Brown Marmorated Stink Bug
IPM Working Group Meeting

University of Maryland
Physics Building, Room 1201
1117 John S. Toll Building #082
College Park, MD 20742

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Submitted by:

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Executive Summary

The eleventh formal BMSB Working Group meeting was held at the University of Maryland in the Physics Building, College Park, Maryland on June 9, 2015. Research and extension personnel from Rutgers University, USDA-ARS, Penn State University, Cornell University, University of Delaware, University of Maryland, Virginia Tech, University of California, National Wildlife Federation, National Pest Management Association, Georgia Ports Authority, Oregon Research & Development Center, Wallenius Wilhelmsen Logistics, Cooper Pest Solutions, New Zealand Institute for Plant and Food Research, Michigan State University, Auburn University, Australian Department of Agriculture as well as EPA, Northeastern IPM Center, Bedoukian Research, Oregon Department of Agriculture, and industry representatives attended the meeting. In addition, participating through webinar were representatives from the Agriculture and Agri-Food Canada, University of California, University of Connecticut, University of Kentucky, IPM Institute of North America, Ohio State University, Hercon Environmental, Du Pont Pioneer, Tswane University of Technology, Toyota Motor Sales, Penn State, U.S. Apple Association, USDA-ARS, and South African Subtropical Growers Association.

There were seventy-seven participants in attendance. Specific discussions on nuisance problems posed by BMSB for homeowners as well as businesses including the shipping industry were discussed. Pest management professionals and researchers spoke about the tactics used to manage nuisance populations in homes, businesses and vehicles. A session was devoted to native and exotic biological control agents and ChiroSurveillance: the use of native bats to detect the invasive BMSB was held. Participants updated Research, Extension, Regulatory and Consumer priorities.

Research Priorities

Rank	Research Priority	Mean Score	# Responders
1	Development of IPM-friendly management tactics	93	28
2	Biocontrol agents--identification and study of parasitoids, fungal pathogens, and predators (native and foreign)	89	28
3	Examine overwintering biology (e.g. triggers for seeking and leaving sites; overwintering mortality factors)	82	28
4	Studies of basic BMSB behavior (host preferences, movement, responses to visual cues)	80	28
5	Evaluate efficacy and host range of candidate classical biological control agents	79	28
6	Further study of pheromone-based monitoring (e.g. active space, trap design, attractants)	76	27
6	Define damage diagnostics, economics of injury and threshold	76	28
7	Investigation of host-plant volatiles as attractants	75	27
7	Evaluation of parasitoid host specificity	75	28
8	Identification of potential repellents	74	29
9	Determine factors affecting population densities	71	26
9	Impact of landscape and habitat on population (local)	71	28
9	Studies of basic BMSB biology (physiology, generations)	71	27
10	Develop economic models that include injury, monitoring and management costs	70	27
11	Crop susceptibility and timing	66	28
12	Response of indigenous natural enemies in relation to BMSB densities and their potential for management	65	28
12	Host utilization, preference, and range	65	28
12	Examine interactions between native and exotic parasitoids (additive, synergistic or antagonistic)	65	26
12	Evaluate effects of BMSB management plans on beneficial agents, including pollinators	65	27
13	Develop forecasting models to ID new risk areas, presence and where BMSB is and will not be	64	28
14	Mapping and assessment of distribution	63	27
14	Assess secondary pest outbreaks related to chemical control of BMSB	63	27
15	Role of the gut symbionts and their potential for management	62	27
16	Examination of potential for trap-cropping	61	27
16	Standardized sampling methods	61	27
17	Use of toxins in combination with attractants	60	27
18	Determine conservation bio control efforts for indigenous natural enemies	59	27
18	Determine how far will BMSB travel to overwintering sites	59	28
19	Determine why BMSB appears to not be present in coastal plains	56	27
19	Evaluate potential impacts of cultural control measures	56	28
19	Determine the impact of elevation on overwintering sites	56	27

Research Priorities (continued)

Rank	Research Priority	Mean Score	# Responders
20	Methods development and improve rearing protocol for long term sustainable colonies	55	26
20	Determine low and high temperature thresholds for all stages	55	27
21	Determining monitoring strategies for urban areas	54	27
21	Study potential for damage of harvested/value-added crops by contamination with BMSB	54	27
21	Develop baseline insecticide toxicity data for resistance monitoring	54	27
22	Standardize multiple methods for screening of new insecticide materials	50	27
22	Assessment of economic impact in urban environment	50	28
23	Assessment of displacement of native stink bugs	49	28
24	Evaluate long term sub lethal effects on BMSB (e.g. effects on reproduction)	48	27
24	Evaluate regional landscape-level/watershed-scale population distribution	48	27
24	Validate current physiology and phenology models in laboratory	48	27
25	Risk analysis of overwintering populations in natural landscapes	46	27
26	Evaluate impact of orchard groundcover management	45	27
27	Development of toxicants and inhibitors for plant transgenic delivery	41	27
28	Examination of cross-attraction of BMSB and green stink bugs	36	26
29	Evaluate potential impact of vertebrate predation	35	26
30	How far do BMSB travel after leaving overwintering sites?	31	1

Priority rank is based on scores provided by individual Working Group participants (importance of a particular priority on a scale of 0-100, calculating the mean value for each, and ranking them accordingly.

Extension Priorities

Rank	Extension Priority	Mean Score	# Responders
1	Education programs to growers and the general public	84	27
2	Deliver economic thresholds / action thresholds	83	27
3	Develop revised and unified management plans	82	27
4	Coordinate efforts of state and regional extension programs	75	26
5	Educating professionals to pest ID and diagnosis of injury	72	26
6	Education programs relevant to development of biological control projects	71	26
7	Include education programs relevant to classical biological control	69	24
8	Develop treatment recommendations and guidelines for urban environments	64	25
9	Extension outreach and education programming for urban environment/homeowners	63	25
10	Educational programming for structural and landscape industries	62	26
11	Educational programs relevant to invasive biology using BMSB	60	24
12	Initiate public awareness campaigns - posters, public service announcements, educational materials, etc.	59	24
12	Demonstrate field application techniques for chemical control	59	25
13	Raise awareness of importance of BMSB as pest - APHIS, local political channels, etc.	58	24
14	Use BMSB as an opportunity to educate children	56	26
14	Direct homeowners to local politicians for complaints	56	25
15	Structure extension groups by commodity or region	48	25
16	Establish links between eXtension community of practice (COP) and StopBMSB.org	47	25
17	Evaluate large scale treatment facilities of export cargo	31	1

Priority rank is based on scores provided by individual Working Group participants (importance of a particular priority on a scale of 0-100, calculating the mean value for each, and ranking them accordingly.

Regulatory Priorities

Rank	Regulatory Priority	Mean Score	# Responders
1	Product testing and labeling of new active ingredients/products - only low toxicity/IPM compatible	84	26
2	Use of toxins in combination with attractants (regulatory status)	82	25
3	Define the economic and ecological threat	72	26
4	Expand use of existing registered products	69	25
4	Coordinate interagency and interdisciplinary funding	69	25

Priority rank is based on scores provided by individual Working Group participants (importance of a particular priority on a scale of 0-100, calculating the mean value for each, and ranking them accordingly.

Consumer/Urban Priorities

Rank	Consumer/Urban Priority	Mean Score	# Responders
1	Development of IPM friendly management strategies (trap style and efficacy, overwintering site selection, insecticide timing, repellent -push/pull, efficacy of treating exterior plants/landscapes)	93	27
2	Preventative measures for reducing entry into human-made structures - outreach needed	81	28
3	Define triggers for movement into homes	79	27
4	Important biological control agents around residential areas	74	28
5	Evaluate efficacy of insecticides/killing agents for homeowners	70	22
6	Forecasting population size	67	27
7	Evaluate materials for home-garden and home-landscape protection	66	27
8	Determining repeated entry and exit by BMSB from overwintering sites	62	22
9	Evaluate the use of environmentally "friendlier" treatment options than insecticides such as heat	31	1

Priority rank is based on scores provided by individual Working Group participants (importance of a particular priority on a scale of 0-100, calculating the mean value for each, and ranking them accordingly.

Overall Priorities

Rank	Category	Overall Priorities	Votes
1	Research	Development of IPM-friendly management tactics	17
1	Consumer/ Urban	Development of IPM friendly management strategies (trap style and efficacy, overwintering site selection, insecticide timing, repellent -push/pull, efficacy of treating exterior plants/landscapes)	17
2	Research	Biocontrol agents--identification and study of parasitoids, fungal pathogens, and predators (native and foreign)	16
3	Extension	Develop revised and unified management plans	13
4	Regulatory	Product testing and labeling of new active ingredients/products - only low toxicity/IPM compatible	11
5	Extension	Education programs to growers and the general public	9
6	Regulatory	Define the economic and ecological threat	8
7	Research	Evaluate efficacy and host range of candidate classical biological control agents	7
7	Extension	Deliver economic thresholds / action thresholds	7
7	Regulatory	Coordinate interagency and interdisciplinary funding	7

Overall priority rank is based on Working Group participants designating their five top priorities across all categories; those priorities receiving designations by at least 10 percent of the membership were ranked.

BMSB Presentations

Presented by: Dr. Tracy Leskey[1] & Dr. George Hamilton[2]
USDA-ARS-AFRS[1] and Rutgers University[2]
Department of Entomology

Summary:

- Welcomed everyone to the 11th annual working group meeting
- Overview of day's schedule
- Nuisance Problems Caused by BMSB

- Goal of Working Group: Identify and address needs of consumer and pest management professionals

    - *Anticipated Impact.* Although development of IPM practices in agricultural systems is being rigorously studied and developed, little is being done to generate IPM strategies for homeowners and businesses and pest management professionals. We will work with our membership to identify areas of expertise and knowledge that can be used to develop IPM strategies for management of BMSB in homes and businesses and transfer this information to pest management professionals.

Haunted House – Getting Rid of BMSBs
Presented by: Dr. Doug Inkley
National Wildlife Federation

- Dr. Inkley discussed issues in dealing with large numbers of BMSB in his home. He removed over 25,000 in a period of just six months. He indicated that commercial light traps available for homeowners do not work, that both old and new construction is vulnerable to BMSB infestation. He discussed the lost of ambience and equanimity associated with infestations. He indicated that homeowners needed more information regarding BMSB-proof exteriors including how to modify soffits, ridge vents, dryer/stove vents, chimneys and vinyl siding.
- Also, he discussed the challenges for backyard gardeners and the need to find solutions for them as well.

"From bubble baths to baking bugs: A potpourri of our urban pest control research endeavors on BMSB in Virginia"
Presented by: Dr. Tom Kuhar
Virginia Tech

- Dr. Kuhar discussed studies conducted in association with citizen scientists aimed at establishing the efficacy of commercial and homemade light traps. They found that the best trap was the homemade water pan trap which captured up to 144 BMSB adults in a single week. This option seemed to be the cheapest and most effective.
- For infested vehicles, heat treatment was also used at 50 or 60 degree Celsius for 15 minutes which resulted in 100 percent mortality

BMSB Effects on Shipping Industry
Present by: Capt Phil Hansen
Wallenius Wilhelmsen Logistics

- Wallenius Wilhelmsen Logistics (WWL) specializes in ocean transportation of cars, rolling equipment and break bulk cargo. There are 13 terminals located at strategic ports in UK, Finland, Belgium, China, and South Korea and on the US East and West coast. Capt Hansen spoke about the detection of BMSB and the requirements needed now at each port. He showed the actions that WWL will be taking to prevent BMSB from entering New Zealand and Australia.
- Capt Hansen also presented needed research and initiatives, future government support and the risks associated with dealing with BMSB.

PMPs and BMSB: Where we stand and where we are going
Presented by: Dr. Bennett Jordan
National Pest Management Association

- Dr. Jordan discussed the challenges in terms of both regulatory and consumer issues for dealing with BMSB and the need for further research.

Structural Pest Control and the Brown Marmorated Stinkbug
Mr. Dave Burgess
Cooper Pest Solutions

- Mr. Burgess stated that BMSB is different than other overwintering pests. They enter earlier and leave later. They are active throughout the entire winter in homes, offices, etc. Clients don't call until they see them; which is too late. Services have to be performed **before** the bugs enter the structure. Their treatments focus on entry point areas and interior services are limited to the attic.
- Commercial buildings are the same idea, just on a bigger scale.

Great Stink Bug Count - Utilizing Citizen Science to Identify Characteristics Important to Overwintering Site Selection for Brown Marmorated Stink Bug
Ms. Torri Hancock
USDA-ARS-AFRS

- Ms. Hancock spoke about the overwintering site selection making sure the characteristics of *natural locations* have been identified and the characteristics identified when BMSB *settle* within the structure
- The research question was "What are the specific characteristics associated with human-made structures that are important when BMSB are *dispersing* to overwintering sites?"
- Brown exterior colored homes had the most results, which was in contrast to what we often hear from homeowners. Structure material results were homes with wood or stone exterior had significantly higher counts compared with all other materials except cement. The aspect result with the greatest counts was the north side of structures; significantly fewer BMSB were found on the south side.
- Among landscapes, significantly greater counts were recorded in rural areas compared with urban settings.
- Peak activity reported by participants was during a very narrow window from September 30-October 2 in 2013.

BMSB Research in New Zealand
Presented by: Dr. David Teulon
Plant & Food Research/B3

- Dr. Teulon discussed Better Border Biosecurity (B3) and research themes such as risks, pathway risk management, diagnostics, surveillance, and eradication and the questions they pose. New Zealand Border Biosecurity as a plant based productive sector is essential to NZ's economic well-being.
- Indigenous flora is unique and central to our culture and tourism. Productive and natural systems are subject to invasion by unwanted and destructive exotic organisms. Growing passenger and trade volumes, increasing imports from new countries, population expansion and climate change and rate of incursion is likely to continue to increase. Ineffective Border Biosecurity will undermine base production, limits our future options, security, safety, and integrity.
- He stated that Biosecurity is An Industry Priority and a Government Priority. BMSB is considered to be a key issue with many pre-emptive projects being developed.

Designing Stink Bug-Free Landscapes
Presented by: Dr. Paula Shrewsbury
University of Maryland

- Dr. Shrewsbury stated that the components are resource use for fruit availability and timing, spatial for edge effects and adjacent habitat, host plant use for patterns, classification or taxonomy and host plant origin. We can use this information for management of BMSB and design BMSB-free landscapes.
- The research questions are do BMSB utilize trees with fruits and does that depend on fruit maturity? How does the timing of fruiting influence BMSB abundances? Does fruit removal depress BMSB abundances?
- She used study sites in two commercial nurseries in Central Maryland with 229 cultivars, 3884 trees, each visited 6 times (every 2 weeks) from late May to early August 2013.

Her goals were to design stink bug-free landscapes, reduce the number of stink bugs in residential landscapes and reduce the numbers that move into homes in the fall (hopefully).
- Her future studies will include damage assessments, relative abundance of cultivars in the landscape, and conservation of natural enemies.

BMSB biology and invasion risk; Australia's perspective
Presented by: Mr. Brian Garms
Australian Department of Agriculture

- Presentation will *not* be posted at this time.

Management of BMSB on Commercial Buildings
Presented by: Dr. George Hamilton
Rutgers University

- Dr. Hamilton presented a map of BMSB detected (green) and agricultural and nuisance (brown) problems reported with severe (red) cases in PA, NJ, DE, MD, VA, and WV. He showed a building with plants beat sampled once a week followed by MDT traps from late August until early October and spray recommendations.
- The research revealed that plant sampling can identify potential problem areas, target fall foliage sprays to coincide with the development of aggregations, and spray infested plants and selected building areas.
- Questions raised were, "What is the best insecticide to use? What is the residual action? Does a building's construction affect insecticide efficacy?"

Using Molecular Techniques to Determine Natural Enemies of BMSB
Presented by: Mr. John Pote
Rutgers University

- Presentation will *not* be posted at this time.

*Chiro*Surveillance: The Use of Native Bats to Detect the Invasive Brown Marmorated Stink Bug
Presented by: Dr. Brooke Maslo
Rutgers University

- Dr. Maslo studied bats as Agents of Invasive Species Surveillance and stated temperate insectivorous bats consume a diverse array of insects; expansive foraging range is ~5km; central place foragers, returning to same roost nightly; easy to sample and bats may be important sentinels if they identify non-native species as prey and we can reliably detect non-native species in bat guano (even when pest is rare).
- Her study revealed that big brown bats recognize BMSB as a common prey item across the season; density-dependent predatory response; bats detected BMSB 3-4 weeks earlier

than blacklight traps; and currently testing *Chiro*Surveillance on tufted apple budmoth, codling moth, and Oriental fruit moth. The next steps are comparison of bat predation with newer pheromones needed to verify the patterns identified here, robust economic analyses to determine cost-effectiveness of *Chiro*Surveillance and can bats be effective agents of control?

Development and use of a real-time PCR assay for detection of Brown Marmorated Stink Bug through Environmental DNA
Presented by: Mr. Rafael Valentin
Rutgers University

- Presentation will *not* be posted at this time.

"Surprising sentinels: exotic egg parasitoid appears at Beltsville; what now?" - Parasitoids of Brown Marmorated Stink Bug (*Halyomorpha halys*) eggs: Comparison of three egg mass types in three Maryland habitats.
Presented by: Ms. Megan Herlihy
USDA-ARS-IIBBL

- Ms. Herlihy discussed results showing that the Asian parasitoid *Trissolcus japonicus* was detected in the wild in Beltsville, MD in 2014. *Trissolcus* was found in the field in 2014 in Beltsville, MD

Developing a fungal biocontrol agent against BMSB - Fungal Pathogens *Metarhizium*
Presented by: Dr. Raymond St. Leger
University of Maryland

- Dr. St. Leger stated there are three basic strategies for selection and/or improvement of biological control agents: find natural isolates, directed adaptation (Mutagenesis and/or Evolugator), and genetically engineer improvements.
- Many novel spider toxins have been transformed into *Metarhizium* strains' targeting malaria vector *Anopheles gambiae*, different orthopterans and, we'd hoped, bugs. The transition from one phase to the next is subject to "go/no-go" decision criteria for efficacy and safety endpoints, to obtain regulatory approvals and social acceptance.
- Brown marmorated stink bug defensive compounds may be the cause of poor fungal performance. Two chemicals present in stink bug defensive secretions (trans-2-octenal and trans-2-decenal) found to strongly inhibit growth of entomopathogenic fungi. *Metarhizium* infects and kills BMSB at high humidity's. Low humidity's reduce germination and increase susceptibility to volatiles. BMSB relies heavily on volatiles; haemolymph defenses are weak.

Northeast Updates

Presented by: Dr. Tracy Leskey
USDA-ARS-AFRS

- Dr. Leskey showed map and the States of PA, NJ, DE, MD, VA and WV as severe cases for BMSB nuisance and agricultural problems reported. There has been an update to add the state of CT to that list. She reported and provided responses from Vermont, Maine, New Hampshire, Massachusetts, Connecticut, Rhode Island, New York, Pennsylvania, New Jersey, Delaware, Maryland, and West Virginia.

Mid-West Updates - Status of Brown Marmorated Stink Bug in the Midwest
Presented by: Dr. Ric Bessin (Dr. Celeste Welty)
The Ohio State University

- Dr. Bessin reporting for Dr. Welty provided the updates for the Mid-Western States consisting of MN, WI, MI, OH, IN, IL, MO, IA. He reported and showed the BMSB tracking in Ohio, Indiana, Illinois, Iowa, Michigan, Wisconsin, and Minnesota. Also, changed Iowa to nuisance problems

Status of BMSB in the Southern Region
Presented by: Dr. Jim Walgenbach
North Carolina State University

- Dr. Walgenbach showed the distribution of detections and established populations and research and extension activities of the southern region. North Carolina is now in the (red) severe agricultural and nuisance problems reported. BMSB has been confirmed in 21 Georgia counties. For the first time, reproducing BMSB populations were confirmed in an ornamental nursery, pecan production, peach production, cotton production, and directly adjacent to blueberry production (scouting was too late in the season for blueberries to be present). Based on the current county map, we think it is highly likely that BMSB is present in most of, if not all, northern and central counties. Pest detections by county (see map). Brown Marmorated Stink Bug Distribution in North Carolina: (see map). BMSB recorded by scouting or confirmed reports (county agent or general public). BMSB recorded by unconfirmed reports (general public).

Update of the Agricultural & Nuisance Pest Problems in the Western IPM Region – SCRI Meeting
Presented by: Dr. Nik Wiman
Oregon State University

- Dr. Wiman highlighted Western problems as massive specialty crop production, specialty crop diversity, valuable export markets, and unique environment types. The BMSB SCRI Planning Grant will define research and extension priorities and will identify how we fit into the greater scheme. Western Specialty Crops include avocados, pistachios, olives, hazelnuts, citrus, cherries and pears. He showed examp1es of damage, current

status, grower outreach, California Focus Groups, OR/WA Focus Groups, Specialty Crop Breakdown, Specialty crop production: Sacramento area, research priorities. Dr. Wiman also spoke about the Portland Planning Meeting and the Research Priorities, Extension Priorities and Conclusions. He made acknowledgements to USDA-NIFA-SCRI #2014-51181-22514 and the meeting participants and group members, approx. 35 people.