Incorporating Female Reproductive Development Into Voltinism Studies

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How can we best predict the number of generations?

- DD requirements for development (538, base 14°C)
- DD requirements of reproductive maturation? (148 DD)

- Complicated phenology:
  - Long lifespan
  - Overlapping generations
  - Diapaus ing adult stage
  - Need an appropriate biofix
Describing Seasonality

• Seasonality through direct sampling methods
  – Visual or beat samples
  – Blacklight traps
  – Pheromone traps

• Investigate female reproduction
  – Reproductive ranking system
  – Field collected individuals
Project Number of Generations

- *Halyomorpha halys* voltinism is both temperature and photoperiod dependant

- Chen et al. 2011 utilized Mont Carlo approximations for grape berry moth
  - Voltinism is influenced by degree day accumulations prior to photoperiod conditions for diapause induction

- Assumes that development and diapause are functions of temperature and photoperiod

- Individual based
  - Diapause termination
  - Degree day development
  - Diapause induction

Nonreproductive female

DD, photoperiod, DD/photoperiod

nutritional status

Reproductive Female

temperature

Egg Mass
1st
2nd
3rd
4th
5th
Adult

°C
°C
°C
°C/°P
°C/°P

DIAPAUSE?

NO

YES
Model Testing and Validation

1. Refine the DD requirements for female maturation
   – 16:8 photoperiod
   – Temperatures 20-33°C

2. Field collection of females from April – October
   – Bridgeton, NJ; Allentown, PA; Kearneysville, WV; Biglerville, PA
   – Rough dissections of females from diapause and host plants
   – Assign to a ranking system

3. Cage studies
Time to Oviposition

• Original study performed at 25°C suggested 13.35 day preoviposition period

• 148 DD

• Evaluate the accuracy of this by studying time to oviposition at multiple temperatures
"Preliminary" Pre-Oviposition Data 2012

\[ y = 0.0062x - 0.08 \]
\[ R^2 = 0.9143 \]
BMSB Female Reproductive System

- Mature oocyte
- Terminal filament
- Ovariole
- Lateral oviduct
- Spermatheca
- Ovary
**Reproductive Ranks**

1 = Previtellogenic, oocytes are undifferentiated or differentiated without oocyte development

2* = Previtellogenic, one or more oocytes are developed

3 = Vitellogenic, proximal oocyte is developed

4 = Vitellogenic, oocytes are developed, at least one lateral oviduct has a descended oocyte

5 = Post-vitellogenic, oocytes are degrading, oocytes distended

* a female that has oviposited previously (i.e. CL present) cannot be previtellogenic, if oocytes/follicles are (re)developing she is a 3.
Katayama et al. 1993 ranking system

Nielsen ranking system (in red)
Number of females per reproductive rank

2008

Corpus Luteum present
Expected Outcomes

• Refine the pre-oviposition period
• Identify appropriate biofix
• Identify number of generations based on female reproductive physiology
• Model the number of generations to predict BMSB generations in each area and as populations spread or temperatures warm
Nonreproductive female

DD, photoperiod, DD/photoperiod

Nutritional status

Reproductive Female

temperature

Egg Mass

1st

2nd

3rd

4th

5th

Adult

NO

YES

DIAPAUSE?
Seasonal Reproductive Development

Rank 1: undeveloped oocystes or one immature oocyte per ovariole

Rank 2: >1 Immature oocyte per ovariole
Seasonal Reproductive Development

Rank 3: At least 1 mature oocyte per ovariole

Rank 4: Mature oocytes + 1 oocyte in lateral oviduct

Rank 5: Post-vitellogenic females, ovaries distended, oocytes degenerating
Stage 1 – immature oocytes, unmated, spermatheca is clear and skinny
Stage 3 – 2 mature oocytes per ovariole, mated, CL present