

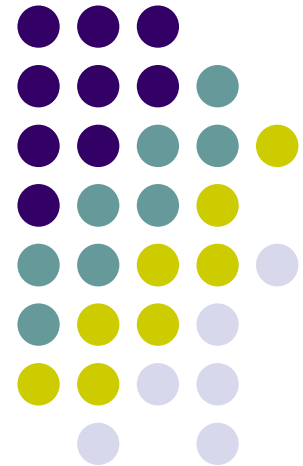
# Development of Behaviorally Based Monitoring Tools and Management Strategies for the Brown Marmorated Stink Bug



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# Threat Posed By Brown Marmorated Stink Bug To Commercial Tree Fruit and Other Crops

- Season-long threat to commercial tree fruit. Persistent movement into orchard blocks from other cultivated crops and wild hosts.
- Both adults and nymphs feed on the fruit.
- Reproduction can occur within commercial orchards.



Egg Mass



1<sup>st</sup>



2<sup>nd</sup>

3<sup>rd</sup>

4<sup>th</sup>

5<sup>th</sup>

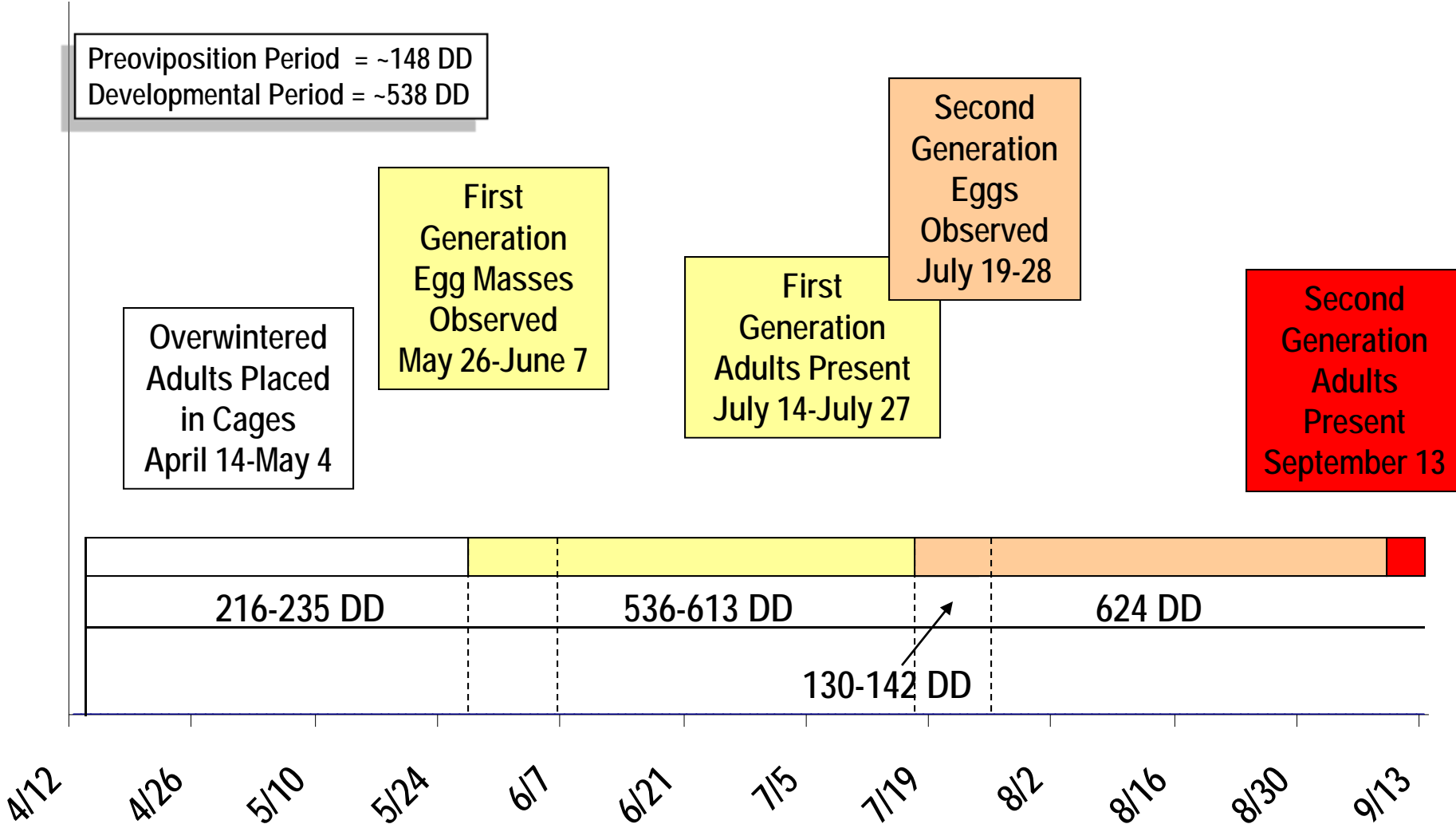


Male

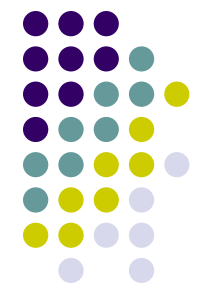


Female

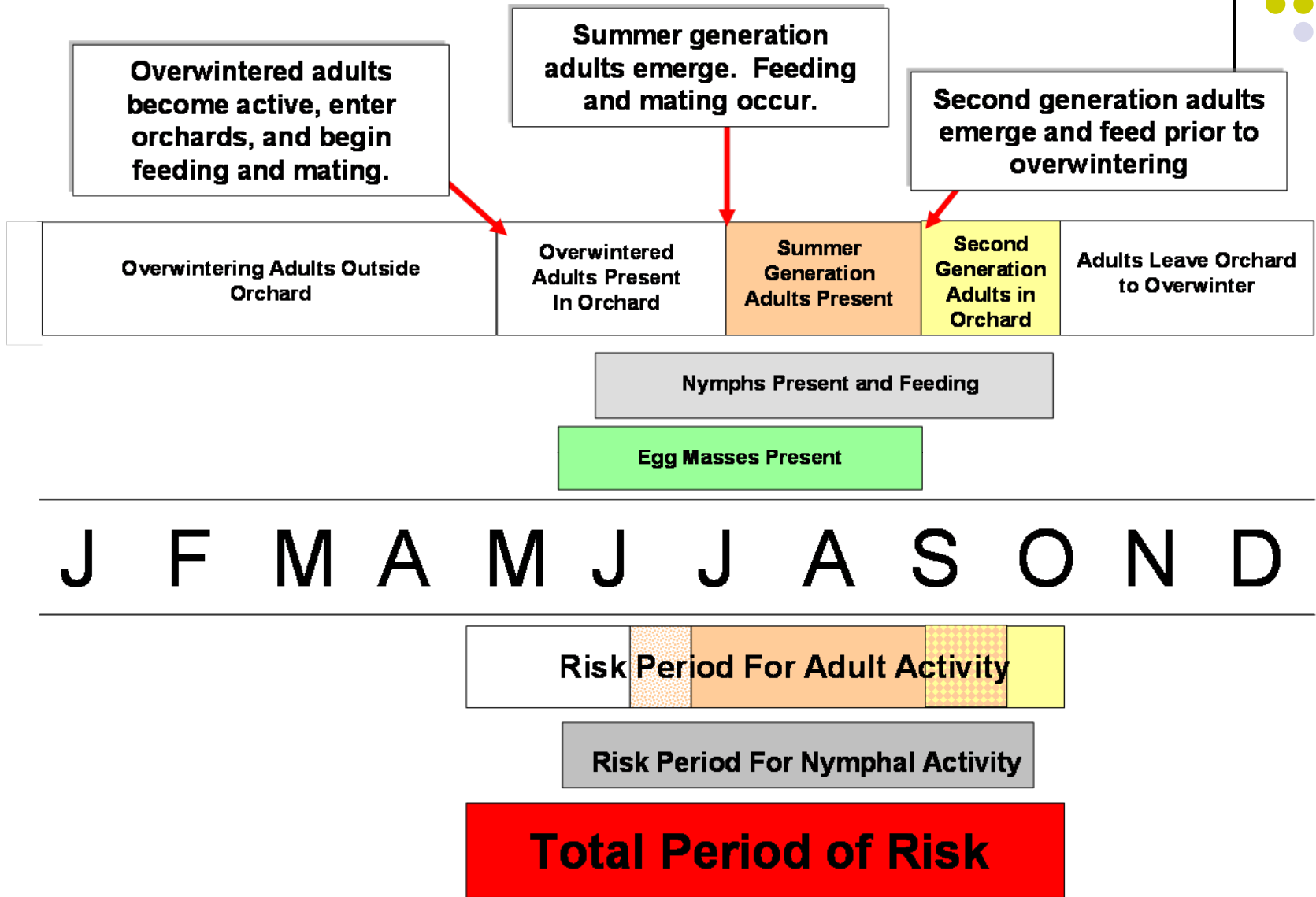
# Bivoltinism Based on Field Cage Study of BMSB Development



~50 d (range of 48-57 d) from Egg to Adult



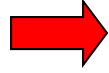
# Apparent Phenology of BMSB in Tree Fruit



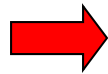
# Threat To Commercial Tree Fruit



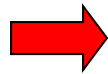
① EARLY SEASON

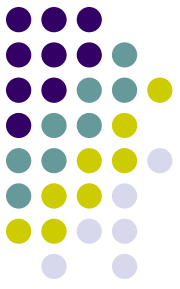


② SEASON LONG



③ LATE SEASON -  
POST HARVEST





# Development of a Behaviorally Based Monitoring Tools for BMSB

- No effective monitoring tools for BMSB.
- Growers need a tool that allows them to detect presence, abundance, and seasonal activity.
- Development of treatment thresholds.



# Development of a Behaviorally Based Monitoring Tool for BMSB

- Visual Cues
- Olfactory Cues
- Capture Mechanism
- Deployment Strategy



# 2009-2010 BMSB Response to Visual Stimuli

Black

Green

Yellow

White

Clear



Trunk  
Mimic

Foliar  
Stimulus

Foliar  
Stimulus

Unapparent  
Stimulus

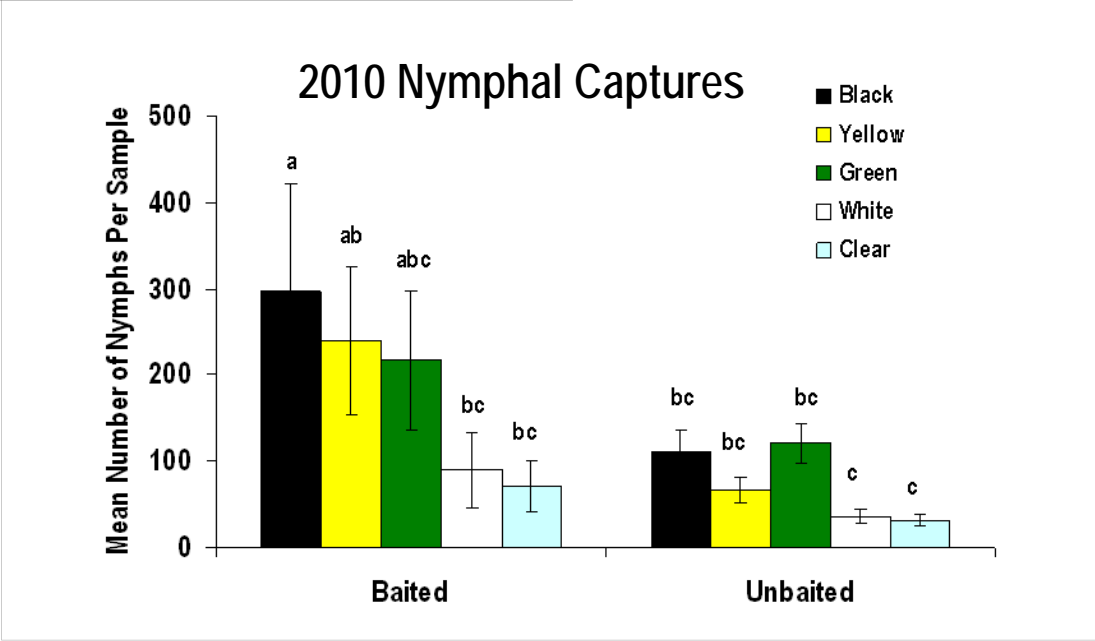
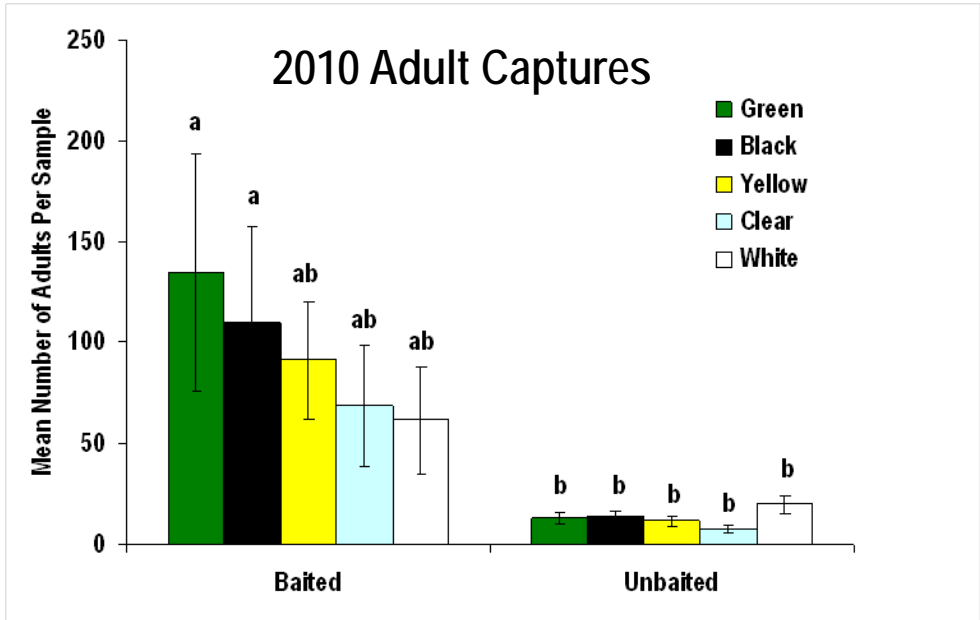
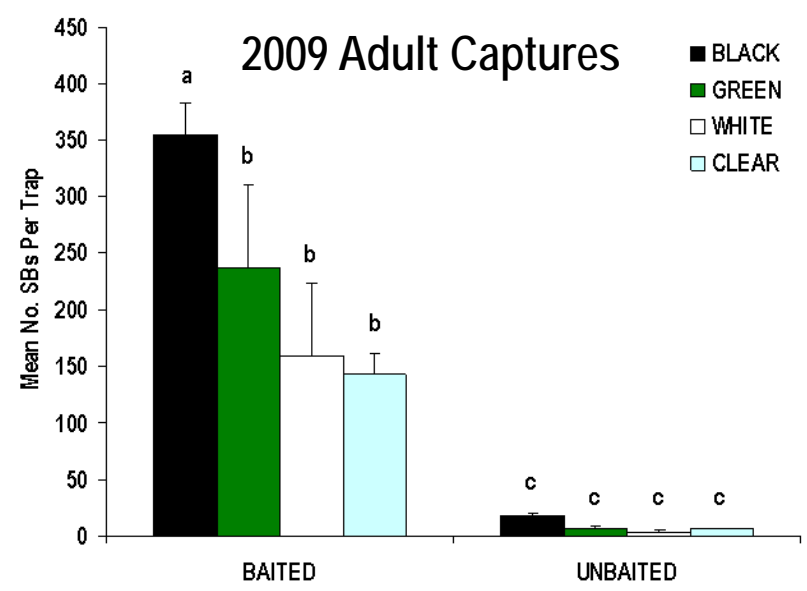
Unapparent  
Stimulus

- Responses to visual stimuli associated with trap bases.
- Baited and unbaited traps at the periphery of orchards. Four replicates. Sampled twice weekly.
- Captures from October 7-November 17, 2009 and July 23-October 14, 2010.





# Adult and Nymphal Captures



# Monitoring Adult and Nymphal Populations (2011)

- Black pyramid traps will be deployed in commercial orchards
- Deployed in border row between trees.
- Baited with 66 mg lures of methyl (2E, 4E, 6Z)-decatrienoate. Known attractant with limitations.
- Six orchards in MD, three orchards in WV. Checked weekly.



# Response To Wavelengths and Intensities of Light





# Trial One - Simple Choice Study

## *Light Intensity*

- Release single individuals into center of arena.
- Treatments include sex and light intensity.
- Light Intensity (Indirect Light, Fixed Full Spectrum)

- 0 Lux (Control)

*Darkness*

- 100 Lux

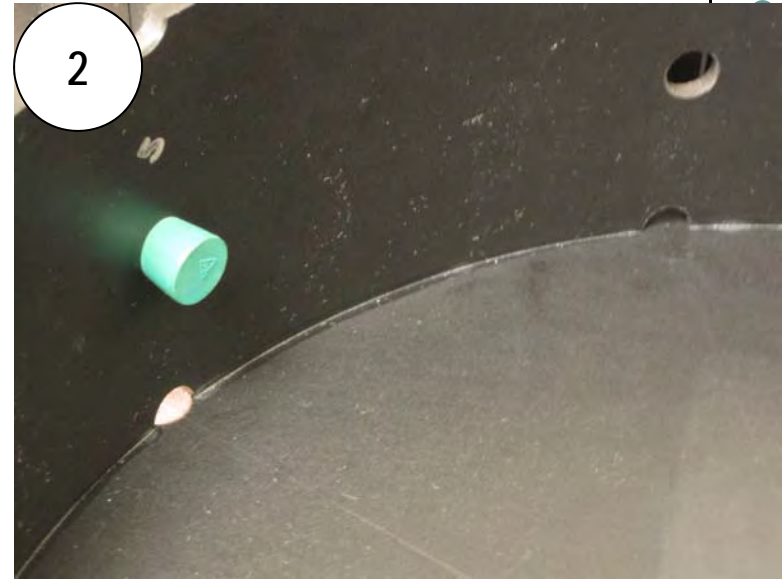
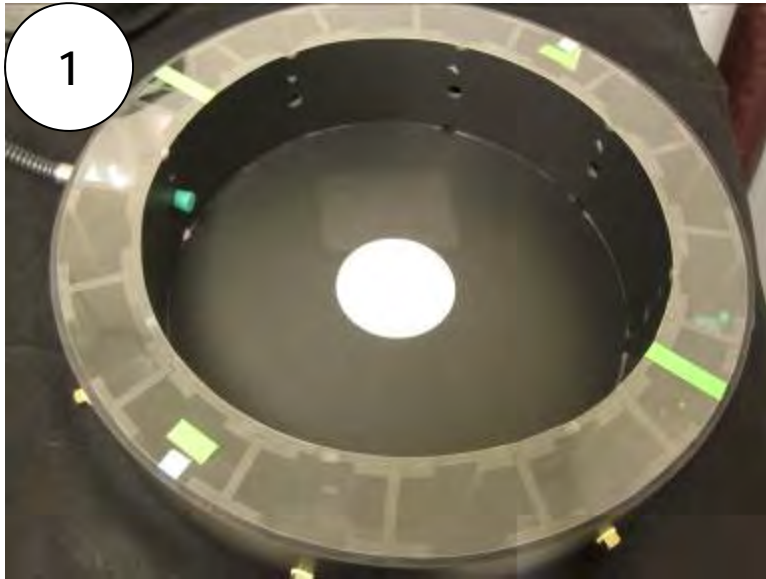
*Fixed Full Spectrum*

- 400 Lux

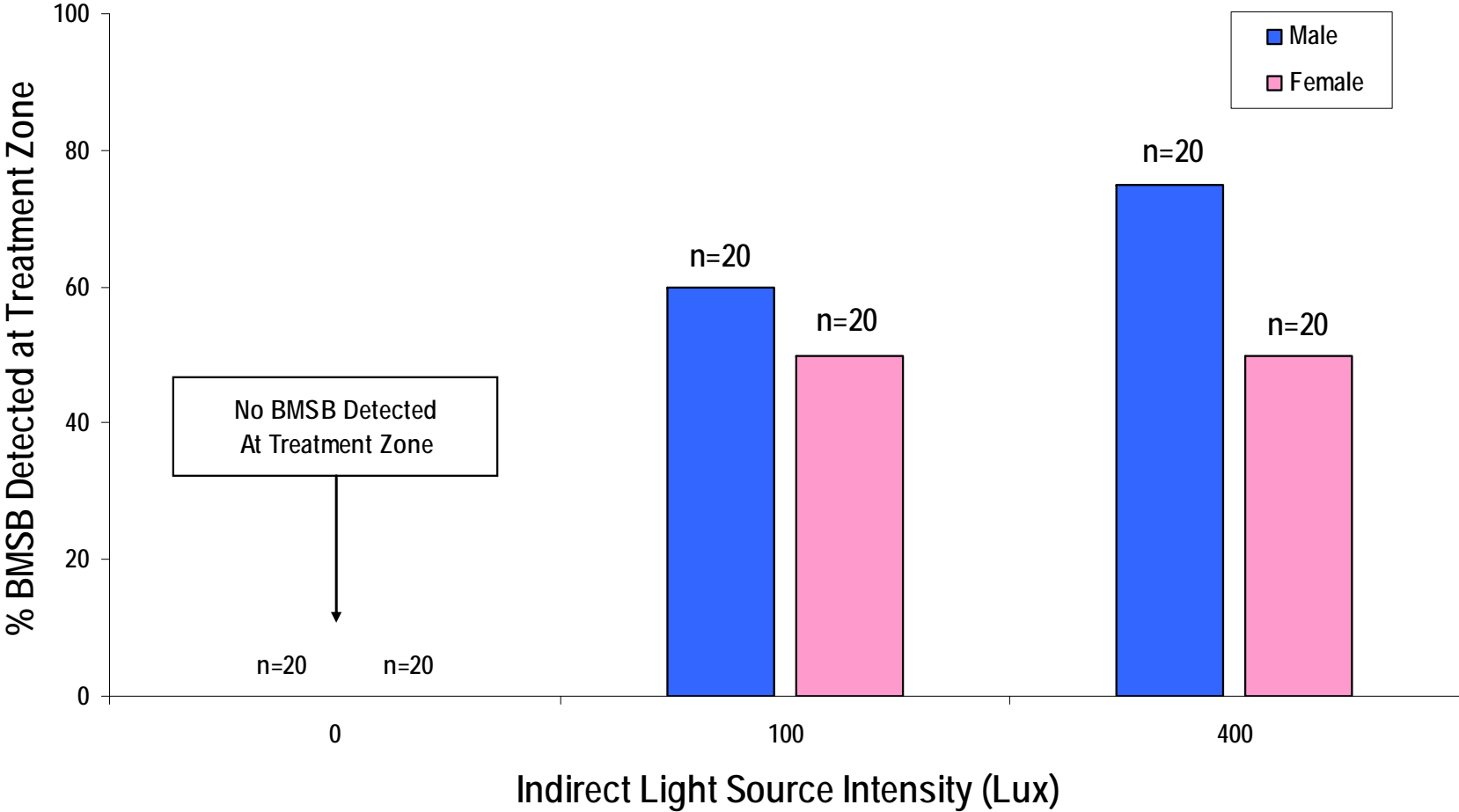
- 1600 Lux

- Trial duration up to 15 minutes.
  - Treatment Zone
  - Remain in Release Zone

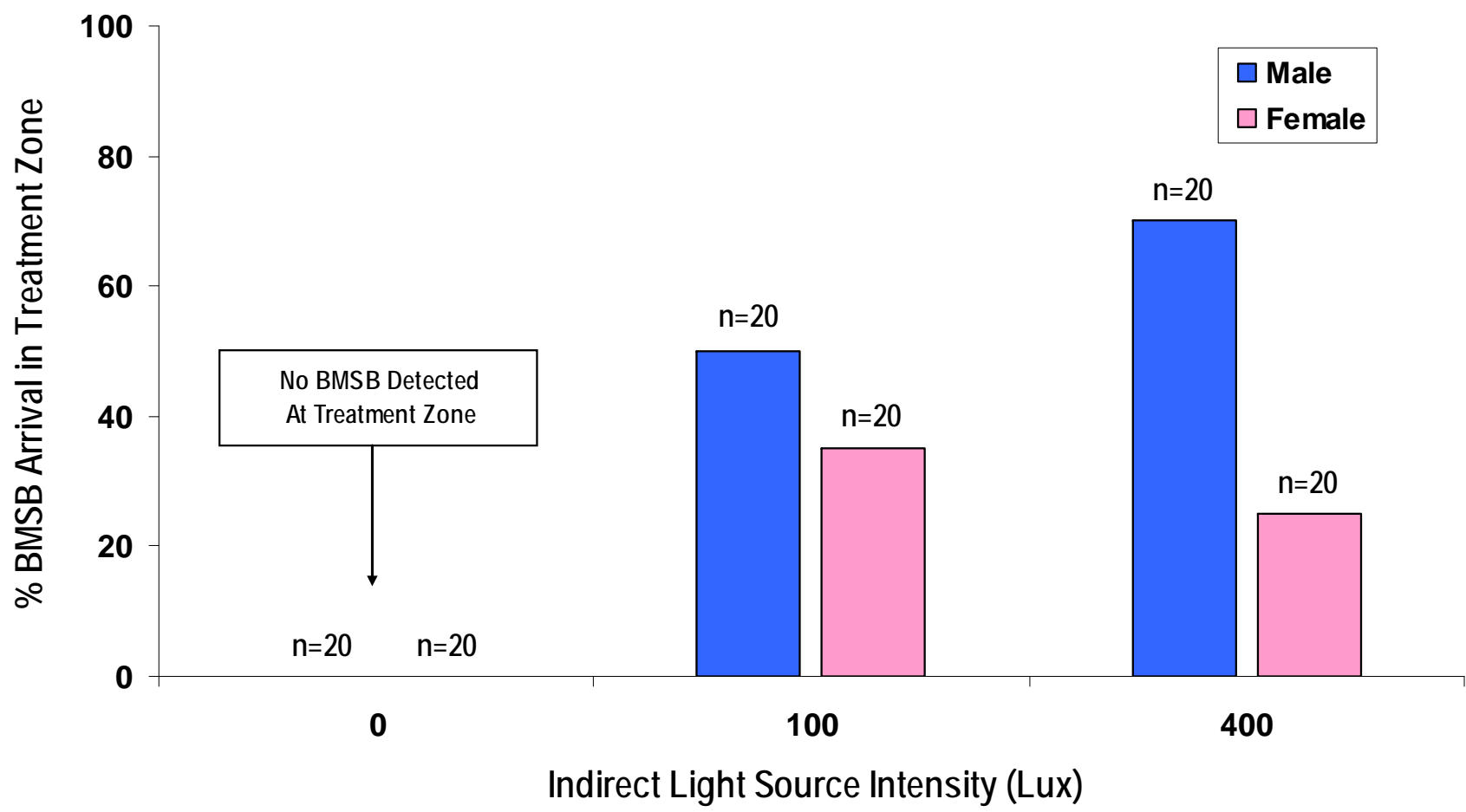
# Light Bioassay



% BMSB Detected At Treatment Zone  
Male vs. Female, Overwintered BMSB  
Tabb Collection (02/16/2011)

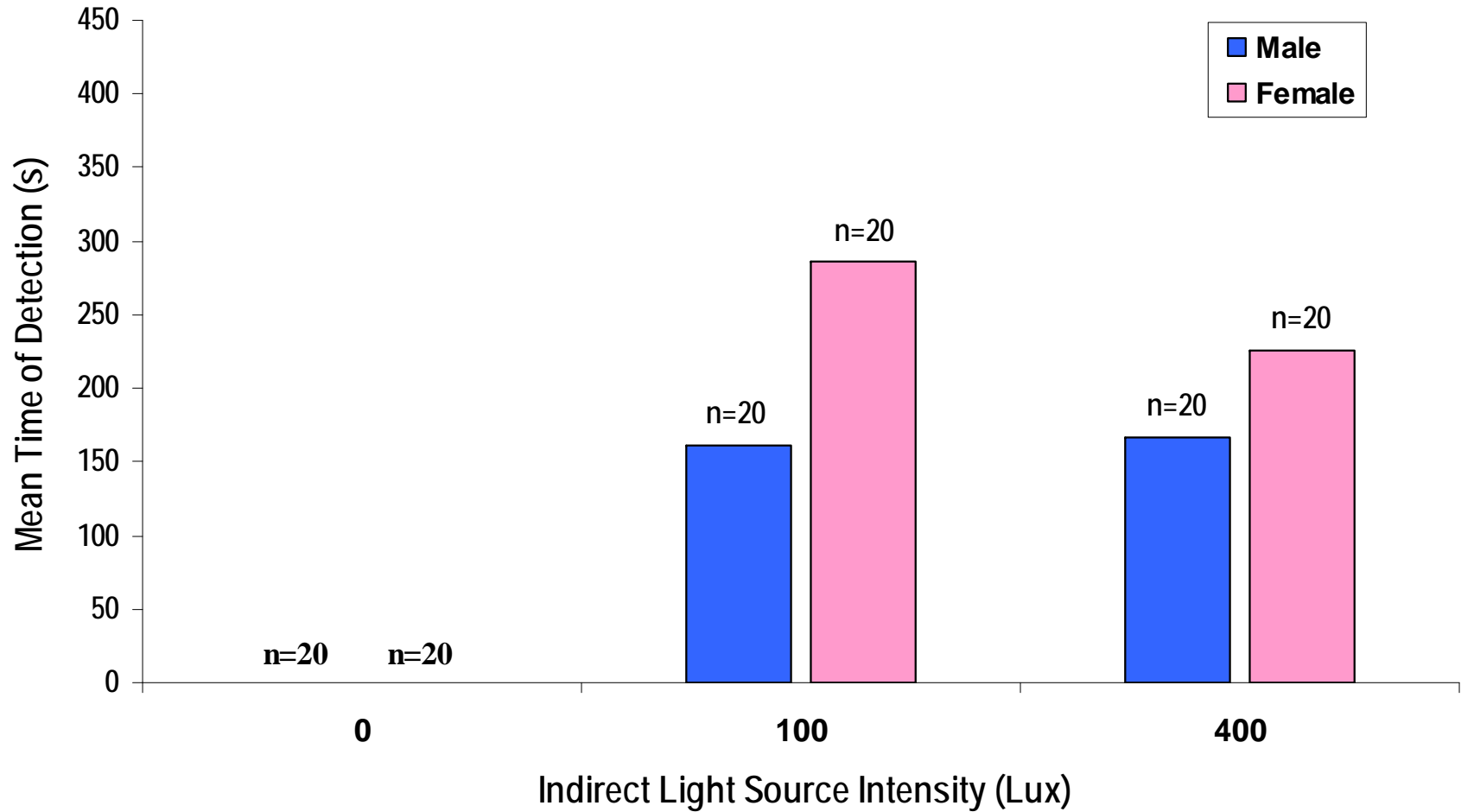


% BMSB Arrival in Treatment Zone  
Male vs. Female, Overwintered BMSB  
Tabb Collection (02/16/2011)





**Time of Detection at Treatment Zone  
Male vs. Female, Overwintered BMSB  
Tabb Collection (02/16/2011)**





# Trial Two - Simple Choice Study

## *Wavelength*

- Release single individuals into center of arena
- Treatments – Wavelength (Indirect Light, Fixed Intensity)

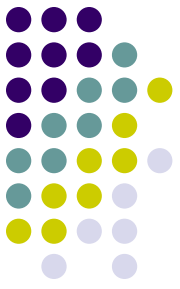
- |  |
|--|
| ● Full Spectrum  |
| ● 320 nm, Long Pass Filter (Ultraviolet and above)           |
| ● 400 nm, Long Pass Filter (Visible Light, Purple and Above) |
| ● 495 nm, Long Pass Filter (Visible Light, Blue and Above)   |
| ● 610 nm, Long Pass Filter (Visible Light, Yellow and Above) |
| ● Control  |



# Identification of BMSB Aggregation Pheromone

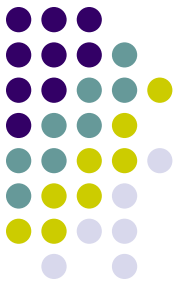


# Tentative Conclusions



- Dark ground-deployed pyramid trap. Visually stimulating and capture mechanism works well because both nymphs and adults have a tendency to walk up surfaces.
- Nymphs were attracted to traps baited with methyl (2E, 4E, 6Z)-decatrienoate season-long.
- A season-long attractant for adults is critical. Identification of true pheromone is critical.
- Augment trap designs with specific wavelengths and intensities of light to improve overall sensitivity and specificity.

# 2011 Research Plans Associated with Development of Monitoring Tools



## Monitoring Traps

- Season-long monitoring of nine commercial orchards in MD and WV with prototype black monitoring trap and kairomone. Complimentary fruit sampling.
- Comparison of baited and unbaited black light and pyramid traps.

## Known Kairomone

- Determine if BMSB are attracted to methyl (2E, 4E, 6Z) decatrienoate early in the season.
- Establish active space of known doses/release rates of methyl (2E, 4E, 6Z)-decatrienoate.

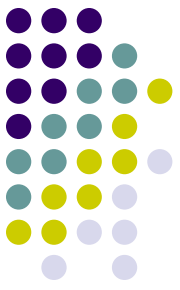
## Visual Cues (Light)

- Continue with laboratory bioassays identifying attractive intensities and wavelengths of light.
- Field evaluation of traps: 1) traps with light; 2) traps with light+attractant; 3) traps with attractant; and 4) unbaited traps.

## Chemical Ecology

- Initial field evaluation of BMSB aggregation pheromone.

# Challenges in Managing BMSB in Commercial Plantings



- Tremendous season-long pressure from populations moving from wild and other cultivated hosts into cropped areas leading to constant re-infestation of plots.
- Greatest efficacy observed when adults have direct contact with finished wet spray material. Only a small portion of damaging population likely exposed to this material.
- Avoidance behaviors allow them to potentially escape treatments.
- Insecticides labeled as excellent against native SBs not showing same field efficacy against BMSB. Knock down and recovery observed in grower orchards. Other materials completely ineffective.

# Laboratory-Based BMSB Insecticide Evaluations

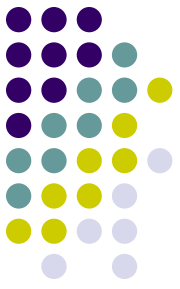
## USDA-ARS-AFRS



- Because of the constant (season-long) pressure from BMSB populations located outside orchards and other cropped areas, BMSB continuously re-infests plots.
- Thus, immigrating BMSB are unlikely to encounter direct contact with finished (wet) spray material.
- This population poses the primary threat to crops. Control depends on residual effectiveness and likelihood of uptake.
- Laboratory insecticide trials designed to be biologically relevant and based on control of this primary threat.
- Evaluation of each material requires a total of 24 person hours.

# BMSB Insecticide Testing, USDA-ARS-AFRS

October 28, 2010 - February 1, 2011



## Carbamates

- Carbaryl (Sevin)
- Methomyl (Lannate)
- Oxamyl (Vydate)
- Formetanate HCl (Carzol)

## Organophosphates

- Phosmet (Imidan)
- Chlorpyrifos (Lorsban)
- Acephate (Orthene)
- Azinphosmethyl (Guthion)
- Malathion (Malathion)
- Methidathion (Supracide)
- Dimethoate (Cygon)
- Diazinon (Diazinon)

## Pyrethroids

- Fenpropathrin (Danitol)
- Cyfluthrin (Tombstone)
- Bifenthrin (Brigade)
- Permethrin (Permethrin)
- zeta-Cypermethrin (Mustang)
- beta-Cyfluthrin (Baythroid)
- Esfenvalerate (Asana)
- lambda-cyhalothrin (Warrior)
- gamma-cyhalothrin (Declare)

## Neonicotinoids

- Thiamethoxam (Actara)
- Clothianidin (Clutch)
- Dinotefuran (Safari)
- Imidacloprid (Provado)
- Thiacloprid (Calypso)
- Acetamiprid (Assail)

## Organochlorine

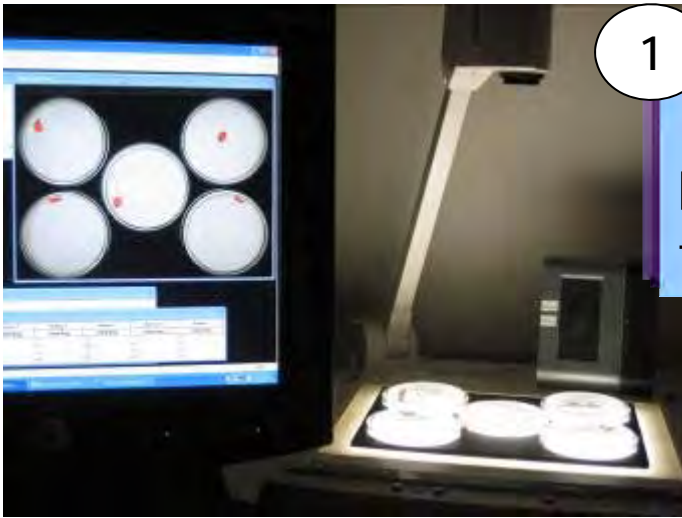
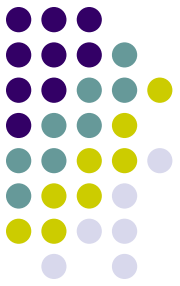
- Endosulfan (Thiodan)

## Other Classes

- Flonicamid (Beleaf)
- Indoxacarb (Avaunt)
- Spirotetramat (Movento)
- Cyantraniliprole (Cyazypyr)
- Abamectin (Agri-Mek)
- Tolfenpyrad (Tolfenpyrad)
- Pyrifluquinazon
- Kaolin Clay (Surround)
- Particle Delivery (Surround+)



# Experimental Trials



1

EthoVision trials for measuring horizontal mobility on insecticide-treated surfaces.

2

Direct observations of vertical movement capacity following insecticide exposure.

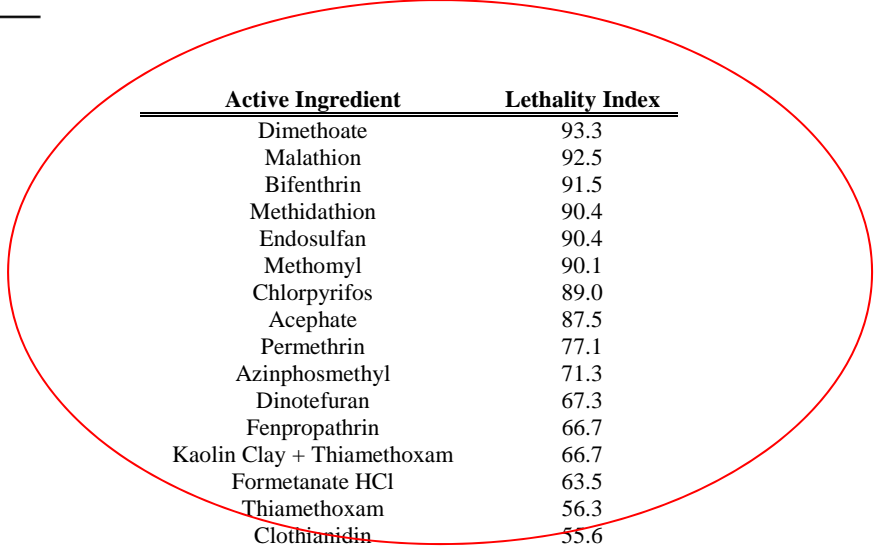
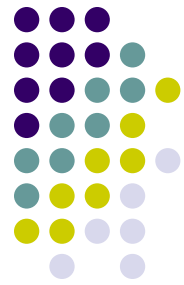


3

Mortality tracked for 7-d followed by final vertical movement trial.

$$\text{Lethality Index} = \frac{\text{Day 0-7} \quad \text{Day 0-7} \quad \text{Day 0-7}}{[(\text{BMSB Alive} \times 0.0) + (\text{BMSB Moribund} \times 0.5) + (\text{BMSB Dead} \times 1.0)]} \times 100$$

**240**

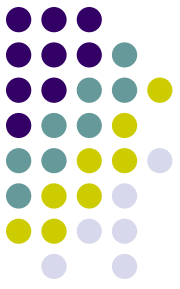


<u>Active Ingredient</u>	<u>Lethality Index</u>
Dimethoate	93.3
Malathion	92.5
Bifenthrin	91.5
Methidathion	90.4
Endosulfan	90.4
Methomyl	90.1
Chlorpyrifos	89.0
Acephate	87.5
Permethrin	77.1
Azinphosmethyl	71.3
Dinotefuran	67.3
Fenpropathrin	66.7
Kaolin Clay + Thiamethoxam	66.7
Formetanate HCl	63.5
Thiamethoxam	56.3
<del>Clothianidin</del>	55.6
Beta-cyfluthrin	54.8
Gamma-cyhalothrin	53.8
Lambda-cyhalothrin	52.9
Zeta-Cypermethrin	52.1
Cyfluthrin	49.0
Esfenvalerate	43.3
Imidacloprid	40.0
Tolfenpyrad (SC)	36.5
Oxamyl	34.2
Tolfenpyrad (EC)	33.3
Pyrifluquinazon	28.3
Kaolin Clay	23.1
Diazinon	20.4
Phosmet	20.0
Acetamiprid	18.8
Thiacloprid	18.3
Abamectin	16.3
Indoxacarb	11.3
Spirotetramat	9.8
Carbaryl	9.2
Flonicamid	7.7
Water (Control)	5.8
Cyantraniliprole	1.7

# BMSB Insecticide Testing Summary Results



- Based on contact lethality, older broad spectrum materials including dimethoate, malathion, bifenthrin, methidathion, endosulfan, and methomyl provided highest levels of contact lethality.
- Within each chemical class, patterns of lethality are similar, but there is a substantial amount of variation between active ingredients in the intensity of effects on mobility and mortality.
- One piece of the story. Finished wet spray material, feeding trials, sublethal effects, field studies.



# 2011 Research Plans Associated with Development of Management Strategies

## Behaviorally Based Control

- Establish active space of known doses/release rates of methyl (2E, 4E, 6Z)-decatrienoate.
- Establish parameters associated with increasing response to known attractant.
- Baited trap trees or trap crops for more spatially precise management of BMSB.
- Deterrents and repellents. Push-pull strategies.
- Augment with light?

## Insecticidal Work

- Behaviorally based insecticide trials

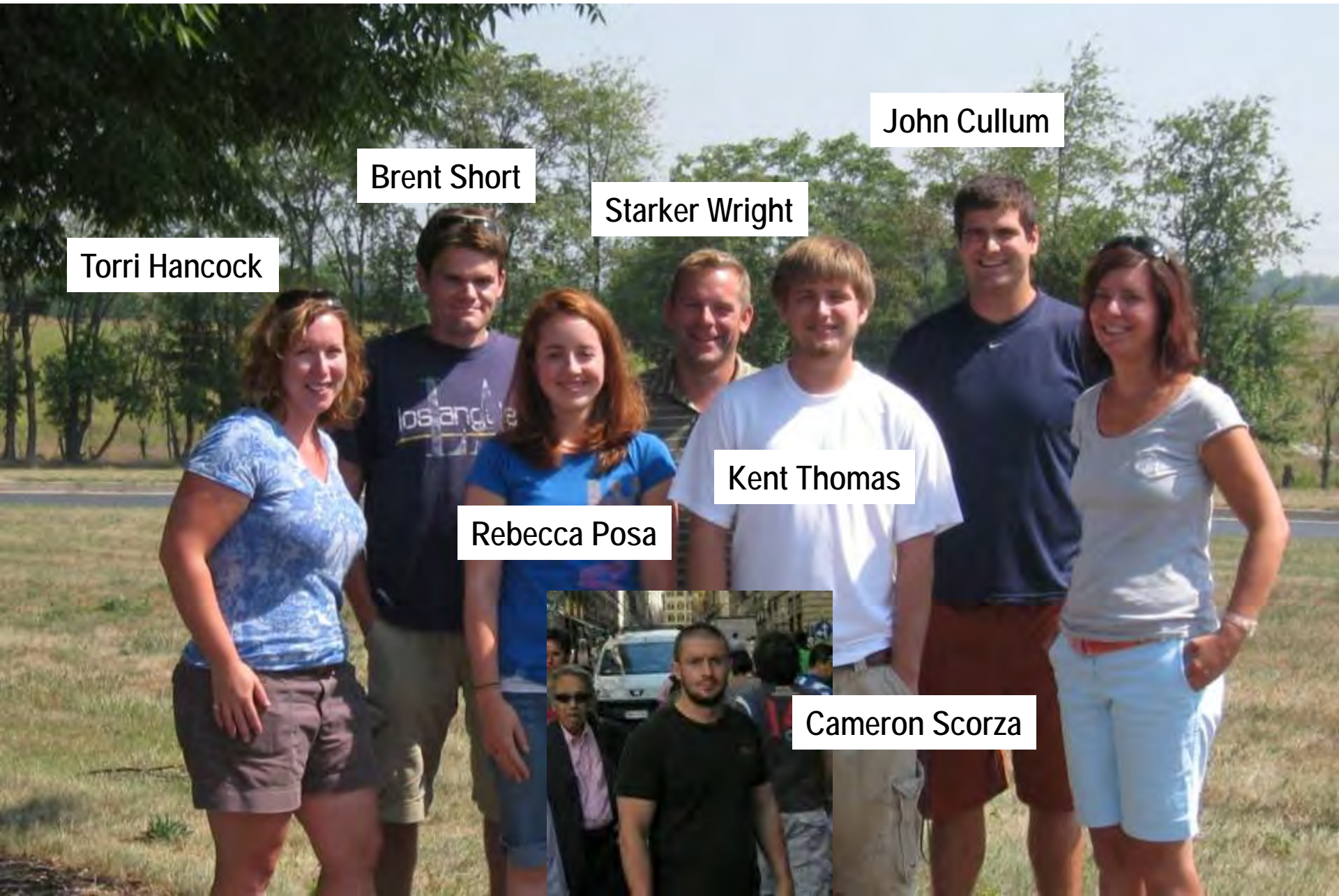
## Fruit Injury

- Caged fruit at different points in the season.
- Identification of late-season injury.
- Post-harvest studies.

## Voltinism

- Repeat voltinism experiments.

# Acknowledgments



John Cullum

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