Brown Marmorated Stink Bug, *Halyomorpha halys* (Stål): Distribution, Detection and Management

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Brown Marmorated Stink Bug is an Invasive Species

Native to China, Japan, Korea, and Taiwan.

Brown Marmorated Stink Bug Life History


Egg Mass

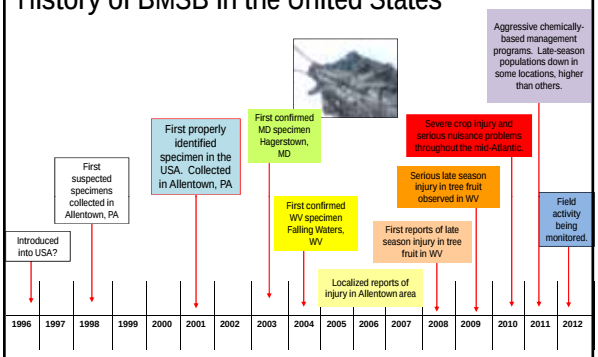

1st

- Deposit eggs on undersides of leaves. Five nymphal stages. One to two generations per year in much of the mid-Atlantic.
- >100 host plants including tree fruit, small fruit, grapes, vegetables, legumes, and ornamentals.

Adult Male

Adult Female

History of BMSB in the United States

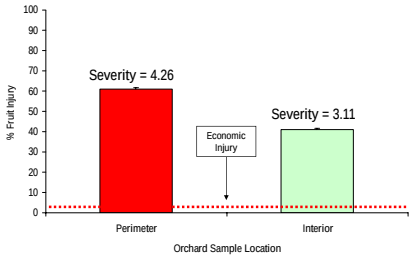


Current Distribution of BMSB in the United States

Updated by BMSB Working Group, June 2012

2008-2010
Escalating Problems in Tree Fruit in the Mid-Atlantic
Transition from a Late-Season to a Season-Long Problem

BMSB Feeding Injury—Rate and Severity
Regional Commercial Apple Orchards
2010 Growing Season



2010 economic loss in mid-Atlantic apples due to BMSB feeding estimated at 37 million dollars (US Apple Association)

Many mid-Atlantic peach growers in WV, MD, PA and VA had significant losses.

Numerous growers lost over 50% of their peach crop in 2010. Some lost all of it.

Significant losses in soybean recorded throughout the region.

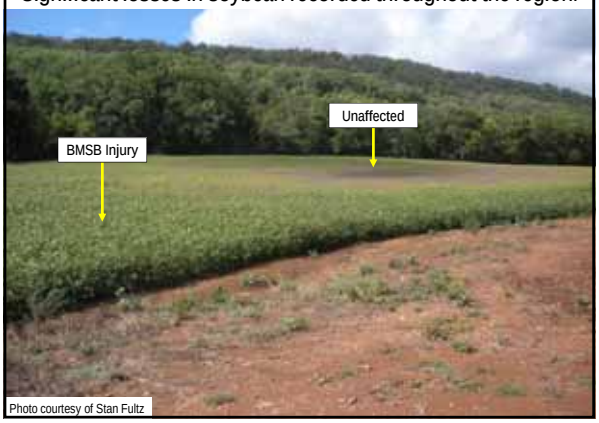


Photo courtesy of Stan Fultz

Broad Range of Cultivated Crops Attacked

Catoctin Mountain and Gardenhour Orchards
Emergency BMSB Meeting
September 3, 2010

Photos courtesy of Doug Pfeiffer

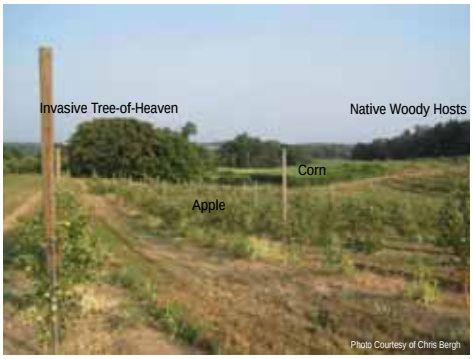
BMSB is a Serious Nuisance Pest

One Homeowner's Plight

"This weekend I vacuumed up more than 8,000 stink bugs (vast majority were alive) in my attic, to add to the now more than 4,000 I've removed from my living space since 1/1/2011. I have now destroyed 12, 348 stink bugs in my home in 45 days since January 1, 2011.

After all the effort this weekend, another 100+ found their way into my kitchen (a two year old addition) Sunday afternoon." (*mid-Feb, Resident near Harpers Ferry, WV*)

Landscape-Level Threat To Crops



USDA-NIFA SCRI CAP

- Title: Biology, Ecology, and Management of Brown Marmorated Stink Bug in Orchard Crops, Small Fruit, Grapes, Vegetables, and Ornamentals.
- Written as a 5-Year Coordinated Agricultural Project.
- Funded for 3 years with opportunity for renewal.
- Total Federal Award $5,739,966.
- Matching Funds $ 7,325,637.

Biology, Ecology, and Management of Brown Marmorated Stink Bug in Orchard Crops, Small Fruit, Grapes, Vegetables, and Ornamentals USDA-NIFA SCRI Coordinated Agricultural Project

Biology, Ecology, and Management of Brown Marmorated Stink Bug in Orchard Crops, Small Fruit, Grapes, Vegetables, and Ornamentals

- USDA-ARS
  - Appalachian Fruit Research Station, Kearneysville, WV
  - Beneficial Insects Introduction Research Unit, Newark, DE
  - Invasive Insect Biocontrol and Behavior Laboratory, Beltsville, MD
  - Horticultural Crops Research Unit, Corvallis, OR
- The Pennsylvania State University
- Washington State University
- North Carolina State University
- Virginia Polytechnic Institute and State University
- Rutgers University
- Northeastern IPM Center
- Oregon State University
- University of Maryland
- University of Delaware
- Cornell University

What Have We Learned So Far?

Development of Effective Detection and Monitoring Tools

- Tools that provide accurate measurements of presence, abundance, and seasonal activity of BMSB.
- Growers can make informed management decisions.

Key Components of Trap-Based Monitoring Tools

- Visual Stimuli
- Olfactory Stimuli
- Capture Mechanism
- Deployment Strategy

Do BMSB respond to visual cues associated with pyramid traps?

- Baited with methyl (2E, 4E, 6Z)-decatrienoate or left unbaited.
- Traps deployed at the periphery of orchards blocks
- Captures from October 7-November 17, 2009 and July 23-October 14, 2010.

Pheromone of *Plautia stali*

- Methyl (2E, 4E, 6Z)-decatrieonate.
- Cross attractive to brown marmorated stink bug and other pentatomids.

Significantly Greater Captures in Baited Black Pyramid Traps

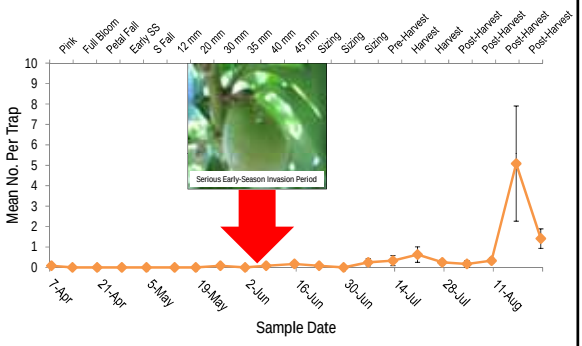
Will BMSB Respond to Methyl (2E, 4E, 6Z)-Decatrienoate early in the season?

- Reports in Asian literature of early-season attraction.
- Previous trials had relied on low doses (<5 mg).
- Evaluated 66 mg lures.

Despite Reports in the Asian Literature, Our Only Attractant Fails During the Early- and Mid-Season

Methyl (*2E,4E,6Z*)-decatrieonate attractive to adults only during the late-season. Confirmed in MD, WV, NJ, PA, VA and other states in 2011. Not attractive to adults in early- and mid-season.

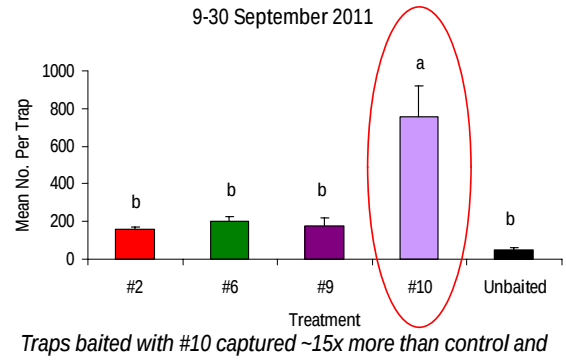
Almost No Captures in Baited Traps, Despite Very Large Immigrating Populations



Progress Toward Identification of BMSB Aggregation Pheromone

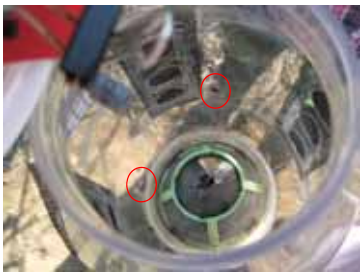
USDA-ARS, Beltsville, MD and Kearneysville, WV

Captures in Traps Baited With #10 Significantly Greater

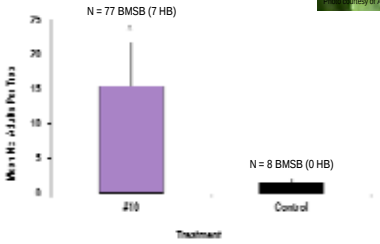


Traps baited with #10 captured ~15x more than control and ~3-4x more than other treatments.

Is #10 Attractive in the Early Season?
Pre-Trial (March 20-April 17, 2012)

Early Season Attraction Documented for BMSB
March 20-April 17, 2012

Broad Validation in Multi-State Trial

- Is BMSB attracted to #10 in the early season?
- Is BMSB attracted to #10 season-long?
- How attractive is this stimulus relative to MDT and unbaited traps?

General Protocol

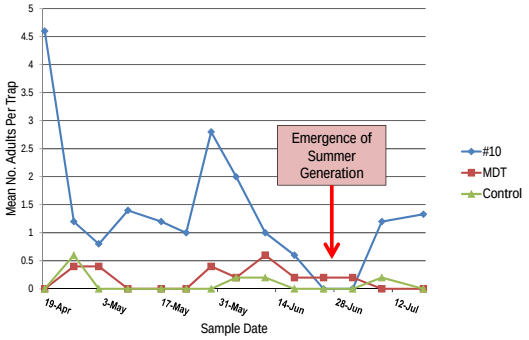
- Black pyramid traps.
- Three odor treatments : 1) #10 (~10 mg load); 2) methyl decatrienoate (provided by Sterling); and 3) Unbaited Control.
- Traps are deployed between wild host habitat and agricultural production area.
- Traps were deployed in mid-April and left in place season-long.

Multi-State Trial: June 2012 Results
12.5 : 1 Ratio (Baited:Unbaited)

States	Crop	Reps	#10	MDT	Control
WV	Tree Fruit	9	41	2	1
MD	Tree Fruit	6	28	4	3
MD	Ornamentals	6	33	5(1)	1
MD	Vegetables	9	6	2(1)	2
NJ	Blueberry	5	22	1	0
NJ	Peach	5	3	3	0
NJ	Grape	5	40	1	0
DE	Mixed Veg	6	3	0	0
PA	Tree Fruit	15	17	6	5
NY	Tree Fruit	3	10	2	2
VA	Vegetables	5	6	3(1)	1
VA	Tree Fruit	5	14	1	2
VA	Grapes	5	0	0	0
OR	Mixed Crops	6	3	0	0
NC	Mixed Crops	6	3	2	0
Totals			226	34 (3)	18

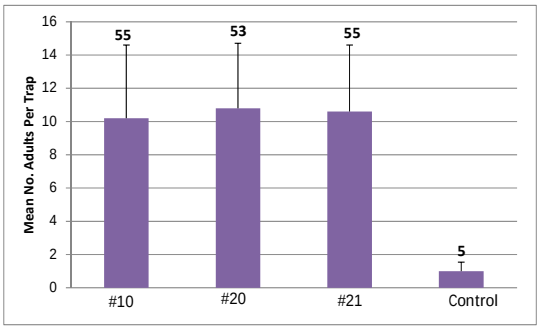
Lures also sent/being sent to OH, WA, IN, MO, and MI

Reliable Season-Long Detection with #10 (10 mg lure) in Commercial Orchards in WV and MD



Lure Affordability: Encouraging Results from Purity Trial

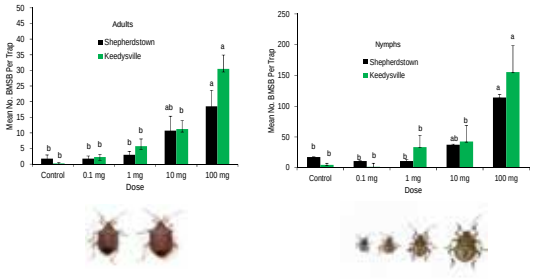
May 14-June 4, 2012
10 mg experimental lure 11:1 Ratio (Baited: Unbaited)



Dose Response Trial

June 14-July 19, 2012

11:1 Ratio (Baited: Unbaited) for 10 mg lure
~25:1 Ratio (Baited: Unbaited) for 100 mg lure



What's Next?

- Documenting season-long attraction to #10.
- Single isomer tests.
- Formulation, utility and commercialization.
- Behavior, biology, and ecology of responders as well as natural enemies.

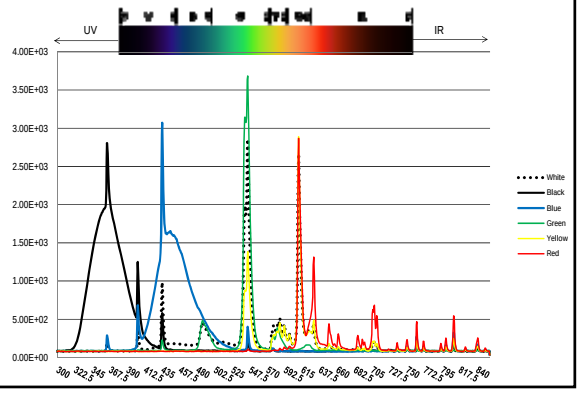
Visual Cues

Identifying Optimal Wavelengths and Intensities of Light

2011 Field Trial

- Are wavelength-restricted light sources more stimulating/attractive to BMSB under competitive field conditions?
- Can we augment ordinary pyramid traps with light sources and capture BMSBs reliably?
- Stimuli included white, black, blue, green, yellow, and red compact fluorescent bulbs and control.

Compact Fluorescent Light, 25W (100W Equivalent)

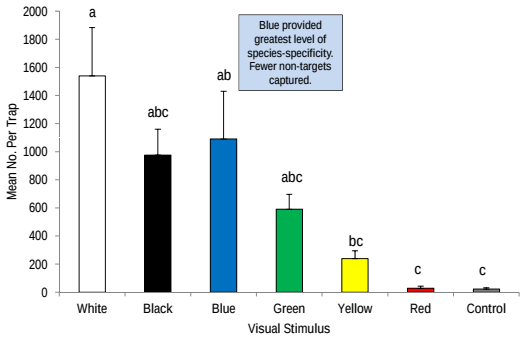


Field Trial Set-Up

Night View

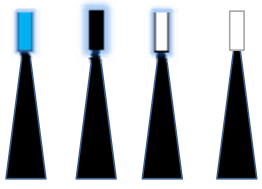
High Captures and Apparent Vicinity-Based Responders

A Total of 21 Traps Baited With Light-Based Stimuli Captured 13,457 Adult BMSB in ~6 Weeks During Late Summer



2012 Species Specificity Trial

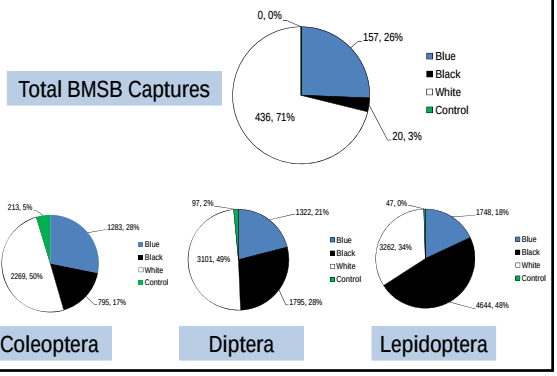
June 3 - July 19, 2012



How species specific are our three most promising light sources and an unlit control?

Encouraging Results With Blue Light Source

Consistent Captures with ~40-50% Fewer Non-Targets



Challenges in Managing BMSB in Commercial Plantings

- Very little information available regarding BMSB management at end of 2010.
- In 2010, we observed 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.
- Section 18 Working Group led by USDA-OPMP and EPA-OPP.
- Laboratory trials conducted by USDA-ARS, Penn State and VA Tech.
- Recommendations made and refined throughout the season in 2011.

BMSB Insecticide Evaluations Against Adults

- BMSB capable of reproduction within orchard plots. Control of this population targets all life stages.
- Constant, season-long pressure from outside orchards leads to constant re-infestation of plots
- Immigrating/emigrating adults are unlikely to encounter direct contact with finished (wet) spray material. Avoidance behaviors.
- Control of this population depends on sustained effectiveness of residue.

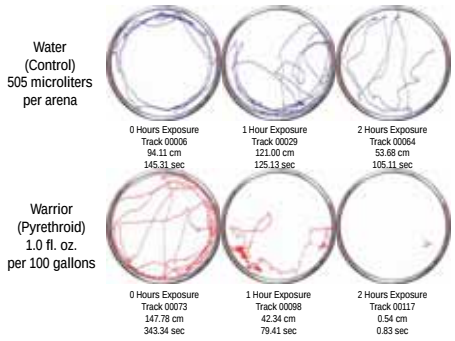
Experimental Trials

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

2 Direct observations of vertical movement capacity following insecticide exposure.

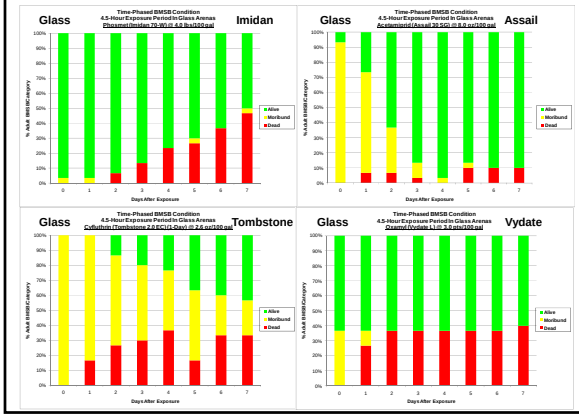
3 Mortality tracked for 7-d followed by final vertical movement trial.

BMSB Insecticide Evaluations Sample Tracks

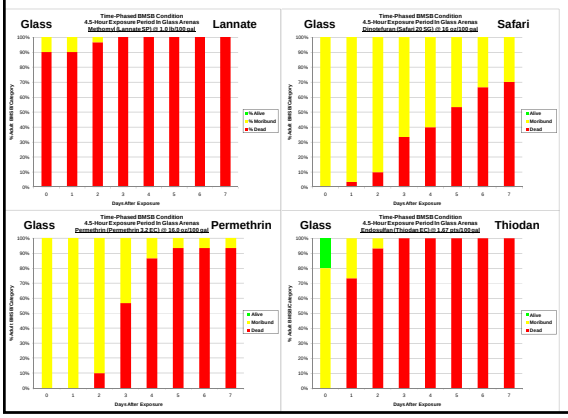


BMSB Insecticide Evaluations 7-Day Survivorship

Weaker Materials



Promising Compounds



BMSB Insecticide Evaluations
Lethality Index

$$\text{Lethality Index} = \left[\frac{\sum \text{Day 0-7}\,[(\text{BMSB Alive} \times 0.0) + (\text{BMSB Moribund} \times 0.5) + (\text{BMSB Dead} \times 1.0)]}{240} \right] \times 100$$

The maximum value of the Lethality Index for each material is 100.0; the minimum value is 0.0, and compounds are ranked in descending order of value.

* After testing ~45 materials, the Lethality Index was modified to accommodate four conditional categories: Alive (0.0); Affected (0.25); Moribund (0.75); and Dead (1.0). This change in conditional interpretation does not change the comparability of Lethality Index across tested materials.

BMSB Laboratory-Based Testing
Lethality Index

Active Ingredient	Trade Name	Lethality Index	Active Ingredient	Trade Name	Lethality Index
Chlorpyrifos/Gamma-Cyhalothrin	Cobalt	**95.4**	Oxamyl	Vydate	**46.8**
Dimethoate	Cygon	**93.3**	MBI-203	MBI-203	**43.4**
Malathion	Malathion	**92.5**	Esfenvalerate	Asana	**43.3**
Bifenthrin	Brigade	**91.5**	Imidacloprid	Provado	**40.0**
Endosulfan	Thionex	**90.4**	Tolfenpyrad SC	Tolfenpyrad SC	**36.5**
Methidathion	Supracide	**90.4**	MBI-205	MBI-205	**35.7**
Methomyl	Lannate	**90.1**	Tolfenpyrad EC	Tolfenpyrad EC	**33.3**
Chlorpyrifos	Lorsban	**89.0**	Pyrifluquinazon	Pyrifluquinazon	**28.3**
Acephate	Orthene	**87.5**	Kaolin Clay	Surround	**23.1**
Fenpropathrin	Danitol	**78.3**	Diazinon	Diazinon	**20.4**
Permethrin	Permethrin	**77.1**	Phosmet	Imidan	**20.0**
Azinphosmethyl	Guthion	**71.3**	Acetamiprid	Assail	**18.8**
Dinotefuran	Safari	**67.3**	Thiacloprid	Calypso	**18.3**
Kaolin Clay/Thiamethoxam	Particle Delivery	**66.7**	Abamectin	Agri-Mek	**16.3**
Formetanate HCl	Carzol	**63.5**	Indoxacarb	Avaunt	**11.3**
Gamma-Cyhalothrin	Proaxis	**59.0**	Spirotetramat	Movento	**9.8**
Zinc Dimethyldithiocarbamate	Ziram	**57.5**	Carbaryl	Sevin	**9.2**
Thiamethoxam	Actara	**56.3**	Water	Control 6	**9.2**
Clothianidin	Clutch	**55.6**	Flonicamid	Beleaf	**7.7**
Beta-Cyfluthrin	Baythroid	**54.8**	Water	Control 2	**6.9**
Lambda-Cyhalothrin	Warrior	**52.9**	Water	Control 3	**6.3**
Zeta-Cypermethrin	Mustang Max	**52.1**	Water	Control 5	**6.0**
Cyfluthrin	Tombstone	**49.0**	Water	Control 4	**4.2**
MBI-206	MBI-206	**48.4**	Cyantraniliprole	Cyazypyr	**1.7**

Conclusions

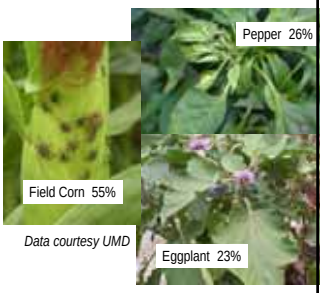
- No chemical class uniformly outperformed all others, but representatives of each major class demonstrated potential value for field use.
- Even at highest doses of the most effective insecticides, BMSB are very hard to kill via incidental/walking contact.
- Potential for recovery from “moribund” state was demonstrated for some pyrethroids and neonicotinoids.
- Residual activity very short in the field.

Biological Control Offers Long-Term Solution

Strategies To Reduce Populations Across Entire Landscape

Classical biological control effort continues with host specificity screening being conducted at quarantine facilities in DE, OR, FL, MS and MI

Contributions from Native Natural Enemies



Data courtesy UMD

Early work indicated low parasitism rates

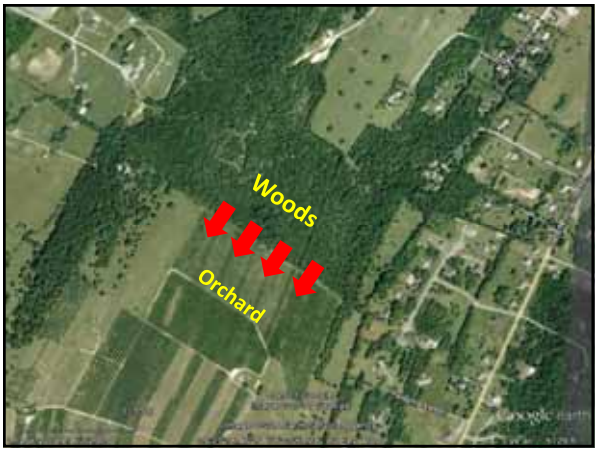
Parasitism and predation rates higher on other host plants

Standardized Biological Control Survey

- Protocols developed by Kim Hoelmer (USDA-ARS) and Cerruti Hooks (UMD).
- Robust ongoing surveys using sentinel and wild egg masses.
- Orchard crops, vegetables, small fruit, row crops, urban environments, wild hosts.
- MD, DE, PA, VA, NJ, NC, and OR.

Where Do BMSB Overwinter?

- Do BMSB overwinter in the natural landscape?
- Where do they overwinter in the natural landscape?
- Do populations overwintering in the natural landscape pose a threat to agriculture?



What's Next?

Acknowledgements

- USDA-ARS, USDA NIFA SCRI # 2011-51181-30937, and USDA-APHIS