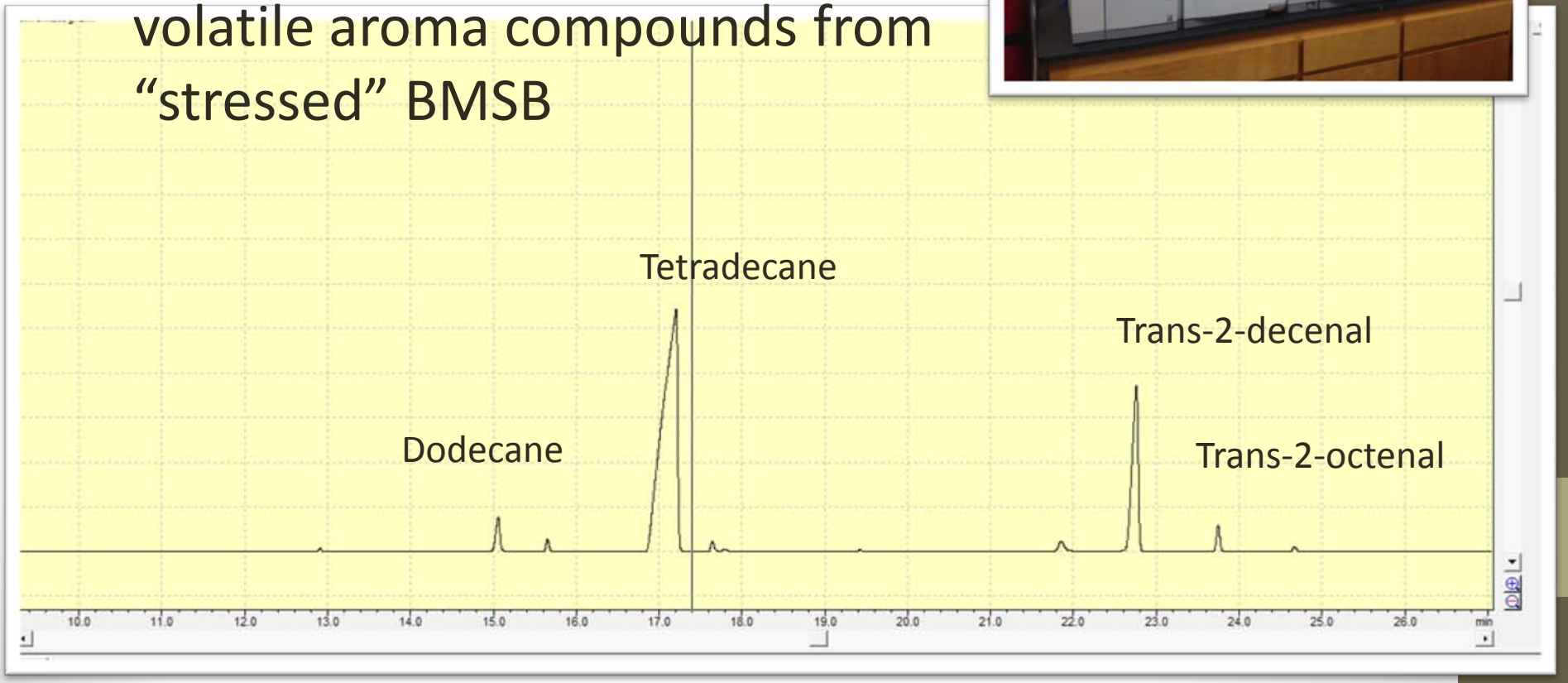
- New OSU faculty with wine sensory analysis and flavor chemistry expertise
- **Research question**: will BMSB contamination result in wine taint?
  - Side note: BMSB found on harvested grapes last year
- Taint likely depends on process
  - High-quality Pinot Noir grapes (generously donated by Adelsheim Vineyard)



Dr. Elizabeth Tomasino

BMSB taint in wine

- **Step 1**: Characterize BMSB defensive compounds
- GCMS chromatogram of the volatile aroma compounds from "stressed" BMSB



BMSB taint in wine

Is the winemaking process a "stressful" enough experience that stinkbugs can impact wine quality?

- **Stinkbugs added to Pinot noir grapes before wine processing**
- **BMSB added to the destemmer**
  - **Control – no bugs**
  - **Treatment 1 (T_1) – 1 bug per 4 clusters**
  - **Treatment 2 (T_2) – 1 bug per 2 clusters**
-
- **Moribund bugs present throughout ferment**
- **Additional taint compounds released at pressing to remove grape skins**
- **Main contaminant in wine was trans-2-decenel**

Evaluating BMSB taint in wine

- **Difference testing (triangle tests)**
- **Consumers discriminated treatment wines from controls ($\alpha = 0.05$)**

- **Consumer rejection threshold very close to detection threshold**
- **Low amounts of BMSB taint have a negative impact on Pinot noir quality**.

Acknowledgements

- Christine Dieckhoff, Kathy Tatman, Tracy Leskey, David Biddinger, Preston Brown, Erika Maslen, Todd Murray, Vince Jones, Jay Brunner, Chris Hedstrom, Betsey Miller, Sam Tochen, Pallavi Mohekar, Zoe Milburn, Bryan Smith

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