

Voltinism 1.1.1

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Collaborating Institutions



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Voltinism

The frequency or number of annual broods

- Univoltine: one generation per year
- Polyvoltine: multiple generations per year



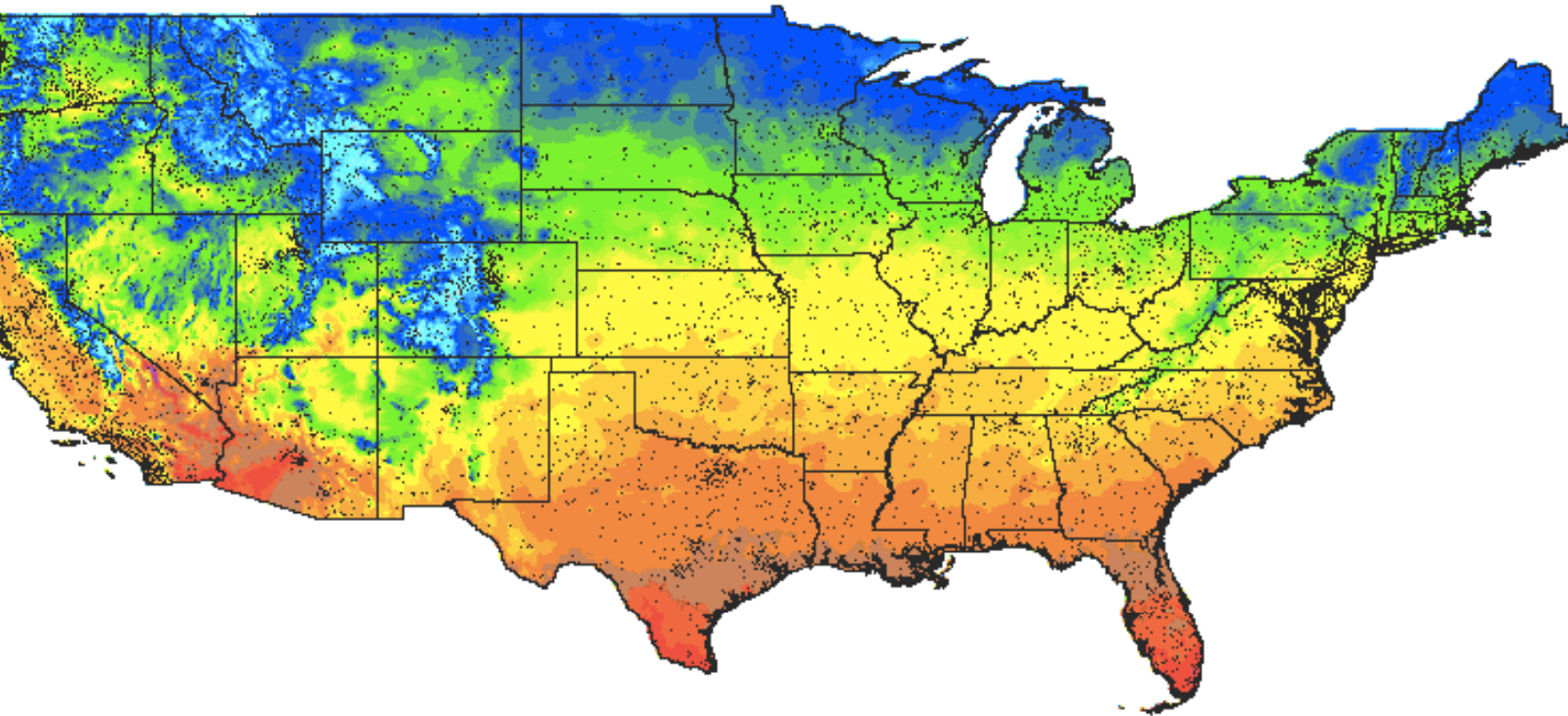
Degree day model for BMSB

Anne Nielsen, G. C. Hamilton & D. Matadha. 2008.
Developmental Rate Estimation and Life Table Analysis for
Halyomorpha halys (Hemiptera: Pentatomidae). Environ.
Entomol. 37(2): 348-355.

- 15 °C base temperature, 33 °C maximum temperature
- Preoviposition period: 148 DD
- Egg hatch: 126 DD
- Egg to adult development: 538 DD



Cumulative Growing DD₅₀



Cumulative degree-days in Us Jan 1 – Dec 2 2013



Nielsen, Fleischer, Saunders, Chen, & Rice

Objective: Develop a model to predict voltinism and population density

Investigate female reproductive physiology

- Field collected individuals: NC, PA, NJ, WV
- Reproductive ranking system
- Fit to DD timing

Develop predictive model: *Assumes that development and diapause are functions of temperature and photoperiod*

- Individual based
- Monte-Carlo approximations



Model Input

To develop a model that will work across latitudes we are using the following data and parameters:

Diapause termination and initiation

- 13 – 15h photoperiod
- Currently evaluating 14.5h based on dissection data
- Watanabe et al. 1979; Yanagi & Hagihara 1980; Nielsen et al. 2008

Diapause initiation

- Currently evaluating 14.5h

Survivorship (stage-specific)

- Kiritani 2006; Nielsen et al. 2008

Fecundity

- Nielsen et al. 2008

Development

- Base 14.14°C
- Preoviposition period (still clarifying): 77 DD
- Egg to adult: 538 DD



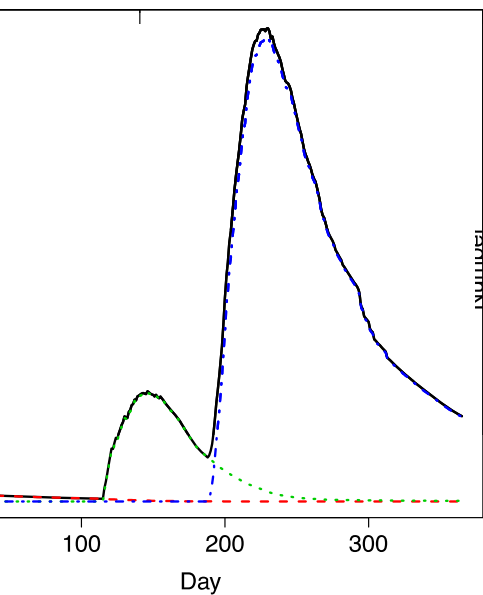
Total Population

1
2

Draft Voltinism Model Outputs

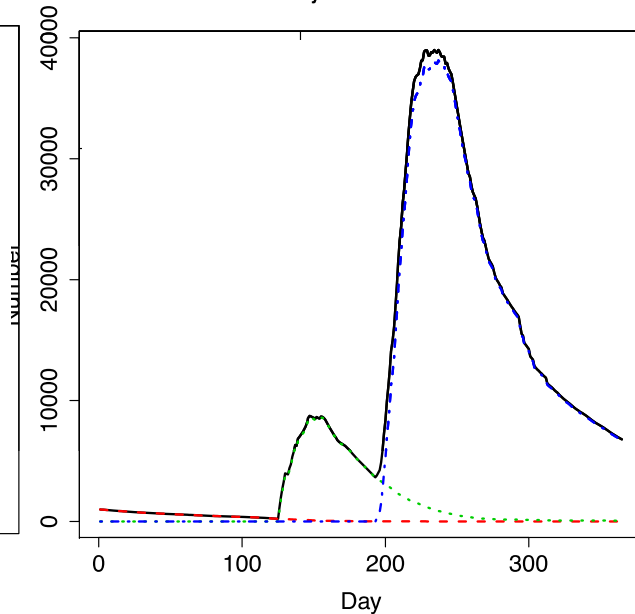
5 h

By Generation



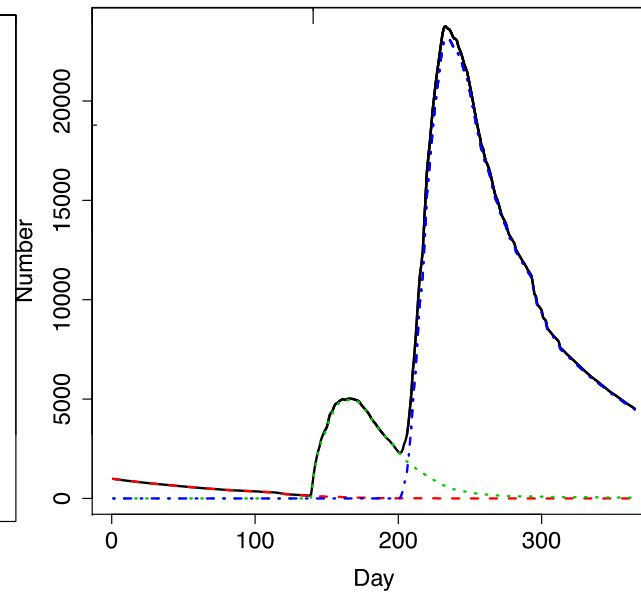
14.0 h

By Generation



14.5 h

By Generation



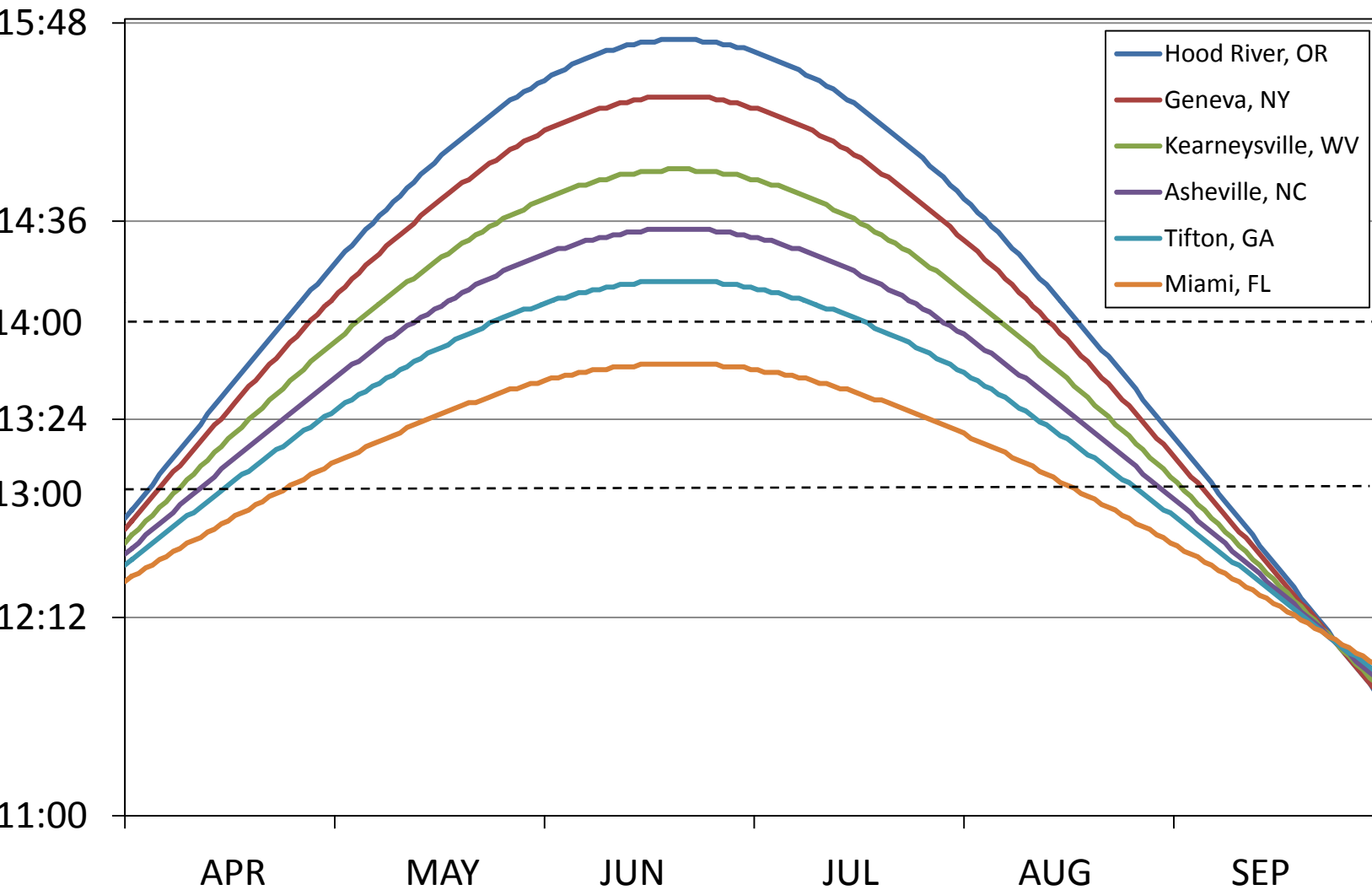
Model uses 1000 individuals leaving diapause

Using photoperiod as the primary factor controlling diapause there is a

large difference in the resulting F2 generation

there is likely an interaction between photoperiod and temperature

Day Length Hours at Different Latitudes



Dates and number of days with 13 and 14 hour day lengths

Location	Latitude	13-h day length			14-h day length		
		Spring	Autumn	# days	Spring	Autumn	# days
Wood River, OR	45° 42'	5 Apr	7 Sep	155	23 Apr	18 Aug	117 (38)
Geneva, NY	42° 52'	6 Apr	4 Sep	151	28 Apr	13 Aug	107
Marneysville, WV	39° 23'	9 Apr	2 Sep	146	5 May	7 Aug	94
Greenville, NC	35° 35'	12 Apr	30 Aug	140	13 May	29 Jul	77
Concord, GA	31° 25'	16 Apr	25 Aug	132	27 May	15 Jul	49 (83)
Miami, FL	25° 26'	25 Apr	17 Aug	113	—	—	—

Field cages used to contain and study BMSB



Mating pairs and/or eggs were generally kept segregated.



provisioned with assorted host plants,
supplemental food in some cases



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- Adds to yard privacy

h up to 60ft.
3 years!



Geneva, NY

1st egg hatch on 22 June (739 DD50F from Jan. 1, or 638 DD₅₀F from start of 14:10 light:dark photoperiod; or 203 DD from egg mass introduction);

2nd instars present on 28 June;

3rd instars present on 6 July;

4th instars present on 18 July;

5th instars present on 11 Aug (1037 DD after hatch).

None made it to adult.



Highland, NY (Hudson Valley)

Adults were placed on 6 May.

Field observations 1st egg hatch on 24 June (783 DD₅₀F from March 1, or 700 DD₅₀F from start of 14:00 light:dark photoperiod);

Adults present on 5th August (1802 DD₅₀F from 14hr L/D photoperiod).

Eggs observed and hatched on August 21st (2110 DD₅₀F from 14hr L/D photoperiod)



2013 PSU BMSB voltinism project



- Cages were assembled in late April.
- BMSB overwintering adults only from wild overwintering sites (until end of May)
- Each egg mass kept separately in net sleeve.
- 2nd instar nymphs moved to smaller net cages with nymphs only.
- Summer adults were kept in separate cages.



2013 PSU BMSB voltinism project - summary

Event (first occurring)	Date	DD base 50F (10 C)
First mating	Unknown	
First egg mass	May 28	0
First hatch	June 04	157
First adult	July 15(M), 17 (F)	1103
First egg mass	July 31	1511
3 rd instar	Aug 27	2054
Who lived longer		

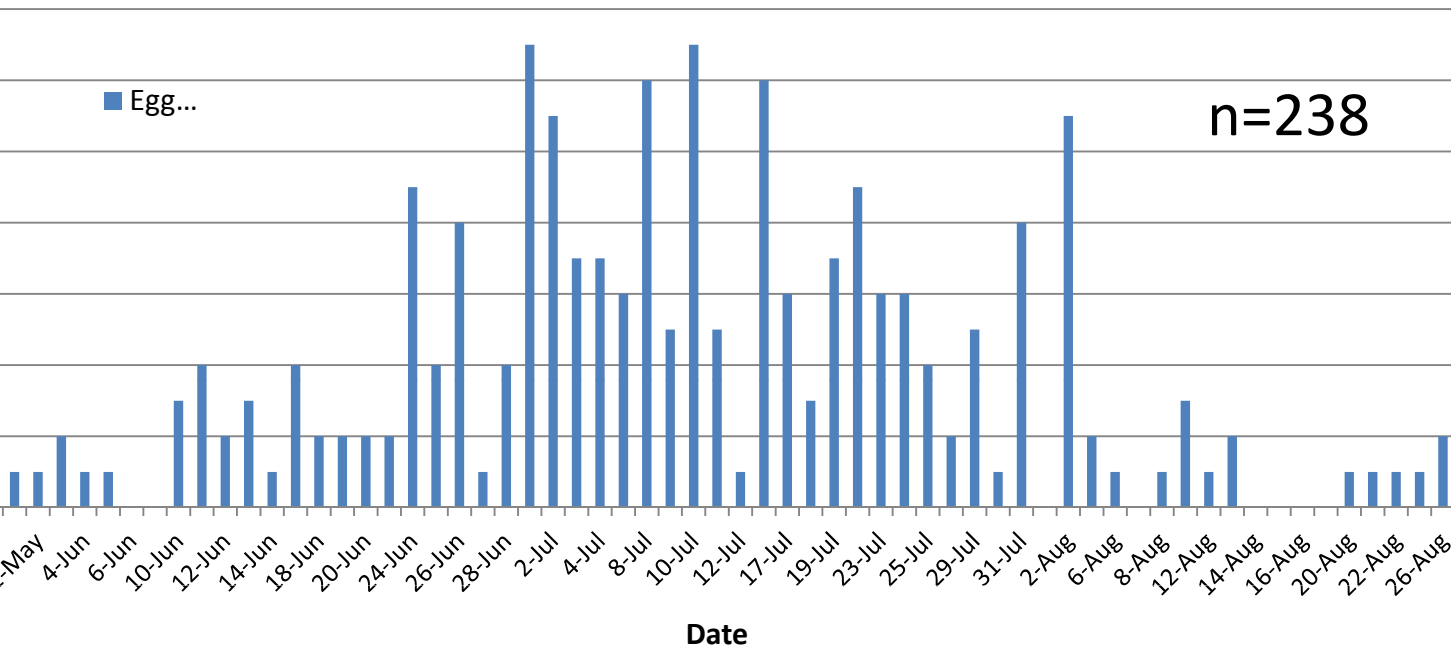
L: 14 h 46 min

wintering generation egg masses – total 238; 225 hatched
summer generation egg masses – total 18; all hatched

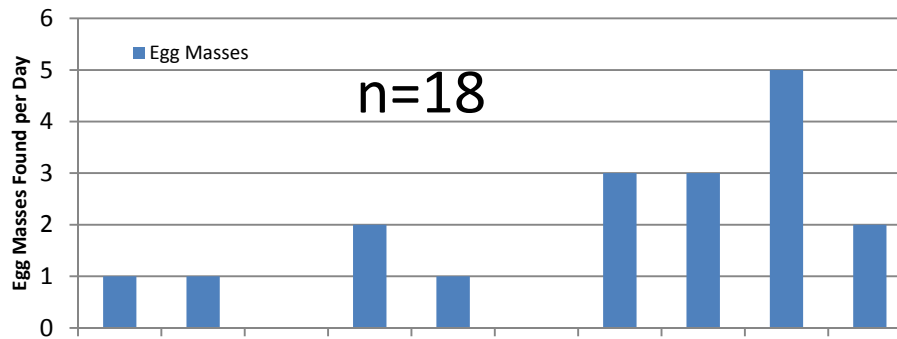


2013 PSU BMSB voltinism project - summary

BMSB Overwintering Generation



BMSB Summer Adult Generation



Number of egg masses collected from various plants from cages in voltinism project . PSU 2013.

USDA-ARS Kerneysville, WV

May 1 was the only cage we had success season-long, used wild-collected adults and egg masses generated in-situ. Host plants used include: peach, *Paulownia*, pea, green bean, pepper, and amaranth.

May 5 – 14 hr day

May 6 – 10 males and 10 females released into cage

May 30 – egg masses found (total DD from May 6-May 30 = 114)

July 19 – adults found (total DD from May 6- July 19 = 542)

July 26 – New egg masses found (total DD from July 19-July 26 = 90)

September 26 – new adults found (total DD from July 26-September 26 = 1000, May 6-Sept 26 = 1132)



NC Voltinism Study - Methods

Cage studies conducted in Mills River, NC

First overwintering adults (4♀, 4♂) observed in local “hotspot” were caged on Paulownia and Tree of Heaven using sleeve cages.

- 4 Eggs observed on Paulownia, none on TOH.

Food sources

- Tree of Heaven, Paulownia, peach
- Sunflower, sweet corn, soybean



C Voltinism Study – Observations (Date)

First oviposition - 27 May

– Day length at first oviposition - 14:20 h

First hatch – 5 June

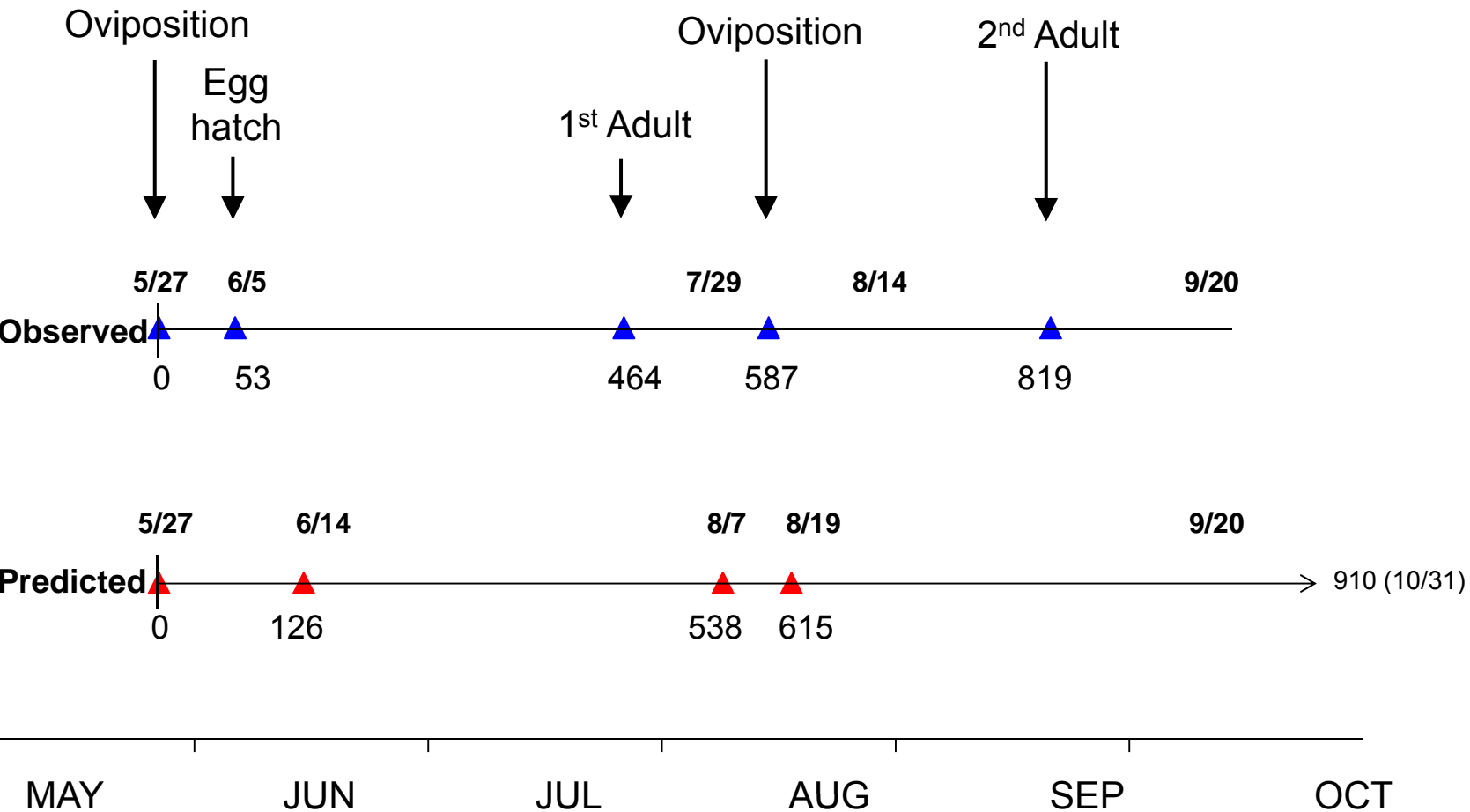
First adults – 29 July

Second oviposition – 14 August

Second adults – 20 September



Phenology of Natural BMSB Populations Mills River, NC - 2013



Problems

Not a problem, but 2013 was very cool and **extremely** wet. Total DD accumulations in May, June, July and Aug only 31, 203, 250, and 214, respectively. Total rainfall from 15 May to 31 August was 40.7 inches.

For the second year, BMSB adults have not laid eggs when caged on tree of heaven.

Did not have temperature recorder in cage. Relied on official research station data for DD calculations (15C low and 33C high).

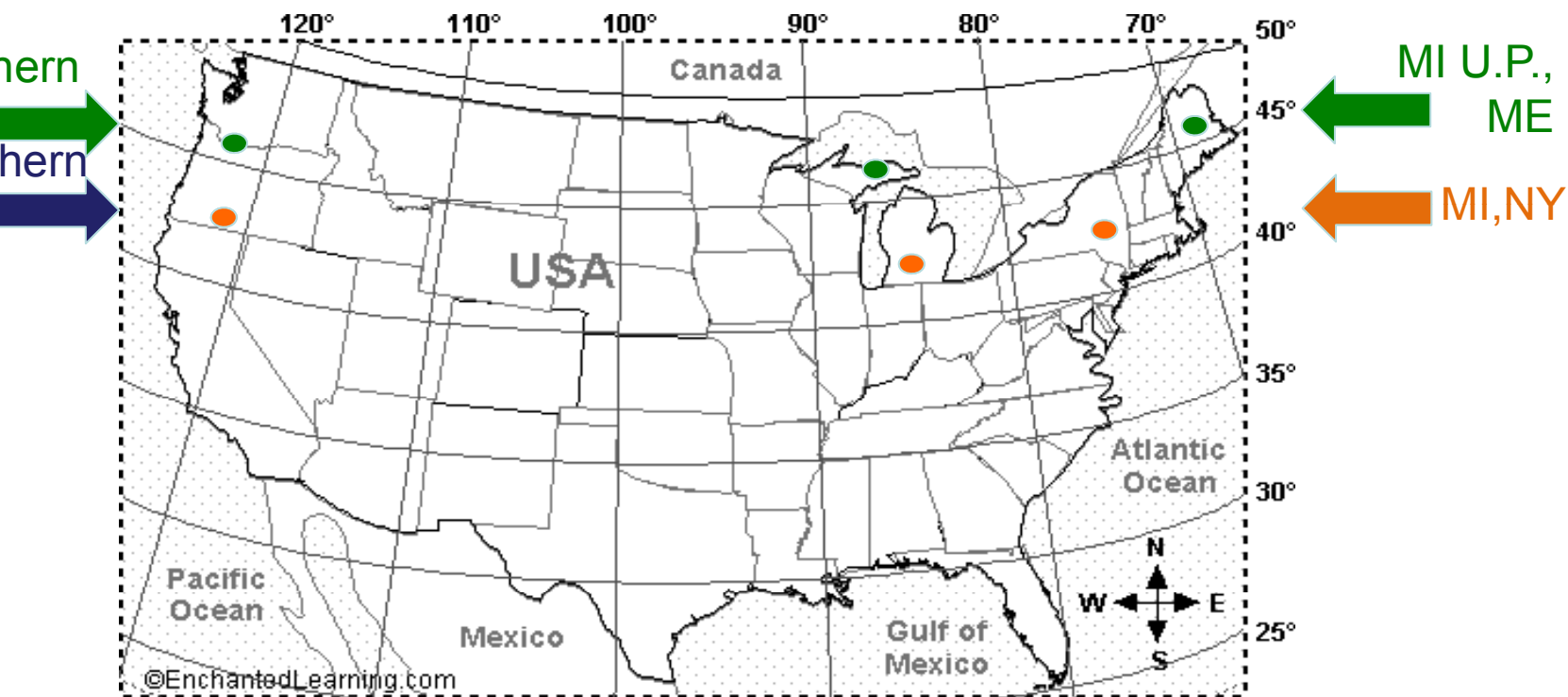
Can't explain early emergence of 2nd gen. adults in September.



Phenology & Voltinism: Cages



Daylength vs. Degree Days



Phenology & Voltinism: Cages



- Follow life history events in a controlled outdoor environment
 - Stage-specific phenology
 - Voltinism
- 7 cages in 5 locations (6x6x6)
- Brent's protocol except free ranging not allowed in 5/6 cages
- Supplemental food provided in sleeve cages in HR
- Established 4/15-4/26



Small Cage Voltinism, Corvallis, OR

	6 ft ³ walk-in	Tent cage 30" x 30" x 45"
BMSB	Wild adults 2♀: 2♂ in mesh	Eggs laid by wild adults in lab
Set-up	May 21, 2013	May 20-28, 2013
Plants	3-4 plants: euonymus, fava, horse chestnut, lilac, maple, paulownia, peach, sunflower, tree of heaven	
Food	<u>Jelly beans</u> in June, then peanuts and green beans	
Oviposition	June 3 (ave. June 16) Daylength 15 hr 23 min	<i>In lab eggs laid May 20 – June 3, put outdoors in 1-3 d</i>
Hatch	<u>June 17 (ave. July 2)</u>	<u>June 7 (ave. June 17)</u>
2 nd instar	June 19 <i>sleeve removed</i>	June 19 <i>freely roaming</i>
3 rd instar	July 3	June 21
4 th instar	July 17	July 12
5 th instar	Aug 5	July 19
Adults	<u>Aug 23</u>	<u>July 31</u>
2 nd Ovipos.	Sep 3	Did not lay
Replicates	4 cages	6 cages



USDA - Lee



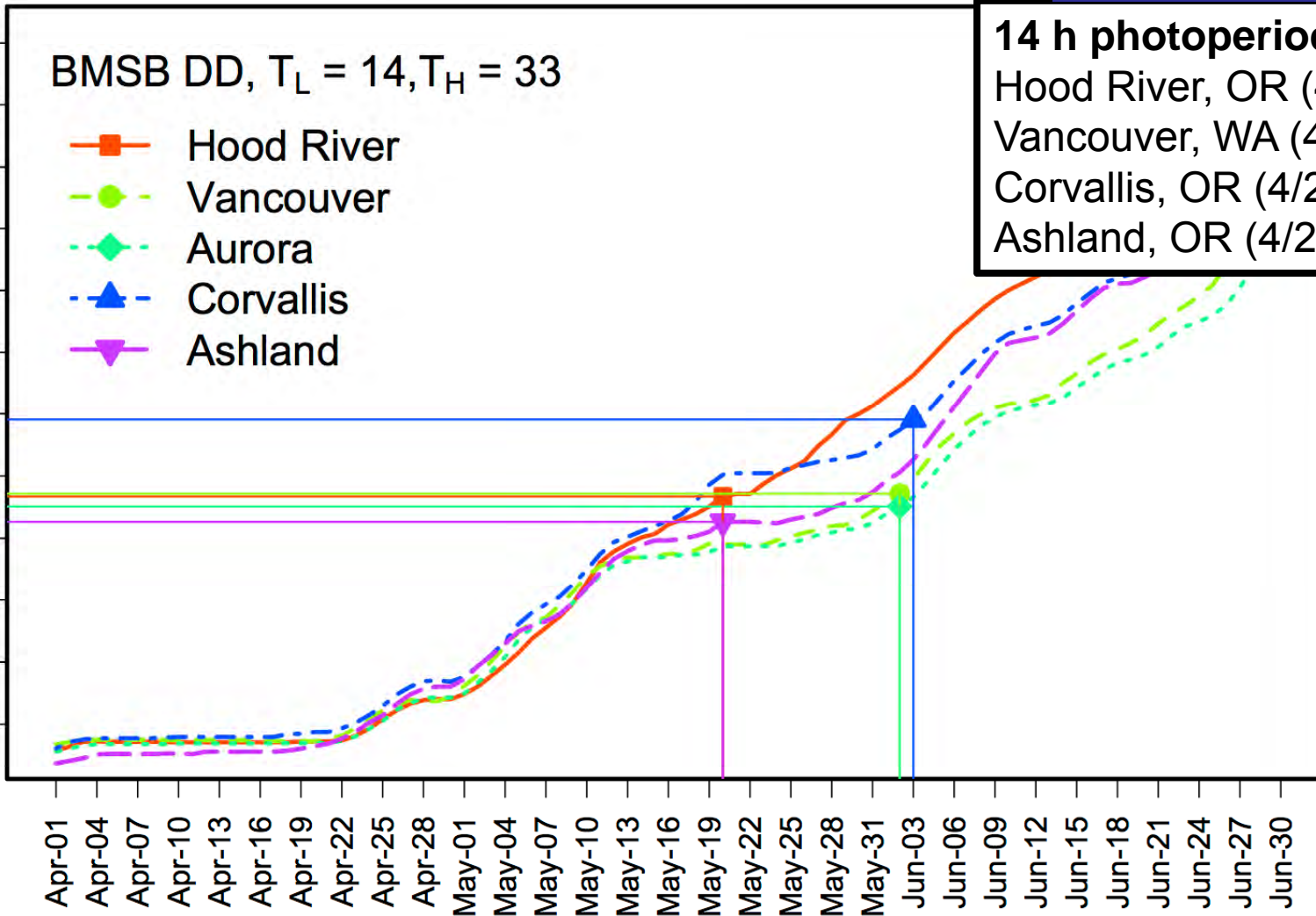
Early Season: First Eggs

Mean DD C	± DD
120.34	7.12

BMSB DD, $T_L = 14, T_H = 33$

- Hood River
- Vancouver
- ◆- Aurora
- ▲- Corvallis
- ▼- Ashland

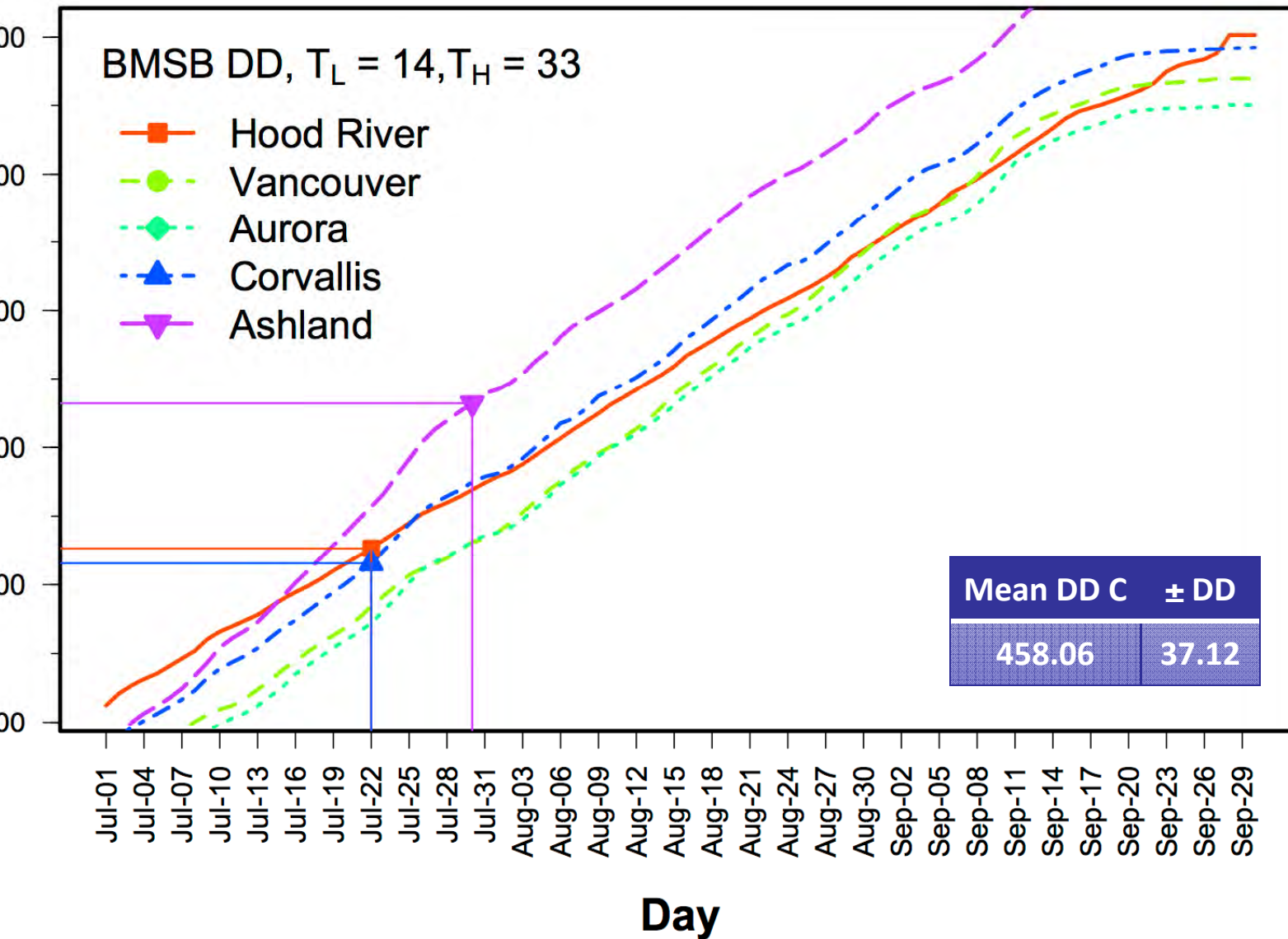
14 h photoperiod:
 Hood River, OR (4/24)
 Vancouver, WA (4/24)
 Corvallis, OR (4/26)
 Ashland, OR (4/29)



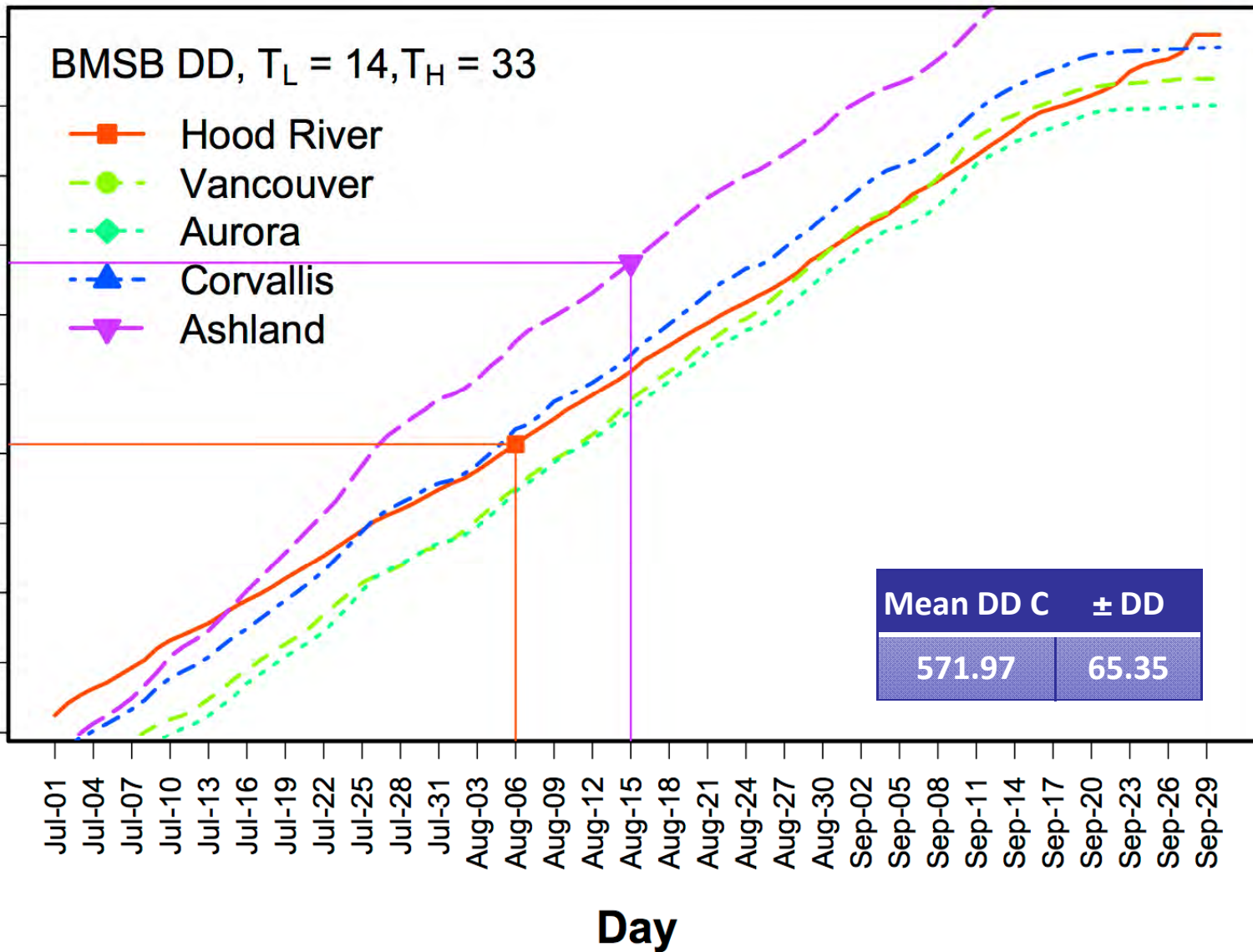
Day



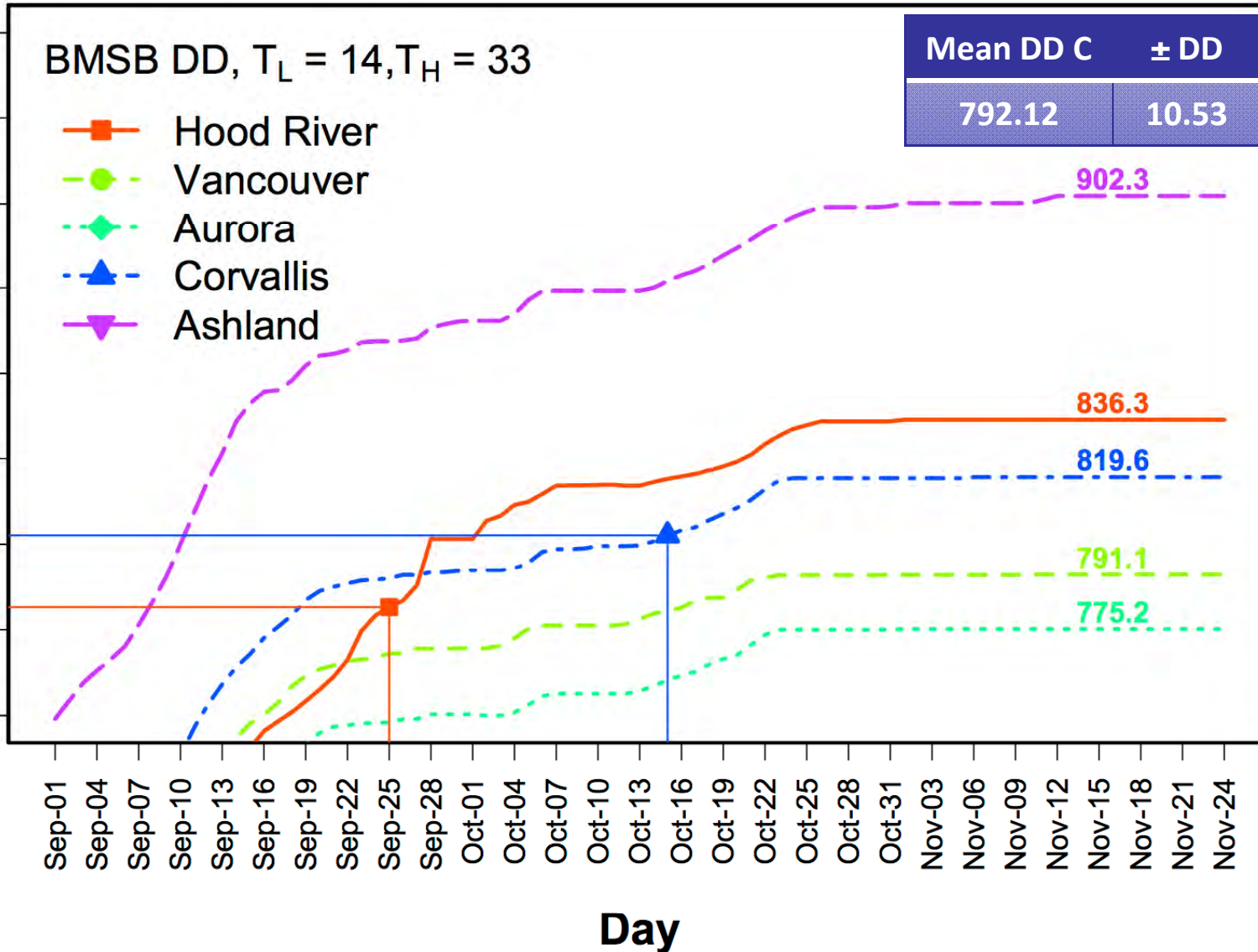
Mid Season: First Summer Adults



Mid Season: First Eggs 2nd Generation



Late Season: First 2nd Generation Adults



Problems:

Keeping sleeves on season-long

- Bugs do escape cages
- Condition for sites, containment

Predators killing nymphs

- Earwigs
- Spiders

Secondary pests

- Spider mites, aphids
- Rapid host plant destruction

Shady vs. sunny sites

- How important is basking behavior?
- Shady cages did poorly

Keeping plants hydrated at remote locations



Voltinism summary

To predict # generations and population size, we need to figure out relationship between heat units (degree days), photoperiod, voltinism and stage specific mortality.

Based on these results, BMSB can have 2 generations per year in some locals, 1 or 2 in others, weather dependent.

Evident that there is a lack of consistency in reporting

Different DD models, biofix dates,

readers for specific objectives are needed.

