Brown Marmorated Stink Bug
IPM Working Group Meeting

Rutgers Agricultural Research and Extension Center
121 Northville Road
Bridgeton, NJ 08302

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Submitted by:

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Executive Summary

The brown marmorated stink bug (BMSB), *Halyomorpha halys* (Stål) continues to spread throughout the United States. BMSB has been detected in 40 states, posing severe agricultural problems in six states and nuisance problems in thirteen other states. Large populations are now established in PA, NJ, DE, MD, WV, VA and D.C.; each state documented severe losses in crops and serious nuisance problems from BMSB since 2010. Crop injury has been also reported in NY, OH, and TN. Established populations also exist in CA, CT, IN, KY, MA, MI, NC, NH, OR, RI, VT, and WA though crop losses have not yet been reported they are considered a nuisance problem only. In addition, BMSB has been detected in AL, AZ, FL, GA, IA, ID, IL, KS, ME, MN, MO, MS, NE, NM, SC, TX, UT, and WI. BMSB has also been repeatedly detected in Hamilton, Ontario, Canada over the past year.

The sixth formal BMSB Working Group meeting was held at Rutgers Agricultural Research and Extension Center on June 11-12, 2013. Research and extension personnel from Rutgers University, USDA-ARS, Penn State University, Cornell University, North Carolina State University, Oregon State University, Ohio State University, University of Delaware, University of Maryland, Michigan State University, Virginia Tech, University of Tennessee, University of California, University of Connecticut, University of Rhode Island and WV Wesleyan College as well as EPA, Northeastern IPM Center, INIFAP Mexico, Ontario Ministry of Agriculture, CABI-Switzerland, National Wildlife Federation, New Jersey Department of Agriculture, and industry representatives attended the meeting. In addition, participating through webinar were representatives from the University of Connecticut, Cornell University, Purdue University, industry members from DuPont and Hercon Environmental and South African Avocado Growers' Association.

The meeting began with a biological control identification workshop. Following the 2-day workshop, regional BMSB updates were reported from the four IPM regions; Northeast, North Central, Southern and Western regions. International updates were provided by colleagues from Canada, Mexico and Switzerland. An EPA representative discussed regulation updates and how it is getting more complicated to add pesticide uses. In addition to regional updates there were presentations ranging from Pheromone-Based Trapping, Climate Driven Models, Tracing BMSB Origin, Outreach, Rearing, and Gut Symbionts to Updates on Biological Control with Asian Parasitoids and Imaging Stacking Software uses. There were approximately seventy participants in attendance. Research, Extension, Regulatory, Consumer and overall priorities were updated by the group.

Research Priorities

Rank	Research Priority	Mean Score	# Responders
1	Development of IPM-friendly management tactics	86	33
2	Studies of basic BMSB behavior (host preferences, movement, response to visual cues)	83	33
3	Biocontrol agents-identification and study of parasitoids, fungal pathogens, and predators	82	33
4	Impact of landscape and habitat on population	79	33
5	Studies of basic BMSB biology (physiology, generations)	79	33
6	Determine factors affecting population densities	72	33
7	Host utilization, preference, and range	70	33
7	Examine overwintering biology (e.g. triggers for seeking and leaving sites; overwintering mortality factors)	70	33
8	Define damage diagnostics, economics injury thresholds	68	33
8	Role of the guy symbionts and their potential for management	68	33
8	Response of indigenous natural enemies in relation to BMSB densities and their potential for management	68	33
9	Evaluate efficacy and host range of candidate classical biological control agents	67	33
9	Crop susceptibility and timing	67	33
9	Further study of pheromone-based monitoring (e.g. active space, trap design, attractants)	66	33
10	Examination of potential for trap-cropping	63	33
10	Evaluation of parasitoid host specificity	63	33
11	Investigation of host-plant volatiles as attractants	62	33
12	Standardized sampling methods	61	33
12	Evaluate effects of BMSB management plans on beneficial agents, including pollinators	61	33
13	Mapping and assessment of distribution	59	33
14	Develop forecasting models to identify BMSB risk to new areas	57	33
15	Assess secondary pest outbreaks related to chemical control of BMSB	54	33

Rank		Mean Score	# Responders
16	Standardize multiple methods for screening of new insecticide materials	53	33
17	Develop baseline insecticide toxicity data for resistance monitoring	52	33
18	Evaluate potential impacts of cultural control measures	50	33
18	Identification of potential repellents	50	33
19	Validate current physiology and phenology models in laboratory	49	33
19	Evaluate long term sublethal effects on BMSB (e.g. effects on reproduction)	49	33
19	Evaluate landscape-level/watershed-scale population distribution	49	33
20	Determine low and high temperature thresholds for all stages	48	33
20	Risk analysis of overwintering populations in natural landscapes	48	33
20	Determine how far BMSB will travel to overwintering sites	48	33
21	Determine why BMSB appears to not be present in coastal plain areas	47	33
22	Develop economic models that include injury, monitoring and management costs	46	33
22	Determine the impact of elevation on overwintering sites	45	33
23	Study potential damage of harvested/value-added crops by contamination with BMSB	42	33
24	Evaluate impact of orchard groundcover management	40	33
25	Assessment of displacement of native stink bugs	39	33
25	Evaluate potential impact of vertebrate predation	39	33
26	Examination of cross-attractancy of BMSB and green stink bugs	37	33
26	Development of toxicants and inhibitors for plant transgenic delivery	37	33
26	Determining monitoring strategies for urban areas	37	33
27	Assessment of economic impact in urban environment	30	33

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	83	30
2	Develop revised and unified management plans	77	30
2	Coordinate efforts of state and regional extension programs	77	30
3	Deliver economic injury thresholds	76	30
4	Educating professionals to pest ID and diagnosis of injury	74	30
5	Educational programs relevant to invasive biology using BMSB	66	30
5	Educational programs relevant to development of biological control projects	66	30
6	Demonstrate field application techniques for chemical control	61	30
7	Develop treatment recommendations and guidelines for urban environments	60	30
8	Raise awareness of importance of BMSB as pest – APHIS, local political channels, etc.	52	30
9	Educational programming for structural and landscape industries	51	30
9	Extension outreach and education programming for urban environment/homeowners	51	30
10	Include education programs relevant to classical biological control	50	30
11	Initiate public awareness campaigns – posters, public service announcements, educational materials, etc.	48	30
11	Use BMSB as an opportunity to educate children	48	30
12	Structure extension groups by commodity or region	46	30
13	Direct homeowners to local politicians for complaints	42	30
13	Initiate an eXtension community of practice (COP), potentially as a central website for information	42	30

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	Use of toxins in combination with attractants (regulatory status)	75	27
2	Product testing and labeling of new active ingredients/products	70	27
3	Coordinate interagency and interdisciplinary funding	69	27
3	Define the economic and ecological threat	69	27
4	Expand use of existing registered products	62	27

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 Priorities

Rank	Consumer Priority	Mean Score	# Responders
1	Define triggers for movement into homes	73	27
2	Forecasting population size	67	27
3	Preventative measures for reducing entry into human-made structures	62	27
4	Important biological control agents around residential areas	58	27
5	Determining repeated entry and exit by BMSB from overwintering sites	50	27
6	Development of IPM friendly management strategies for homeowners	43	27
7	Evaluate efficacy of insecticides/killing agents for homeowners	39	27
8	Evaluate materials for home-garden and home-landscape protection	36	27

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		Overall Priority	# Votes
1	Research	Development of IPM-friendly management tactics	11
2	Research	Studies of basic BMSB behavior (host preferences, movement, responses to visual cues)	10
3	Extension	Education programs to growers and the general public	9
4	Research	Biocontrol agents—identification and study of parasitoids, fungal pathogens, and predators (native and foreign)	8
5	Research	Define damage diagnostics, economics injury thresholds	6
6	Research	Develop forecasting models to identify BMSB risk to new areas	5
7	Research	Studies of basic BMSB biology (physiology, generations)	4
7	Research	Mapping and assessment of distribution	4
8	Research	Further study of pheromone-based monitoring (e.g. active space, trap design, attractants)	3
8	Research	Evaluation of parasitoid host specificity	3
8	Research	Impact of landscape and habitat on population	3
8	Research	Crop susceptibility and timing	3
8	Extension	Develop revised and unified management plans	3

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% of the membership were ranked.

Oral Presentation Summaries

Regional BMSB Updates

Northeast Region
Presented by: George Hamilton
Rutgers University
Department of Entomology

Summary:

- Year one of the SCRI project was a very productive year
- As of November 2012 we are ahead of the projected schedule on most objectives
    - Objective 1 – Establish Biology and Phenology of BMSB in Specialty Crop
    - Objective 2 – Develop Monitoring and Management Tools for BMSB
    - Objective 3 – Establish effective management programs for BMSB in specialty crops
    - Objective 4 – Integrate stakeholder input and research findings to form and deliver practical outcomes
- What's next?
    - Year 2 will see a lot of training going on and looking at landscape
        - The big question to answer is where are they coming from and where do they go?
    - Get the word out. Share StopBMSB.org website.
    - Development of a renewal application is to be submitted in January 2014
- OREI grant was approved for 3 years and involves 14 different organizations
    - It is different than the SCRI grant because it only targets organic growers
    - Investigate dispersal behavior within the farmscape
    - Integrates behavior with core organic pest management strategies:
        - Trap Crops
        - Conservation biological control
        - Natural enemy surveys
        - Physical barriers
    - It's important that it complements the SCRI grant without duplicating it
- Multistate project brings states together to work on one specific project
    - Objective will be similar to the SCRI
    - Ten states participating
        - Anyone is welcome to be a member
    - Annual meeting
        - Possibly meeting at the end of the ESA meeting or Working Group Meeting
    - Currently in the process of converting it to a 5 year project

Western Region
Presented by: Nik Wiman
Co-authors: Peter Shearer, Vaughn Walton, Silvia Rondon, Jana Lee, Jeffrey Miller, Chris Hedstrom, Richard Hilton, Shannon Davis and Preston Brown
Oregon State University
Department of Entomology

Summary:

- Background
  - 2004 BMSB identified in Portland OR
  - 2004-2011 nuisance problem
  - 2012 first find in commercial agriculture, widely distributed
  - 2013 more finds in commercial agriculture
- 2012 was infested in the most important growing region in Hood River, tree fruit region and Southern Willamette Valley counties where there is a potential for severe damage
- Southern OR is important for wine grapes and BMSB is making headway there
- Current research
  - Degree Day model is currently being used. There are some reports from people saying they are seeing BMSB on sunny winter days sunning themselves.
- New research
  - Host plant - 2013 will look at what host plants BMSB are attracted to
    - In 2012, BMSB were found in 90 holly trees. maple, dogwood and Himalayan blackberry are important host plants to look at
    - Crop plants – hazelnut orchard and cane berries
  - Phenology and Voltinism Cage study
    - Purpose is to follow life history events in a controlled outdoor environment. Currently it is thought there is 1 generation in Oregon but this study will help determine how many generations there really are.
    - Sleeve cages are used in Hood River, it's a bag that opens from the top and has peas and bean plants
    - Potential trigger – degree day (DD) length, 14 hrs of daylight
      - At 4 different sites there is anywhere from 2 – 11 degree day difference
        - Hood River OR and Vancouver WA DD 4/24/13
        - Corvallis OR DD 4/26/13
        - Ashland OR DD 4/29/13
        - Winchester VA DD 5/5/13
    - Calendar day survival – overwintering bugs live half as long as summer adults
    - Most reproduction occurs soon after collection
    - Conclusion: Methodology appears to have predictive potential; reproductive periods agreed with observed, better than development model. Potentially more informative model than that based solely on developmental thresholds. Model predicts survival and reproduction of overwintered females for most of the season. Almost no females

classified as summer generations were fertile. If there was a 2nd generation in 2012 it was very small and partial

- Electronic SB feeding monitor.
  - Built structure to determine feeding patterns of male, female and nymphs, determine seasonal patterns and examine how environment shapes feeding behavior
  - SB will stick stylet through the screen and feed on the bean. Each time it feeds a circuit is completed.
  - Possible future uses of this technology is insecticide bioassay, feeding stimulants and feeding deterrents
- Biocontrol Work
  - Sentinel Egg Work. Objective – determine parasitoid diversity and rank
    - Problem they face is growers will not allow fresh viable egg masses in the field
      - Solution is freezing the egg masses and making them sterile
      - If you keep them cool they will last almost 7 days. If they get a lot of heat they start to degrade and a fresh egg mass is only good for about 24 hrs
      - 6% parasitism on sentinel egg masses
- 2012 hazelnut feeding damage trials.
  - All stages of hazelnuts tested appear to be susceptible to feeding damage
  - Damage is very similar to other tree nuts by other members of Pentatomidae
  - Trends observed suggest early season feeding can result in corking and necrosis
  - Will repeat trial in 2013
- Tainted wine
  - Will BMSB in grapes taint wine?
  - Taint likely depends on the process. A triangle test was done on the high quality Pinot Noir grapes and low amounts of BMSB taint had a negative impact on Pinot Noir quality

Southern Region
Presented by: Jim Walgenbach
North Carolina State University
Department of Entomology

Summary:

- Southern regions affected
  - 2007 Mississippi first detected BMSB on pear trees
  - 2010 Tupelo Mississippi,
  - 2012 Hancock Mississippi,
  - 2012 three detections in Texas. A student going to college in VA carried them back to TX in their car
  - Multiple detections in Florida. Important is that the detections have not become established yet

- Residential areas and the city of Birmingham Alabama, Atlantic Georgia, and Columbia SC have limited establishment
- Western North Carolina, Tennessee and Kentucky have an agriculture and nuisance problem
- Virginia has a severe problem spread throughout parts of the state

- Southern region sponsored BMSB projects
  - Southern Region IPM Program – NC and VT
    - Objectives:
      - Quantify stink bug species diversity, abundance, phenology, and natural enemy complex in different habitats.
      - Evaluate damage caused by different life stages of BMSB to tomato and pepper.
      - Determine effects of different insecticides on BMSB, and develop guidelines for tree fruits and vegetable crops.
  - Voltinism study
    - Objective:
      - To determine the maximum number of generations that occurs at different latitudes.
      - Ovarian development can occur at 13-15 h day length; 14 h reported most often.
      - In 1012, colonies initiated with laboratory reared eggs placed in cages on date of 14-hr day length. In 2013, additional cage with overwintered adults
  - Biological Control of BMSB and Native Stink Bugs on Southern Region Organic Farms
    - KY, NC, TN and VA participating in USDA-OREI project
    - Sentinel egg masses deployed to assess parasitism and predation of BMSB eggs
    - Two crops and two farms per state
    - NC has expanded survey to include conventional farms, other crops, and non-managed habitats

North Central Region
Presented by: Matt Grieshop
Co-authors: Larry Gut, Mark Whalon and Earnest Delfosse
Michigan State University

Summary:

- BMSB was a late comer to Michigan and Ohio
  - Ohio 2012 blacklight and pheromone trials were set up in 12 counties
    - 1 county reported more than 300 BMSB blacklight captures in central Ohio
    - 3 southern counties reported 1-10 captures mostly in blacklight traps
    - 8 counties reported 0 captures
  - Michigan 2011-2012 blacklight, sweep net, limb jarring and attractant traps were set up in 12 counties

        - 1 BMSB was caught in a blacklight trap in 2012
    - Michigan 2013 projects include:
        - State-wide survey with traps
        - Multi-state pheromone trial in tree fruit
        - Natural enemy survey (OREI)
        - Classical biological project
- Experimental apparatus being tested
    - Will be setting up a video system to record sentinel egg mass in the field for a 48 hour period to see what is going on.
        - Questions:
            - What was the cost of the system you are using? *Approximately $650, the camera system was $100, the DVR $50, batteries $100 and $400 per channel.*
            - Have you used wireless camera? *Yes, but the bandwidth was too tight and we received ghost images. Single channel worked much better.*

Discussion Period

Summary:

- During this time the priorities were updated; remove priorities that have been completed, refine existing priorities and identify future priorities and key gaps in knowledge
    - Research Priorities
        - Removed 4 priorities
            - Identification of true pheromone
            - Generate methods and baseline for evaluation of resistance development
            - Host plants
            - Translation and synopsis of research to date from Asia
        - Changed 3 existing priorities
            - Define damage diagnostics, economic injury thresholds
            - Develop baseline insecticide toxicity data for resistance monitoring
            - Standardize multiple methods for screening of new insecticide materials
        - Added 7 new priorities
            - Develop forecasting models to BMSB risk to new areas
                - Determine why BMSB appears to not be present in coastal plain areas
            - Determine low and high temperature thresholds for all stages
                - *Question:* If temperature is too high then what happens to the eggs? Eggs don't hatch above 35° C.
                - *Discussion: China developed a prediction model based on temperature not host plant. VT currently working with MEX Chinese model to use weather data. So far it is grossly in error so they are overlaying altitude, host plant etc to develop this predictor. VT is working with 2002-*

2008 data so far. Intensity and year to year level of intensity. Still in question is "does it include weather patterns from various years" and "can you use following year environmental factors to give risk factor to growers?

- Determine the impact of elevation on overwintering sites
  - *Discussion: Thousands of BMSB are found at high elevation on top of ridge lines. Nothing nearby these sites. Example of geography at two sites in Virginia (Mt. Weather and National Zoo site). Peek days are same each year, same pattern of density of bugs year after year. Switzerland sees a similar pattern at a restaurant on top of a mountain.*
- Determine how far BMSB will travel to overwintering sites
- Develop economic models that include injury, monitoring and management costs
- Validate current physiology and phenology models in laboratory

- Extension Priorities
  - Changed 2 priorities
    - Deliver economic injury thresholds
    - Demonstrate field application techniques for chemical control
  - Moved #14 and 15 to Consumer Priorities
    - Evaluate efficacy of insecticides/killing agents for homeowners
    - Evaluate materials for home-garden and home-landscape protection
- Regulatory Priorities – no changes
- Consumer Priorities
  - Removed 6 priorities
    - Efficacy and deployment strategies of homeowner traps
    - Factors associated with selection of overwintering sites
    - Efficacy of traps or home-garden use
    - Timing of treatment for homeowners
    - Repellents (push/pull) for homeowners
    - Efficacy of treating exterior plants/landscapes
  - Changed 1
    - Define triggers for movement into homes
  - Moved 2 from Extension Priorities
    - Evaluate efficacy of insecticides/killing agents for homeowners
    - Evaluate materials for home-garden and home-landscape protection
  - Added 1
    - Development of IPM friendly management strategies

The Invasion of BMSB in Europe
Presented by: Tim Haye
Co-authors: Denise Wyniger and Tara Gariepy
CABI - Switzerland

Summary:

- BMSB were officially reported in Europe in 2008 based on material collected in Zurich in 2007. Original introduction was probably much earlier in the 1990's
    - A Swiss newspaper article from 2004 shows a picture of BMSB
    - Initially it was not recognized because it looked like a native *Rhaphigaster nebulosa* and has a similar ecology
    - 2006 numbers increased in houses and it was identified as BMSB
    - Possible causes are that it came in with a shipment from Asia or a US shipment from PA
        - Could it be a coincidence that in 1993 a Chinese garden was built at the Lake of Zurich with plants and material imported from China
        - In 1998 roof tiles of the temple were replaced with original material from China which BMSB could have come in with these shipments and projects from China
    - Since 2007 it had quieted down and no one looked into it again until 2012 when they decided to see what the population looked like in the area
    - Although present since 2004, first damage was reported in 2012 from pepper crops in the Swiss Canton Aargau
        - Private gardeners reported damage on cherries, almonds, apricots, nectarines etc.
        - Attracted to houses with balconies directed to the southwest, light painted walls, exposed houses on top of mountains and houses with plants growing up the walls (ivy, Japanese creeper)
    - It is not considered an economically important pest …yet
- The question is: *Why is H. halys only slowly spreading in Europe? Could native European parasitoids be the reason?*
- Current studies
    - Egg exposure of 62 egg masses in Switzerland no parasitism observed
        - Saw them sitting on egg masses but no parasitism observed
        - More than 11,000 eggs of 7 Pentatomids species were exposed in the CABI Switzerland institute garden
        - Laboratory no-choice tests with European parasitoids
        - Behavior observations - they attack but cannot development them
- Future Work
    - Ecological host range studies in China in 2013/2014
    - Testing of additional native European egg parasitoids
    - Exposure of *H. halys* egg masses in Europe will be continued
    - Phenology of BMSB in Europe
- Questions:
    - Do eggs die? *No they don't die, nymphs emerge*
    - What is the process of introducing exotic species into Europe? *It is extremely difficult. You must do a lot of testing and is a difficult process.*
    - Do the species that invade the homes spill over into the fields? *No, so far it has only spilled over into the forest habitat*

Plant Health Task Force of PROCINORTE: Activities in Mexico against BMSB
Presented by: J. Isabel Lopez-Arroyo
Co-authors: J.A. Quijano-Carranza, A. González-Hernández, M.L. Ramírez-Ahuja, E. Cortez-Mondaca
PROCINORTE, Mexico

Summary:

- Even though BMSB have not been detected in Mexico yet, they are taking a proactive approach by checking crops and wild life areas, parks and homes
- Resources for managing BMSB are slim
- BMSB is not ranked in the first 30 species that are a problem in Mexico. They rank 3rd in the second group of passive pests
- They are monitoring borders in Baja California Sur, Chihuahua and Tamaulipas Mexico
- Puerto Vallarta is a hot spot and they are afraid it will come to Mexico via boats from CA or FL
- Mexico has 8 host plants that BMSB are attracted to
- National Center for Biological Control will get involved if BMSB becomes a problem
- They currently monitor information from our StopBMSB.org website

2013 Update on BMSB Research Initiatives
Presented by: Hannah Fraser
Co-authors: Cynthia Scot-Dupree, Tara Gariepy, and Tracey Baute
Ontario Ministry of Agriculture
Ontario, Canada

Summary:

- BMSB is established locally in one area and probably others
- Interceptions as early as 1993 coming in through shipments from China or US campers crossing over the boarder
- 2010 found BMSB in Hamilton Ontario and continued to find them in 2011 and 2012
- Hamilton is a transportation corridor from Niagara Falls to Toronto
- 3rd instar nymphs found in July 2012 in her neighborhood
- Also found a lot of BMSB at Princess Point feeding on buckhorn. Homeowners are finding them and the press is starting to report finds
- Hotspot is currently in Hamilton and Burlington. Most finds were 2012 and winter 2013
- 2013 did have their most recent find in an agriculture area
- Concerned they are in more locations than just Hamilton area but the big concern is where?
- Research plan funded for 2013-2014
    - Assessing the distribution and abundance of, and patterns of host use by BMSB in southern Ontario;
        - Sentinel plants – known non-crop landscape hosts
        - Surveys in field and horticulture crops
            - Sweeps, beat trays, and nets

- Visual observations (including binoculars)
- Traps
- Based on Nik Wiman's work, OSU

- Identifying agricultural areas in southern Ontario at risk from BMSB impact;
  - Landscape factors conducive to population build-up and migration, abundance of seasonal hosts, overwintering sites, track movement of BMSB
- Inventory parasitoids and predators that are using BMSB as a resource. This will provide baseline data on the potential for augmentative biological control of BMSB in Canada.
  - Expose newly-laid sentinel egg masses of several stink bug species (non-BMSB!) on a weekly basis
  - Obtain parasitoids for morphological ID
  - Determine host-parasitoid associations (if any)
  - Collect BMSB egg masses to determine level of parasitism/ predation by native natural enemies
- Evaluation of new pheromone trapping system
  - Efficacy
  - Active space
  - Utility for early detection
- Public Outreach
  - Facilitate knowledge transfer on the status of BMSB in Ontario
  - Develop information for use in communications including websites (e.g., ontario.ca\stinkbug and stopBMSB.org)
  - Newsletters, tweets/blogs, conferences, online tools for IPM (e.g., CropIPM), outreach to traditional (i.e., grower)
  - Non-traditional (e.g., homeowner, botanical gardens, pest control companies and tourism) stakeholder groups.

Progress in Pheromone-Based Trapping
Presented by: Tracy Leskey
USDA-ARS

Summary:

- Data was collected from colleagues across the country
- 2012 field season
  - Black pyramid trap
  - Olfactory included three treatments
    - #10
    - 2) MDT
    - 3) unbaited control
  - Results
    - Early season
      - #10 attracted 13:1 over MDT Unbaited 2:1
    - Mid season

                - Nymphs captured greater number with MDT 19:1 over 8:1 with #10
                - Adults #10 11:1 over MDT 8:1
            - Late season
                - Adults very attracted to MDT 26:1 over #10 9:1
                - Nymphs attracted to MDT 14:1 over #10 4:1
- Dose response trial
    - Works well when dose is increased
    - Important note - you don't have to have a highly purified lure to have it work
    - Effect of synergist when combined with #10 saw an increase in bug captures
    - Saw good response with combination throughout the season
- 2013 field season
    - Comparing commercially available synergists in combination with #10
    - 21 states participating in the trial
    - Coordinated data so far seeing enhanced activity over #10 alone.
- Threshold studies
    - USDA and VT developing threshold for orchard crops. Setup with fruit block trap at each border and one interior. Residential woodlots, neighboring fruit block and row crops/pastures
- Dispersal from Overwintering sites
    - VT and USDA trying to answer 3 questions
        - Under what abiotic conditions (temperature), do BMSB become active?
        - What does the pattern of emergence from overwintering sites look like?
        - Do they respond to pheromone traps immediately after exiting overwintering sites?
    - Trap Type Study
        - Are capture patterns similar among ground-mounted standard 4-ft pyramid trap and smaller pyramid style traps deployed in canopies?
        - 4 trap types in season long trial in commercial orchards

Climate Driven Individual Based Model for Brown Marmorated Stink Bug
Presented by: Shi Chen
Co-authors: Anne Nielsen, Jody Timer, Shelby Fleischer, Michael Saunders
University of Tennessee

Summary:

- Key idea is tracking each individual BMSB versus tracking the population
- Pros and Cons
    - Pros
        - Track each individual explicitly (deal with distributions)
        - Incorporate interactions between individuals
        - Easy to visualize
    - Cons
        - Need to have comprehensive knowledge of the modeling system
        - Computational burden
- External environmental variable

    - Temperature is very important, it drives
        - Diapause Termination
        - Development Rate (Stage-Specific)
        - Mortality Rate
        - Fecundity
    - Photoperiod linked to
        - Diapause Induction
        - Diapause Termination (*unverified*)
    - Key processes.
        - Each process is temperature or photoperiod dependent
        - Each individual has specific time to development
- The model
    - Initialization
        - 1000 Overwintering (Previtellogenic) Adult
    - Simulation (in 1-day time step)
        - Degree day accumulation in each day for each adult
        - Determine life history transit, birth/death, etc.
    - Output
        - Individual adult life history trajectory
- Results
    - We see 2 generations using the data set in PA
- Questions still exist for the model
    - How to do model validation? Population in the field is hard to verify and want to hear suggestions to verify the model of population in the field

Tracing the Origin of U.S. BMSB
Presented by: Jiawu Xu
Co-authors: Dina Fonseca, George Hamilton, Kim Hoelmer, and Anne Nielsen
Rutgers University

Summary:

- First question is where are they from?
    - Native range: China, Taiwan, Korea and Japan
    - Invasion to the US: Allentown, PA in 1996; now in 40 states, confident it entered from Beijing
    - Damages: serious loss in agriculture, residential nuisance, erosion of local biodiversity
    - Control: insecticide application
- Need genetic marker
    - Genetic analysis – used mitochondrial genome (mtDNA sequences)
    - Sequence the gene
        - Cytochrome c oxidase II (COII)
        - 12S ribosomal RNA to control region (12S/CR)
        - Cytochrome c oxidase I (COI)
    - Haplotype distribution
        - Sequence 77 samples had 43 haplotype; 26 from China and 7 from Korea

        - Detected very limited gene flow in China only 5 were linked
        - Recovered two haplotypes in the US
- Relationship among populations
    - Genetic population - all populations from China, Korea and Japan are different
- Genetic Diversity
    - Native range: 43 haplotypes in 77 bugs
    - US: 2 haplotypes in 55 bugs
- Significant genetic differentiation in native range
- High genetic diversity in East Asia versus extremely low diversity in the US

BMSB in Grape and Raspberry: Research to Date
Presented by: Sanjay Basnet
Co-authors: Doug Pfeiffer, Tom Kuhar and Curt Laub
Virginia Tech

Summary:

- Most of the research of BMSB is focused on tree fruits and vegetables. Very few studies have been conducted on the impact of BMSB in grapes
- There is a potential to taint the taste of wine, but taint intensity fades away with the fermentation process
- Significant economic problem in vineyards in mid-Atlantic states
- In 2011, three different geographical locations were selected to investigate the distribution of BMSB in grapes
    - Northern Virginia, Southwestern Virginia and the Eastern shore
    - 3 vineyards were sampled in each location and three samples were taken at the border rows and middle rows
    - There was a significant difference in the abundance of BMSB with respect to locations
        - In northern Virginia, the highest population density of BMSB was found
        - Southwest Virginia, a very few number was collected
        - The Eastern Shore, no BMSB were found, but farmers have seen BMSB in vineyards
- Feeding preference and injury
    - BMSB move in early in as fruit matures, found BMSB usually in pairs
    - BMSB do have a preference to the white varieties versus the red varieties. It appears it's not white or red but the sugar content of the berry
    - Injury to berries was not found when the grapes were in pea-sized and versain stage
    - Saw some punctures when the berries were in pre-harvest stage. The white varieties had punctures in all the stages
- Raspberry in southwest Virginia
    - In 2012, found BMSB population had become established in raspberries
    - Adults collected were significantly higher than nymphs

BMSB Outreach: Recent Work and Your Counsel
Presented by: Keoki Hansen, Carrie Koplinka-Loehr and Chris Gonzales
Co-authors: Kevin Judd
Cornell University and Northeastern IPM Center

Summary:

- Keoki Hansen is working with Eric Day and conducted an outreach survey to get a baseline for seeing what growers want to know about BMSB.
- BMSB Survey Results
    - Identification
        - 37% properly identified both the adult and nymph BMSB; 56.9% identified either the adult or nymph; and 6.1% did not properly identify either.
        - 43.2% scouting for BMSB properly identified both the adult and nymph BMSB.
        - 42.9% using IPM properly identified both the adult and nymph BMSB.
        - Those able to identify BMSB reported greater percentage and amount of profit loss due to BMSB and were more aware of their losses
        - If BMSB are not properly identified then errors in reporting will be higher
    - Use of IPM tactics
        - There was more loss reported in both percentage and amount for farmers using IPM.
        - There was more loss reported in both percentage and amount for farmers that reported scouting for BMSB.
        - If any control tactics were used, the majority of reporters used sprays as their means of pest control, with only 5 reporting the use of traps and only 2 using biological sprays.
        - Those using IPM reported a greater number of damaged crops compared with those not using IPM.
        - Participants that reported using IPM indicted being stressed by the BMSB more often than those not using IPM.
        - The more aware you are the more aware of loss and aware of damage survey
    - Next Steps
        - Assess the possibility of administering another survey
        - Revise current survey, based on previous findings
        - Administer to only growers, farm managers and farm workers
        - Delete questions with low reliability (i.e. damage assessment)
        - Assess need for additional questions based on learning's from past year
        - Make survey shorter, shorten things up, reword survey
    - Questions
        - How many growers were surveyed? *800 growers and independent consultants. Mostly coming from VA and some from NY*
        - What portion of it was done in specialty crops? *It was done mostly in vegetables and some fruit.*

        - How did you determine if they could identify BMSB? *Pictures were used for them to look at. One had two correct answers and in the revision they will be separated out. Look alike was green stink bug and western conifer seed bug. Native brown should be used and spine solders bug. Do away with green stink bug.*
        - Will you be expanding to other crops other then specialty crops? *Eric Day volunteered to do it when he went out to grower meetings, but if everyone could take the survey when they go out it could expand the survey. Survey may have to be modified depending on the grower.*
        - Could it be put online so they could have more input? *When you go online growers may not access it versus going to the meeting and getting them to do it.*
        - Does the survey let them identify what commodity they are growing? *No, can change the survey according to fruit, vegetables or row crop growers.*
- Chris Gonzales
    - How to move forward
        - Website updating news updates, writing articles, featuring news issues
        - Working on map and keeping it up to date. Hawaii's on the map
        - Surveyed 50 PD/PIs - asked what media they are in contact with
            - 13 responses reporting
                - 7 workshops, symposia and conference papers
                - 50 media interviews, features, non-referred publications and media outlets
                - At least 35,000 people reached
        - Homepage updates on imagines and thumbnails
        - Articles
            - Tracking by spreadsheet to help keep organized
            - Put stories on facebook and twitter
        - Videos
            - Story placement trade public pubs, trade sites,
        - Statistics
            - stopBMSB.org unique visitors 11,894
            - stopBMSB.org pageviews: 42,454
            - NortheastIPM.org – BMSB Working Group pageviews: 4,508
            - YouTube views: 3,173
            - Twitter followers: 577
            - Facebook likes: 121
        - What do you want to see on website
            - Want to see more on chemical management of BMSB
            - Homeowner issues
            - Gardener information
    - Question: Do you see the profile of who is accessing the website? *Yes, but we can only see the state not the person.*
- Carrie Koplinka-Loehr
    - We are in the process of deciding how the host plant project could be most useful for everyone

        - Plan is to create an electronic version that can be downloaded on home or office computer. Is there any other way the document can be useful for you? Possibly could print a professionally document if you feel it is necessary.
        - It's important to know what BMSB are feeding on. There is a big difference of preference depending on the growth stage.
    - Questions
        - Homeowners are asking if there are any trees you recommend not to plant? I*n the article of designing stink bug-free landscapes, ornamentals are mentioned.*
        - How confident do you think homeowners will know the actual name of the plant? *Unfortunately there is not enough space to add pictures and homeowners will likely not know the scientific name of a tree or plant.*
    - Would like to produce an info-graphic on BMSB to drive home what it looks like, something like Ontario has produced. Info graphic illustration publication.
        - Recommend using a combination of things that emphasize what BMSB has versus what it doesn't have
    - Are there any other topics you want other then identification and management? Send your ideas to Chris Gonzales (cg496@cornell.edu) or Carrie Koplinka-Loehr (ckk3@cornell.edu)

Role of Gut Symbionts in Development of BMSB
Presented by: Christopher Taylor
Co-authors: Peter Coffey and Galen Dively
University of Maryland

Summary:

- Many true bugs (Hemiptera: Heteroptera) vertically transmit bacterial symbionts with their eggs for inoculation every generation, including BMSB
    - BMSB will smear on egg mass and nymphs will get it that way
- 1st generation significant delays in development without symbiont, 10 day delay between sterile and molt. Did not do well from 3rd instar
- Behavior results: when they hatch they sit clustered on the egg mass until they molt. Saw faster dispersal rate in the control group versus the sterilized group
- Conclusion BMSB relies on symbionts. When removed it sees manifestation in 1st generation not in 2nd generation
- Conclusion
    - BMSB is heavily reliant on its gut symbionts for development and survival
    - Deprival of its symbionts manifests itself biologically in the first generation and causes massive die off in as little as the second generation
- Questions still remain; does temperature affect symbionts which affect development and survivorship?

BMSB Rearing: Knowledge needed to maintain Consistent Colony Performance
Presented by: Galen Dively
University of Maryland

Summary:

- Colony rearing is an essential prerequisite in doing research on BMSB
- It requires sentinel eggs year round to do the research
- Currently there is no one designing experiments to optimize the method of rearing BMSB. There is a need to know the best possible method of rearing because the experiment will be going along fine and then something goes wrong with the colony.
    - Example is, it peaked at Christmas with 60 egg masses per day, lab reared, 30 cages 1/3 young nymphs and 1/3 adults
    - Gradually we saw a decline even though there had been no change in the process
    - In March started bringing in field collected post diapauses bugs
    - Kept field ones in separate cages
    - Was surprised to see the 2 field collected cages that were kept separated continued to lay eggs and their mortality rate was high versus the lab rearing cages
    - 2 lab reared cages, 40 egg masses in a cage, laid eggs for two weeks and then stopped
        - High mortality rate in lab reared , there may be too many bugs in a cage
- There are still many questions that need to be answered
    - What is optimum, what size cage should be used, split cages once they get more then 250 in cage?
    - What food sources should be used? Spanish peanuts work well in OSU experiment and Rutgers experiment. Carrots and apples are used. Sunflower seeds and soybean seeds. Dry figs and raisin. We need to test what is the best food source for maximum egg production.
    - Population from time to time needs to go through diapauses to reset themselves. Do they need to be replenished?
    - Give them dirty water versus tap water?
    - How do you store them?
    - Bugs with lower weight have died off. Should we feed them in the fall before they go to overwintering storage?
    - Have to watch how you grow the plants that you feed them also.
- Questions:
    - How many generations have you reared in the lab? *About 6 generations reared in the lab.*
    - What's the humidity? *65%*
    - Are pesticide related issues a factor for decline in colony? *Shouldn't be they are fed organic beans, greenhouse plants so feel pesticides shouldn't be an issue. No guarantee they are pesticide free but try and limit it.*

BMSB Parasitoids
Presented by: Elijah Talamas
Co-authors: Kim Hoelmer and Christine Dieckhoff
USDA-ARS

Summary:

- Historically it was divided into two families' platygastridae and scelionidae. Now it is treated as a single family, Platygastridae
- Taxonomy is the foundation for species identification
    - Naming and identification keys are done so people know what they are dealing with and minimize confusion and use of correct names. It is the basis of all other biological studies
- Platygastroid diversity largely unexplored
    - *Oreiscelio:* 4 → 19 species
    - *Trichoteleia:* 2 → 42 species
    - New World *Paridris*: 2 → 15 species
    - *Paridris neptha* species group 1 → 15 species
- Revision of East Palearctic Trissolocus
    - Multiple authors on subject but didn't look at other authors work when they did their work
    - Rarely examined holotypes
    - Stability of species names is dubious
    - Real species distributions is unknown
    - *Trissolcus* may be prone to over-description
- Status of the revision
    - All holotypes/lectotypes of *Trissolcus* (worldwide) in USNM have been imaged
    - 5 additional holotypes from East Asia examined/imaged
    - Additional type material in
        - St. Petersburg
        - Kiev
        - Lund
        - Hanoi
        - Vienna
    - All work associated with hymenoptera is located in an online database at Ohio State University
        - Phenology diagram shows when species are collected, can see by geographic area
        - Part of database designed for host association
        - Database automatically has history tool group and repositories
        - Images produced automatically goes into the data base. Once it's in the database you can search by name, area, cuid etc.
        - It can be made public or nonpublic

        - It can link images to another matrix and results created for all specimens and list of identifiers
    - Near future
        - Lucid Key to species of North America
            - Each species/character system illustrated with high resolution images
        - Freely available online
- Bar-coding specimens
    - Put barcode on each collected event and each specimen for tracking. It seems like a lot of work but essential to track specimen
    - Do you want OREI project to do the same barcoding? If you do not have your own unique methods use their method.
    - Data is going to be put in the database so it won't be lost

Update on Biological Control of BMSB with Asian Parasitoids
Presented by: Kim Hoelmer
Co-authors: Christine Dieckhoff
USDA-ARS

Summary:

- Diversity of information collected from Asia:
    - Last 6 years visited Japan, Korea and China and collected BMSB at a variety of locations.
    - Japan has cooperators that collect throughout the season and has a variety of Trissolcus species
- Looking at selection of species to provide molecular data
    - Interesting pattern correlates
    - Tree at top of list falls into several distinct groups but all are Trissolcus. Interestingly it is attached to other groups related species but different enough that may be another species. Value of making repeated collections
- Funding for host range evaluations:
    - Farm Bill funding (APHIS PPQ)
    - NIFA SCRI multi-institution BMSB grant
    - Collaborators:
        - University of Delaware
        - Florida Dept. Agriculture & Consumer Services, Division of Plant Industry
        - MSU – Michigan State University – Department of Entomology
        - Oregon Department of Agriculture
        - Oregon State University – Department of Horticulture
        - USDA-ARS Stoneville & Mississippi State University, MS
- Host specificity screening. OR CA MI DE MS FL screening
    - Standard test protocol for all collaborators
    - Parasitoid females used in the tests
        - 24 h old

        - Mated but naïve (no previous experience)
        - 24 h exposure to each egg mass
        - 20 replicates of each non-target species
    - Measures of host acceptability:
        - Attack rate (# eggs parasitized/egg mass)
        - Proportion of undeveloped parasitoids in eggs
        - Number of viable adult parasitoids emerged
        - Size of emerged parasitoids
        - Sex ratio (proportion adult males : females)
    - No Choice Test
        - 24 hr single egg mass of non-target species.
            - If there is an attack on an egg mass then they continue to do more testing
            - If there is not an attack then no further testing is required
        - No choice tests: no successful parasitism means parasitoids emerged out of eggs and came out versus parasitoids that did not emerge
    - Results
        - Some parasitism recorded. Some adults came out of egg masses so some level of parasitism.
        - *Euschistus servus* a non-target host was not attacked
- Questions:
    - Are you doing any field cage studies? *We can't do field studies because they need to be quarantined. We are gathering information as we are rearing them Consensus is they will overwinter in crevasses but have not see that in quarantine yet.*
    - Did you ever alternate non-target vs. target? *We have not done that but it's a good idea.*
    - Did you look at mortality? What percent of non-target was killed? *There are some cases of mortality rate. The size of host eggs may make a difference.*
- Further assessments
    - Choice Tests
    - Behavioral Observations
        - Searching Behavior (role of plant texture, chemical cues etc.)
        - Patch Residence Times & Leaving Tendency
        - Oviposition Behavior
        - Intra- and Interspecific Competition
    - Role of Parasitoid Physiology
        - Effect of parental experience & physiology on host choice behavior
        - Effect of host choice on offspring (sex ratio, fitness, size)

Regulatory Update
Presented by: Clayton Myers
Environmental Protection Agency

Summary:

- Good news - bifenthrin has been re-authorized and is registered for a lot of uses
    - Apples and peaches have to go state by state
    - Sample residue much higher and made risk assessment worse. Toxicologist found a way to apply a processing factor which decreased the risk. 2013, 7 states and 7 areas in NY have been accepted
    - Trying to get more sampling from PDP for more balanced sample in apple
    - Since it was granted earlier in the season there should be more time for more samples to be collected
    - Hopefully in a few years bifenthrin can be registered without having to go state-by-state
- Moving forward more complicated to add new pesticide uses. Need to figure out best way to assess risk with insecticides. Turn around maybe slower than in the past.
- Additional states may be added in future, think of priority for peaches, apples or certain states. Be aware of where severe crops are and if you need to use a new chemical let EPA know if you are thinking about section 18

BMSB Imaging using Stacking Software
Presented by: Benedict Pagac

Summary:

- Why do we want imaging? Vector born diseases were the focus at first. They wanted to come up with a low cost and practical use for medical importance. Instead of sending a specimen to a specialist they could have an electronic way to see it. Took several items and married them all together. It was important to get a high resolution image.
    - This process may be something the BMSB researchers would like to use
- Use of a digital camera on a rail that moves and is controlled by a controller
    - It takes stacking imagines and stitches them together
- The camera moves and takes picture while the object stays in place
- The military is looking at a smaller item and have the specimen move versus the camera
- You can set up your own system for approximately $5000
    - Camera — Canon EOS 5D MarkII [$2.6k]
    - Macro Lens — Canon Manual 60 mm 1-5X (MP-E65/2.8) [$1k]
    - Macro Flash — Canon Twin Lite MT24EX [$700]
    - StackShot Rail — 1.4 by Cognisys, Inc (www.cognisys-inc.com) [$525]
    - Zerene Stacker — V1.04 (www.zerenesystems.com) [$280]
    - Styrofoam Cooler — approx 15”W x 16”D x 13”H [$6]
    - Misc: camera-rail interface cord, black fabric, clay, pins [$100]
- Questions: What is the smallest thing you’ve photographed? *2mm, some as small as heads off of bees.*
- How did the 2mm images look? *It still needs to be worked on for a clearer picture.*

- Would the BMSB image be made available for us to use? Yes, there are no *restrictions for your use.*
- How do you mount them? *This is the time consuming part, superglue a pin on their back, photo chopping to get rid of the pin.*
- Can you image vertically in alcohol? *They are looking at how to take pictures of specimens suspended in hand sanitizer. It is in the works.*