Photoperiod effects on diapause

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Funding

USDA United States Department of Agriculture National Institute of Food and Agriculture

Specialty Crop Research Initiative

Collaborating Institutions

ars · NC State University · PennState · OSU Oregon State · University of Maryland · University of Georgia · Washington State University · Northeastern IPM Center · Cornell University · Utah State University · Rutgers University · The Ohio State University · University of Kentucky · UC Davis · University of Minnesota · Virginia Tech · Berkeley · Michigan State University · UC Riverside

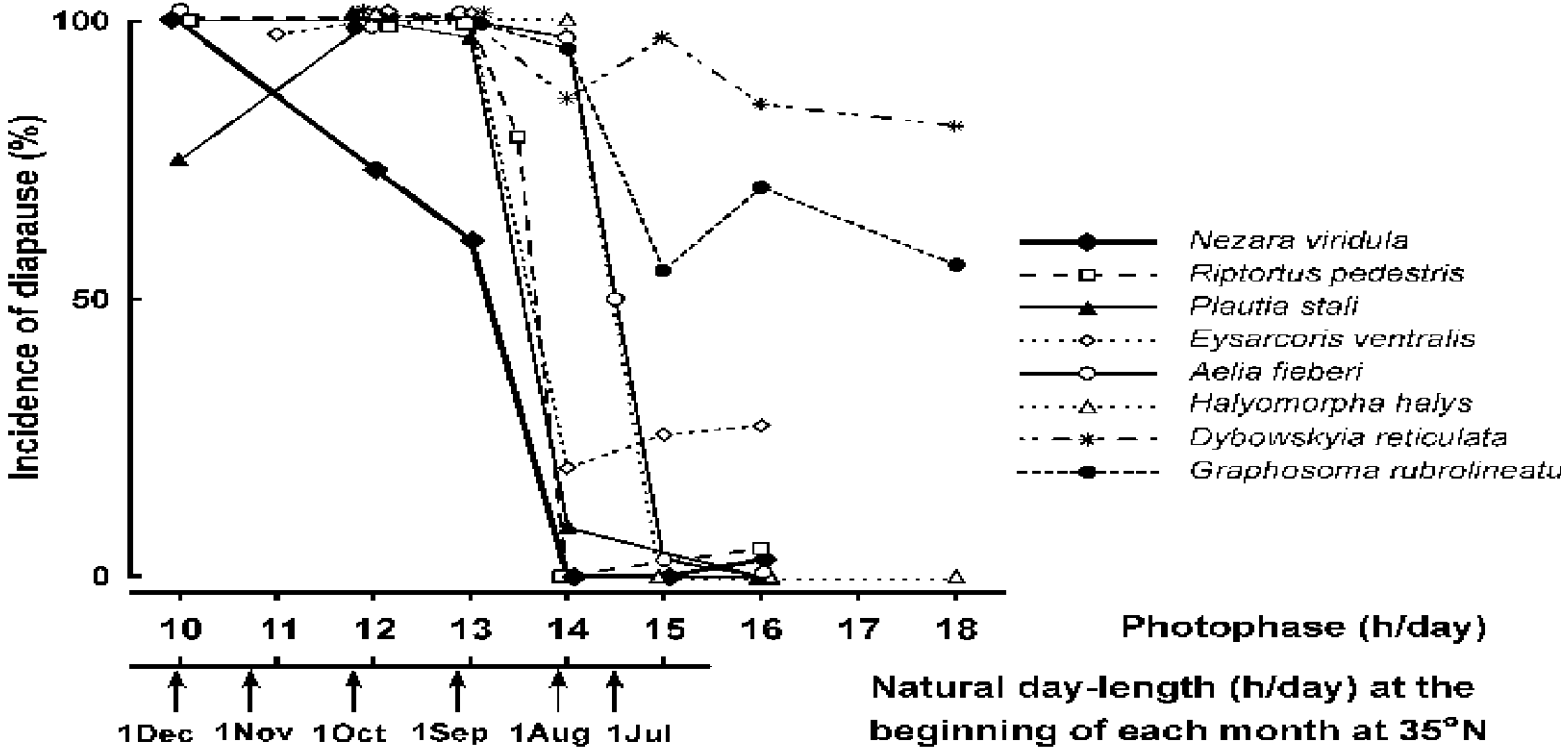
This material is based upon work that is supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, Specialty Crop Research Initiative under award number 2016-51181-25409.

Insect Diapause

- Physiological adaptation to survive changing environments
- Diapause allows synchronization of life cycles and host phenology
- Most common stimuli are photoperiod, temperature, moisture

Tauber and Tabuer (1976) *ARE*; Musolin (2012) *Phy. Entomol*

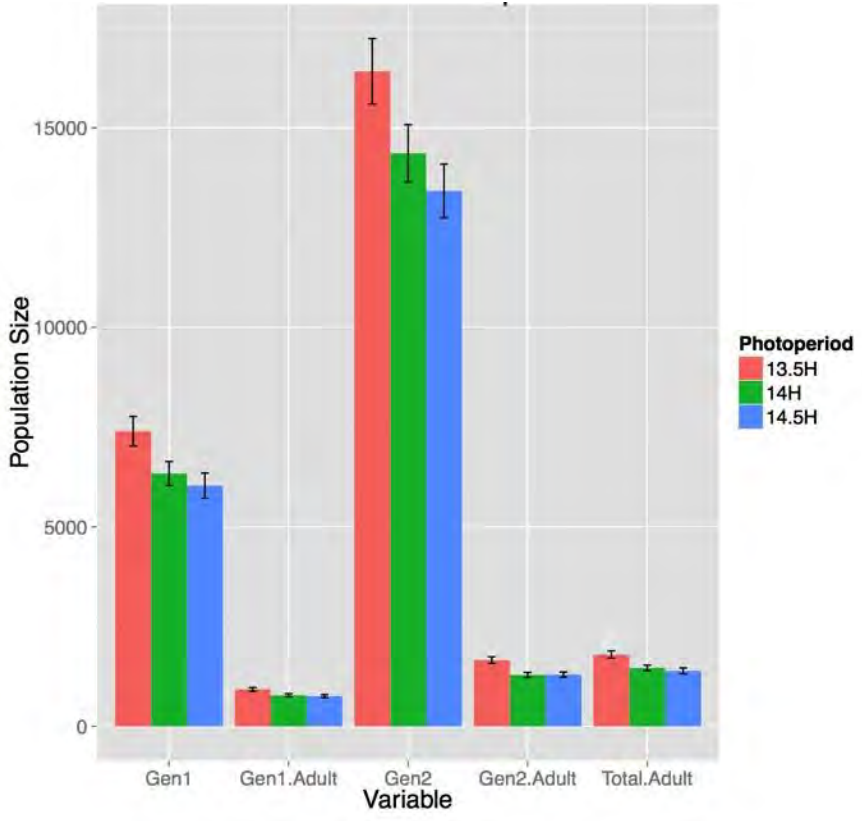
Diapause in Pentatomidae



Musolin & Numata (2003) *Phys. Entomol.*

Brown Marmorated Stink Bug

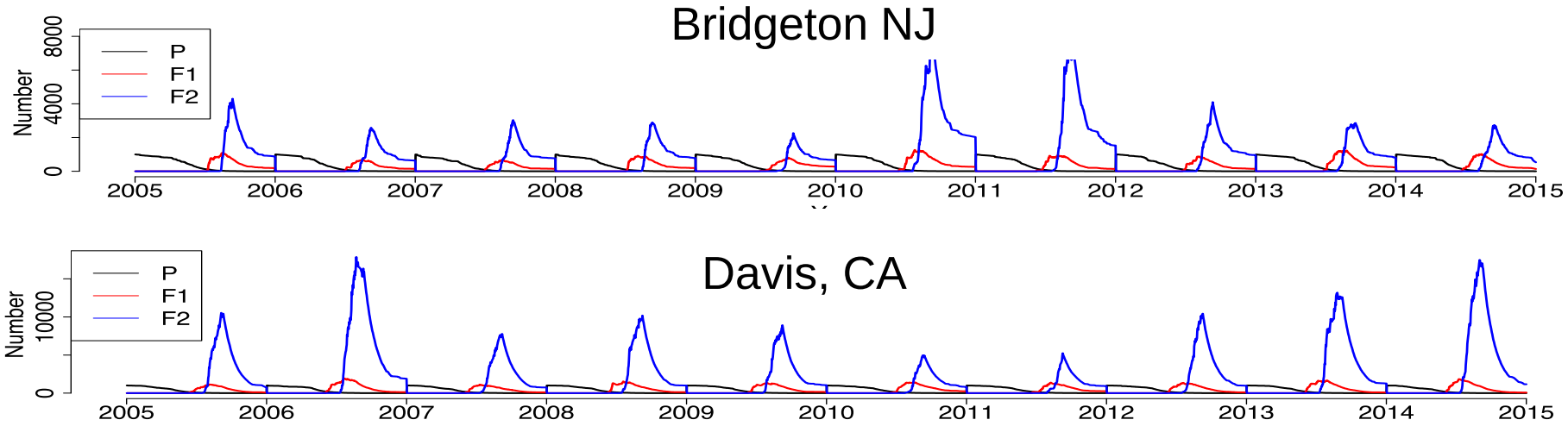
- Literature from native region reports variable information on diapause cues
- When seasonality of different populations are modeled using the same developmental parameters
  - Differences in seasonality
  - Photoperiod plays a significant role in resulting population size



Nielsen et al. (2016) *Front. Physiol.*

Brown Marmorated Stink Bug

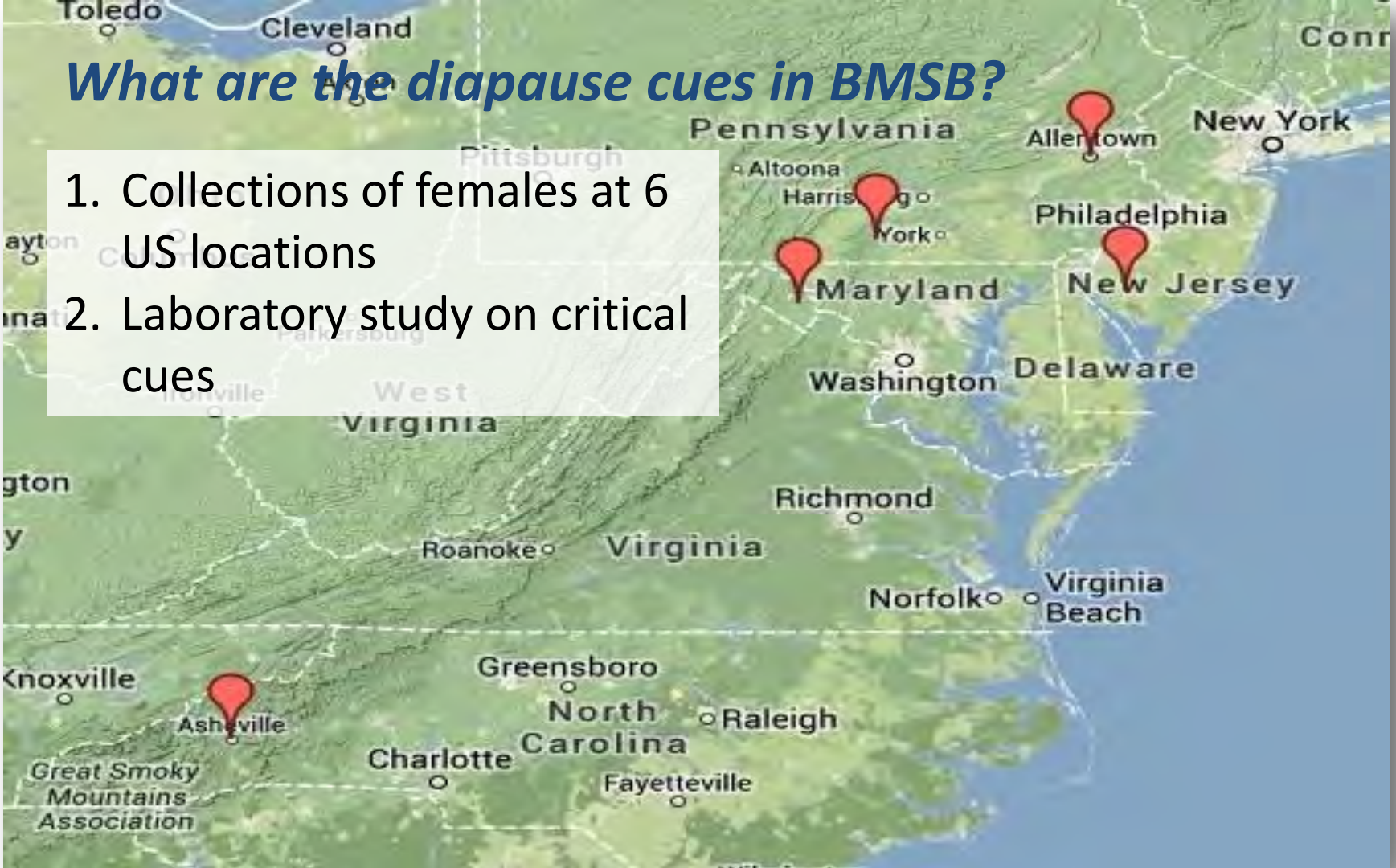
- When seasonality of different populations are modeled using the same developmental parameters



Nielsen et al. (2016, 2017) *Front. Physiol.*

What are the diapause cues in BMSB?

1. Collections of females at 6 US locations
2. Laboratory study on critical cues



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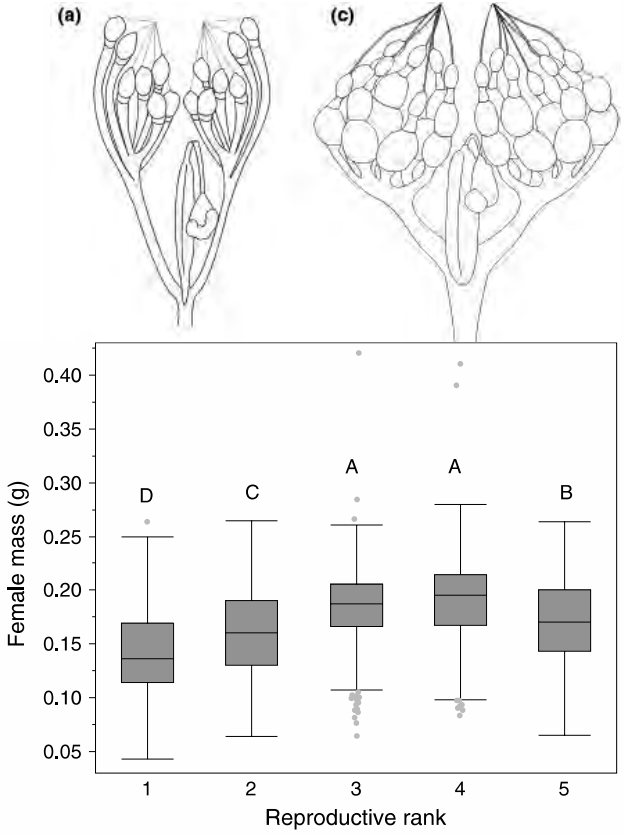
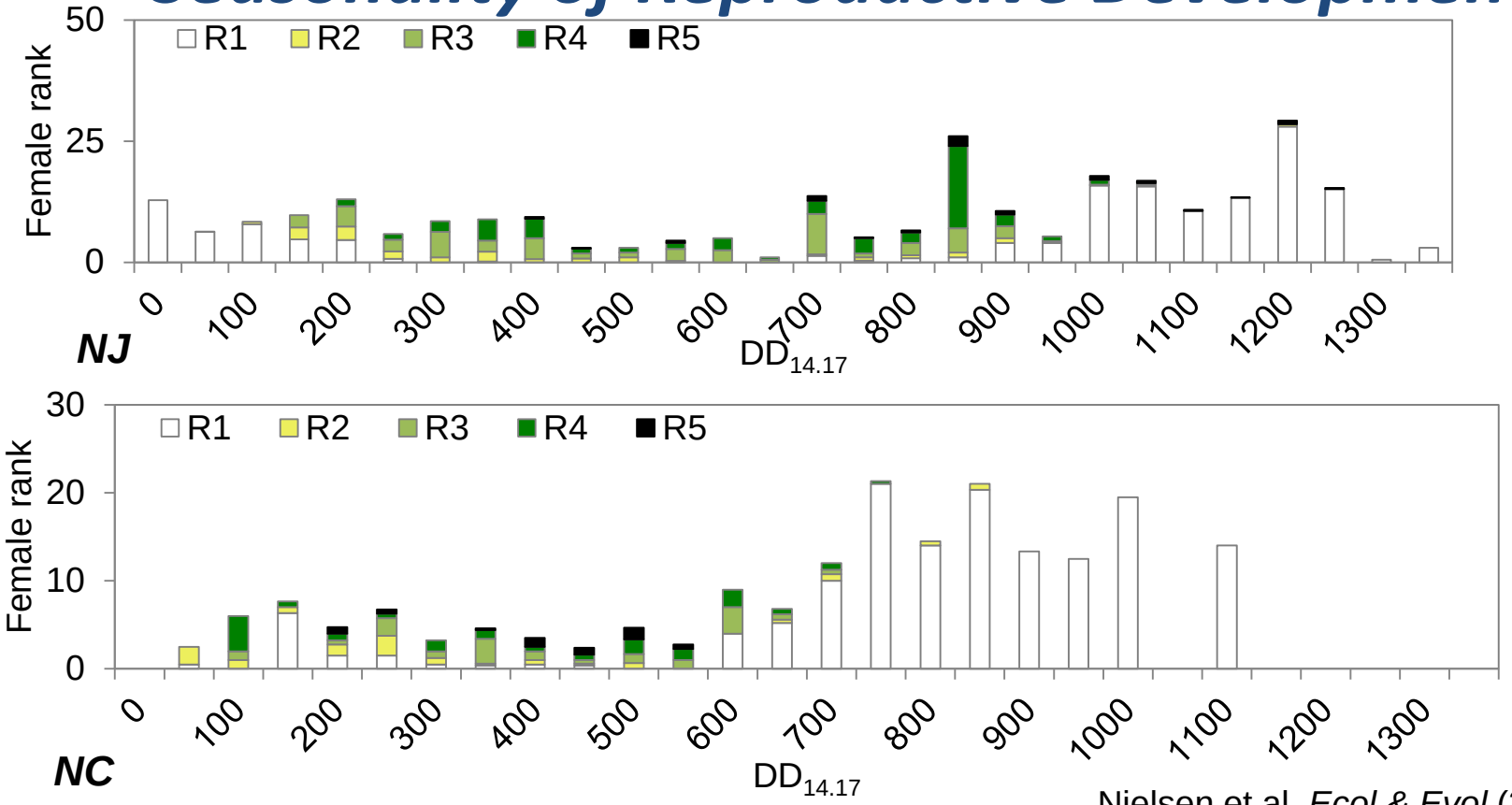
Abbreviation	Location	Coordinates	Year	*n*
NC	Asheville, NC	35.42°N 82.56°W	2013	315
			2014	240
NJ	Bridgeton, NJ	39.52°N 75.20°W	2012	607
			2013	952
			2014	190
OR	Willamette Valley (Aurora, OR)	45.23°N 122.75°W	2012	24
			2013	85
			2014	87
PAA	Allentown, PA	40.55°N 75.52°W	2006	61
			2007	264
			2008	552
			2012	534
			2013	718
PAB	Biglerville, PA	39.93°N 77.25°W	2013	544
WV	Kearneysville, WV	39.35°N 77.88°W	2012	471
			2013	205
			2014	62
Total				5,911



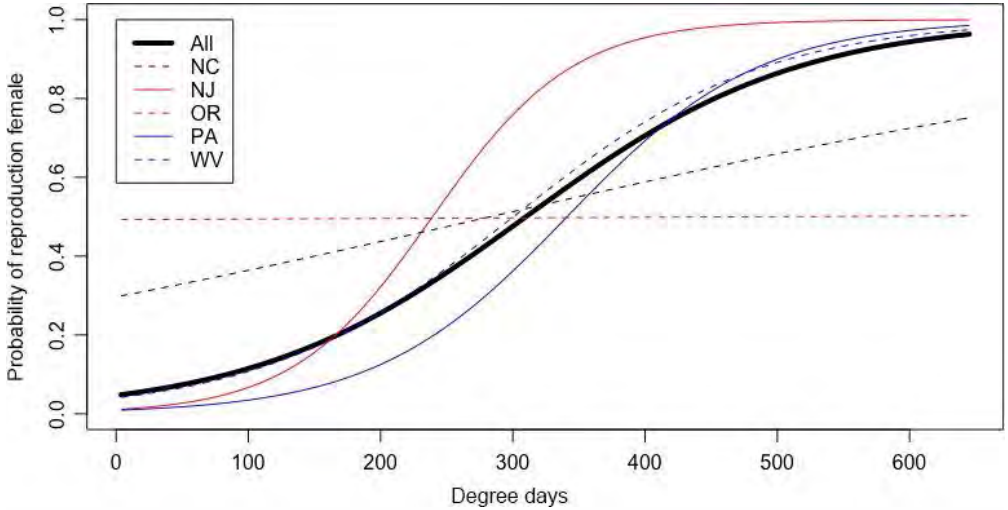
Seasonality of Reproductive Development



Nielsen et al. *Ecol & Evol* (2017)

Female Seasonality Results

- 99.7% of females collected in overwintering habitats were reproductively immature
- Reproductive state is not plastic
- Biofix estimation of 12.7h daylength as critical diapause cue



- Differences in rate of reproductive maturity between locations

Nielsen et al. *Ecol & Evol* (2017)

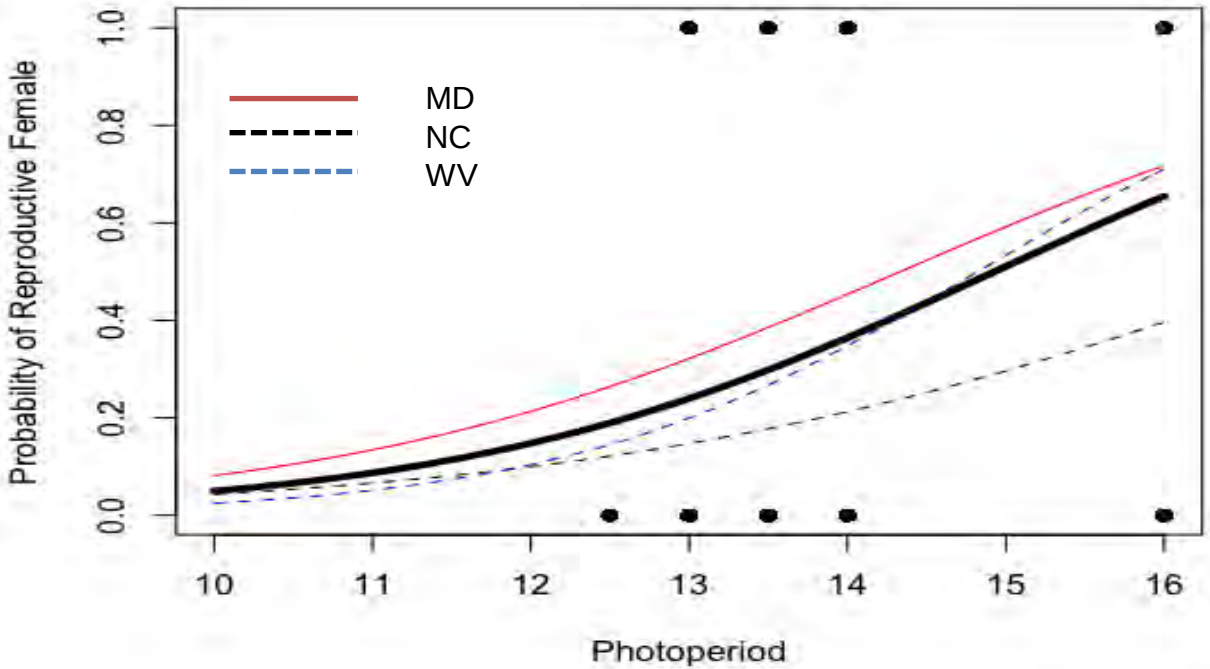
Diapause Termination Cues

- Evaluate diapause termination in laboratory studies
- Oviposition used to measure diapause termination
  - *Could measure gene expression or hormone levels*
- Overwintering bugs collected
- Females held individually with 1 or 2 males at 25°C
- Daylength was varied from 12.5 – 16.0 h of light

State	2015	2016	2017
NC	10	20	20
WV	40	-	-
MD	30	70	-
TOTAL PAIRS/PHOTOPERIOD TRT	*80*	*90*	*20*

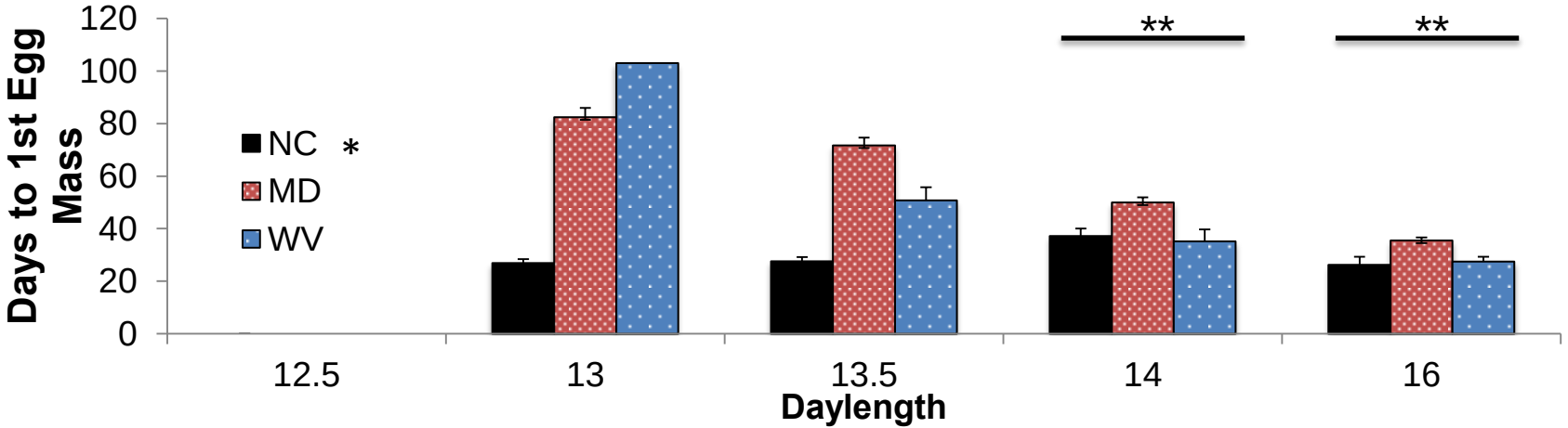
Is Photoperiod a Critical Diapause Cue?

- State was not significant (AIC 926, df=779, *P*>0.05)
- Photoperiod was significant (P<0.001)
- Predicted probability of reproduction at 50% is 13.5h of daylenth



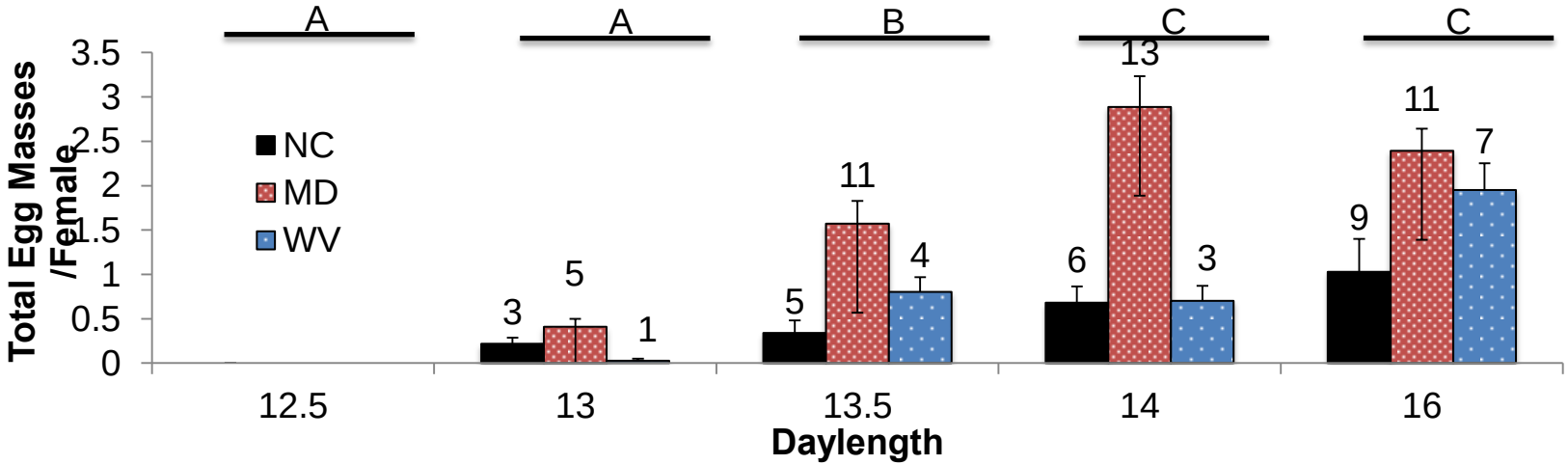
Days to First Egg Mass

- Time to 1st egg mass differed significantly between photoperiod treatments (*P*<0.0001, df= 3)
- Longest at 13.0 h
- Pre-oviposition period at the critical threshold of 13.5h was longer than non-diapausing females at 25°C (13 d)



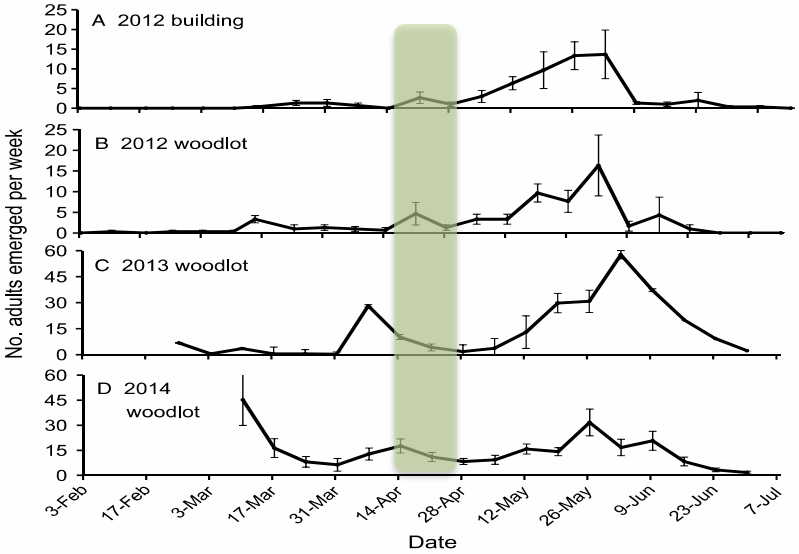
Egg Masses Produced

- Photoperiod was a significant effect ($P<0.001$, df=4)
- Lower egg production in NC population
- Total egg production was low but within normal range



Conclusions

- *H. halys* responds to long-day critical diapause cues
  - 13.5 h
  - Reproduction may be lower in this population than in F1
- Matches with female seasonality data*
- Data suggests that there are population differences



Bergh et al. Entomol. Experimentalis. 2017

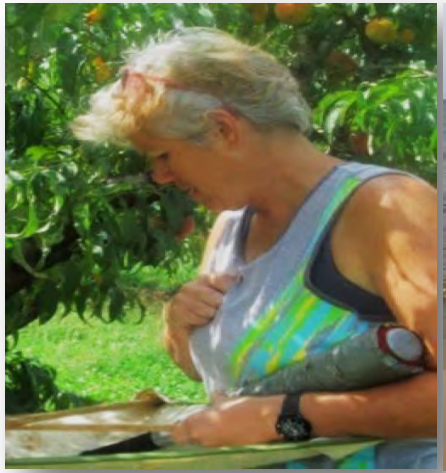
- Matches with the data on overwintering emergence patterns
- Critical diapause cues can be used as biofix to begin accumulating DD

- Invasive species have demonstrated rapid evolution to critical diapause cues moving towards shorter daylengths in southern regions after range expansion
- *N. viridula* begins reproducing earlier under simulated climate change
- Data supports the idea of differences between geographically separate populations

- Photoperiod is a critical cue for diapause termination and an be used as a biofix for population models and degree-day accumulation

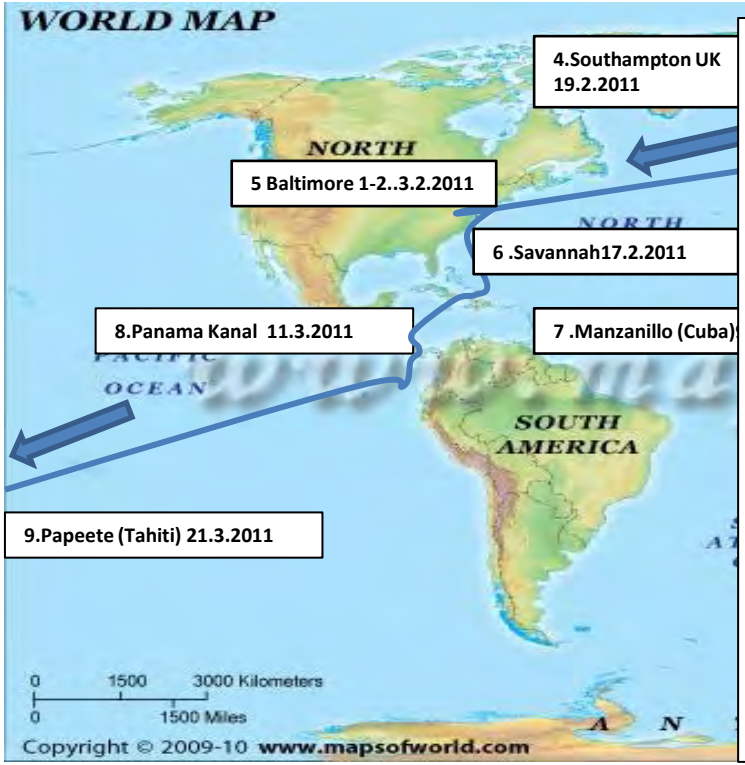
Urbanski et al. *Am. Nat.* 2012; Bradshaw & Holzapfel *PNAS* 2001

Thank you!



SCRI: 2016-51181-25409

Impacts of Shipping on BMSB Reproduction



- Port of Baltimore (USA) to Auckland, NZ
- Overwintering adults in a diapause state (February)
- Simulated shipping container
  - 10°C → 30°C
  - Raise by 2°C each day for 10 d and then hold at 30°C for 17 days
  - Pairs were then put in 16:8 at 27°C