Assessing the Invasiveness of the Asian Brown Marmorated Stink Bug

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Invasion ecology is the study of how organisms spread into non-native habitats so as to better understand the invasiveness of species and the invasibility of habitats. Since 2008, the Asian invasive Brown Marmorated Stink Bug (BMSB), Halyomorpha halys (Stål), has advanced from Mid-Atlantic States northward to the lower and Mid-Hudson Valley and at present, through much of the central regions of the state. It was first recognized as a household novelty, quickly becoming an established and yearly urban nuisance, yet slowly and steadily developing into an agricultural pest in the southeastern region of New York. This insect is but one of the many invasive organisms that in recent years has been transported from various parts of the world to the United States, establishing, spreading and often threatening our natural, urban and agricultural landscapes. Over the past three years we have attempted to track the spread of the brown marmorated stink bug, to determine its presence in both the urban and agricultural environment, while following its growth and potential impact on the NYS tree fruit industry.

Urban Monitoring Efforts

A Citizen Science Study (CSS) was launched in 2010 to determine the presence of BMSB in urban environments. The overall objective of the study was to use urban collections of the insect, derived from submitted samples by CSS participants to determine the evolving spread of the insect through NY State. Specimens obtained from man made structures were submitted as live specimens by post or by digital imagery via e-mail, confirmed by Hudson Valley Laboratory entomologists and assigned zip code designations and GPS coordinates. Over the past three years, specimens were collected from sites throughout the state, from the central and western regions of the state with highest concentrations of the pest predominately in the mid and lower Hudson Valley.

The rise in urban BMSB populations and the insect’s predisposition to overwinter in homes has escalated its importance as an urban nuisance pest. The yearly emigrations of BMSB to the urban environment begins in the early fall, after the insect has fed intensively on fruit and seeds during late August, then entering homes to find dry shelter for the long winter. During the overwintering phase the insect diapause reduces activity in cold temperatures, becoming active as temperatures increase, relying only on stored reserves to survive the long winter. The BMSB migrate out of the home and back to the natural environment during the following spring, as they actively seek their way out of overwintering sites and back to plant hosts. The onset of these yearly cycles, incite homeowners to find urban pest management solutions, often leading them through internet search engines to participate in the CSS and contribute BMSB specimens to the study.

Our requests for NY based citizen science submissions of BMSB specimens began in March 2011 with regional newspaper articles on the presence of the insect moving to the urban environment, which included fact sheet based descriptive text and image of the insect along with a web site printable form for details on date, location and mailing address. During the first year we received 232 ‘live’ submissions almost exclusively from the Hudson Valley Region. The following spring we received 460 specimens from 87 distinct zip code locations, of which 90.6% of the specimens were confirmed as BMSB. Statewide outreach during the spring and fall of 2011 began through radio, web based news channels, television spots and blog site outreach, encouraged ‘Citizen Scientists’ to send images from GPS enabled ‘Smart Phone’ imagery or digital photography via e-mail. From these communication channels we received specimen submissions of 126 images, predominately from central and western NY, from 67 distinct zip codes in 24 counties. Surprisingly these specimens had a lower confirmed BMSB rate of only 71.0%. Central NY submissions had a significantly higher rate of non-BMSB urban complex pests, comprised predominately of box elder bug Boisea trivittatus and western conifer seed bug Leptoglossus occidentalis.

A summary of the data representing a timeline of confirmed BMSB submission locations can be found at the Hudson Valley Regional Tree Fruit link to the BMSB site: http://hudsonvf.cce.cornell.edu/bmsb1.html.
To date, the Citizen Science Study data has collected and verified BMSB specimens from 33 NY counties. The data from this study has verified the presence of the insect in NYS with increasing populations of BMSB in homes since its first detection in 2008 (Figure 1). Hudson Valley participants perceived a 71% increase over the previous year (N=62).

As BMSB populations escalate and spread, the insect’s presence is being detected in the mid and lower Hudson Valley along agricultural borders of susceptible commodities that include tomato, pepper, sweet corn, pome and stone fruit, grape and small fruit. (Figure 2).

**Agricultural Monitoring in 2012**

To determine if BMSB was present in the field we began by conducting intensive monitoring of the pest in a statewide effort in 2011. The lure that had been used in the mid-Atlantic States at that time, methyl (E,E,Z)-2,4,6-decatrienoate (MDT), was derived from the male-produced pheromone of another pentatomid common in eastern Asia, Plautia stali Scott, is attractive to BMSB and was commercially available. Using this lure we set 72 Tedders traps throughout the tree fruit, grape and vegetable growing regions of NY. Yet only a single site capturing BMSB in September of that season, in a field of green pepper in Marlboro, NY. The lack of trap based field captures in 2011 led us to begin intensive surveys for BMSB in hedgerow, woodland understory and deciduous tree foliage from the ground and using a trailed lift to obtain upper canopy presence data. During border evaluations we also scouted the perimeter rows of tree fruit and vegetable commodities. Simultaneously, we employed a variety of trapping methods to compare trap captures with field observations that included black light trapping, which provided significant adult and nymph captures during the middle of the season (Figure 3). These survey observations demonstrated the seasonal presence of BMSB along the agricultural woodland interface. Among the border plants monitored for BMSB during the growing season, the highest numbers of BMSB were observed on 7 plant species including Tree of Heaven, American sycamore, Aspen / Popular, Eastern black walnut, Russian Olive, Staghorn Sumac and White Ash (Figure 4). Highest numbers of BMSB were observed feeding and developing on the female *A. altissima* fruiting clusters. In one of three monitored orchards where the BMSB was found to exist on *A. altissima*, it did not migrate to feed on tree fruit, remaining on *A. altissima* until its migration to overwintering sites. It’s also important to note that on farms where the Tree of Heaven was absent from deciduous woodlands or hedgerows, BMSB can successfully complete multiple generations using a variety of hosts. In two sites where these conditions occur we found adults emerging from arboreal habitat late in the growing season moving into tree fruit to feed intensively on apple late in the season.

The BMSB is known to be predominately an arboreal, tree-inhabiting insect. It has been observed on hundreds of plant species in US surveys conducted over the past 15 years with a diverse feeding host range (Neilson 2009). In the Hudson Valley of NY one tree host stands out as an important point source for BMSB population growth. The tree species, *Ailanthus altissima*, or ‘Tree of Heaven’ is also an Asian invasive species, found to harbor high populations of BMSB throughout the growing season. Our partnership with the Heritage Foundation, CCE PRISMs and iMapinvasive has provided access to develop mapping displays that now represent the presence of *Ailanthus altissima* relative to *Halyomorpha halys* in their ecological presence throughout NYS (Figure 5). In 2012 the BMSB was observed completing two distinct generations on *A. altissima*, utilizing this tree species as a reproductive host for egg laying and as a food source for developing nymphs (Figure 6).

Trapping this insect along agricultural borders now employs a Tedders trap baited with a newly developed pheromone synthesized by USDA known as the #10 lure along with the synergist, methyl
(E,E,Z)-2,4,6-decatrienoate (MDT). The lure combination has been found to be very effective at capturing the overwintering BMSB adult weeks earlier than our intensive observational surveys of host plants or black light traps (Figures 7 & 8). The native green stink bug (GSB), Chinavia hilaris (Say) and Harlequin bug, Murgantia histrionica (Hahn), both Pentatomidae in the family Hemiptera, are also attracted to this lure.

Over the past two years we also employed light trapping methods to determine the Pentatomidae complex. The use of season long black lights, often used in sweet corn trapping of Lepidopteran insects, provides us with comparative weekly BMSB captures. However, to determine the stink bug complex in an 8-hour period we use a 4000k tower light positioned in the horizontal position to attract the insect at night. Placing insecticide treated netting between the light and commodity will lure insects into the net, killing them during the trapping period onto which they land on a white plastic sheet at the base of the net for assessment. To determine the stink bug complex in an orchard where fruit feeding injury was observed, we sampled a block of Red Delicious in two consecutive nights, on the 8-9th of September, using a high intensity light. The placement produced 30 BMSB and 37 GSB along the perimeter rows of the apple block. On the following night the trap was placed in the interior of the orchard with only 3 BMSB and 10 GSB captures (Figure 9 & 10). The high intensity survey results provided stink bug species information to determine the optimum insecticide for use in tree fruit. Efficacy and insecticide information can be found on the Hudson Valley Regional Tree Fruit website (http://hudsonvf.cce.cornell.edu/resources/Tree Fruit/NY BMSB Insecticides Efficacy Update 8-9-13.pdf).
Field and Pack-out Assessment of Fruit Injury in 2012

On a commercial farm in Orange County, NY, the first BMSB adults to give rise to economically damaged fruit were observed by IPM scouts on the 27th of August. Feeding injury became evident by early September in Red Delicious and by mid September in Pink Lady. Pheromone and light traps were set, with subsequent captures of the stink bug complex began on the 8th of September. Traps were maintained until the first week of November when harvest was over and BMSB had completed its movement to overwintering sites (Figure 10).

In damage assessments used to determine stink bug injury, fruit was considered to be injured by stink bug if darkened depressions, containing one or more feeding sites or ‘holes’ from the insertion of the insect rostrum and or evidence of a ‘feeding tube’, was present. These sites, in conjunction with corking, are collectively symptomatic of pentatomid feeding as described in the literature. Figure 11). Our first harvest evaluation of BMSB fruit injury was conducted in field-run Golden Delicious on the 5th of October in Milton, NY. Fruit grown in a 5-acre block surrounded by wooded hedgerow and woodlots were harvested into bins and evaluated to assess the extent of BMSB feeding injury, randomly selected from three representative bins. A 1000 fruit sample was rated for BMSB feeding site injury, finding 24%, 54% and 68% feeding injury in each of three bins averaging 48.7% fruit loss (Figure 12).

In our second evaluation of BMSB fruit injury, field evaluations of ‘Pink Lady’ were made on the 16th of October (Figure 13). A five
A 5-acre block of field-run Golden Delicious in Milton, NY averaging 48.7% fruit loss.

Figure 13. Stink bug feeding injury to Pink Lady fruit.

Figure 14. Field evaluations of BMSB injury to a 10-acre block of ‘Pink Lady’ showing high degree of stink bug feeding injury concentrated along the wooded edge in plot 1 (far left) with entire block averaging 21.2% fruit loss.

A 10-acre block of ‘Pink Lady’ fruit injury showing a high degree of stink bug feeding injury concentrated along the wooded edge in plot 1 (far left) with entire block averaging 21.2% fruit loss.

Figure 15. Pack-out evaluations of BMSB fruit injury to Red Delicious using GeoSort software in a Greefa sorting and packing line.

Figure 11. Evaluation of a 5-acre block of field-run Golden Delicious in Milton, NY averaging 48.7% fruit loss.

In our third evaluation of BMSB fruit injury, pack-out evaluations of Red Delicious fruit were made in Walden, NY on October 30th. From 52 bins, 100,556 fruit were graded using GeoSort software with iQS (intelligent quality sorter) in a Greefa sorting and packing line.

A 10-acre block of trees in their 5th leaf on M-9 rootstock, spaced within the row at 3’ intervals with 11’ drive rows averaging 9.5” in height were assessed within the center two rows and outside perimeter rows, all running North and South in the block. For each row evaluated we began along the wooded edge of the block, assessing 100 fruit from 10 trees in 30’ of row in each of 9 plots toward the center of the block, totaling 3600 fruit. ‘Pink Lady’ fruit injury averaged 21.4% throughout the entire block (Figure 14).

In our third evaluation of BMSB fruit injury, pack-out evaluations of Red Delicious fruit were made in Walden, NY on the 30th of October (Figure 15). From 52 bins, 100,556 fruit were graded using GeoSort software with iQS (intelligent quality sorter) in a Greefa sorting and packing line for external imaging characteristics. From this lot, 15 bins or 31,300 fruit were rejected for external damage, comprising a 31.1% loss. Of the damaged sorted fruit sent to juice, three representative bins were evaluated to determine the extent to which BMSB feeding was the causal agent, with 100 fruit evaluated from each bin. From these samples 97%, 90% and 93% of the fruit exhibited BMSB feeding injury, representing 29,212 fruit loss or 29.1% overall BMSB loss from this block.

**Trap Tree Research**

The principle of trap cropping rests on the fact that virtually all pests show a distinct preference to certain plant species, cultivars, or a certain crop stage. Manipulations of the trap crop in time and space so that attractive host plants are offered at the critical time in the pest’s and / or the crop’s phenology lead to the concentration of the pests at the desired site, the trap crop. Of the border trees and shrubs we monitored in two orchard locations throughout the 2012 growing season, the ‘Tree of Heaven’ harbored the highest BMSB populations in field surveys. To better understand the potential of employing trap trees to reduce BMSB populations, we conducted a trap tree study using injected and implant insecticides to ‘Tree of Heaven’ during the 2012 growing season to determine the potential efficacy of this approach. All life stages were found inhabiting the female *A. altissima* fruiting clusters till the end of the tree fruit-growing season during our monitoring efforts.

The ‘Tree of Heaven’ acts as a significant food source for BMSB adults and nymphs. Insecticide treatments made to the *A. altissima* during the onset of each generation would target the most susceptible life stage, the early instar nymphs that feed on foliage and seeds. ‘Tree of Heaven’ can grow to 60’ in height, making them poor candidates for foliar applications. However, injection and or implants insecticide technologies are already in use by the commercial ornamental tree industry. There techniques are a practicable approach to BMSB pest management when compared to spraying the canopy or making soil injections, where off target drift or soil water contamination can be a concern. Treatments to *A. altissima* that effectively reduce BMSB populations in the tree canopy could reduce BMSB populations before they move into agricultural crops, sustaining the health and attractiveness of the tree for subsequent BMSB generational development and sustained seasonal management. The long-range goal of this approach is to reduce insecticide loading in the orchard late in the season when BMSB cause the most fruit injury and when residue on fruit becomes a greater concern, while preserving non-target beneficial insects that tend to be highest late in the season.

To conduct a preliminary study on the effectiveness of insecticide injections and implants in ‘Tree of Heaven’ we made applica-
Results of hanging trap capture showed highest numbers of dead BMSB in trees injected with Acephate compared to Acephate implants and untreated trees. Bioassay results comparing mortality of adult feeding on two treatments or untreated foliage of A. altissima, demonstrated highest levels of mortality feeding on Acephate injection tree foliage (45%) compared to Acephate implants (41%) and the untreated trees (14%). Both injection and implant of Acephate declined rapidly in efficacy 4 weeks after treatments. This preliminary study provides evidence to support the use of trap trees such as A. altissima to reduce BMSB populations bordering agricultural commodities when managed using insecticide implants or injections.

Future Study of the Brown Marmorated Stink Bug

Developing BMSB Presence Thresholds: We plan to intensively trap for this insect pest in 2013 in specialty crops throughout NYS. We will partner with 17 CCE cooperators and 5 Cornell faculty members to employ black light, high intensity light and Tedders traps. We will be using the USDA #10 lure and MDT synergist, in 35 commercial farm locations in 15 counties placed in vegetable and fruit growing regions of NY. Weekly collections of data submitted by cooperators will be hosted by the Eastern NY Horticultural Team and displayed on the Hudson Valley Regional Fruit web site (http://hudsonvf.cce.cornell.edu/bmsb1.html) to provide real time observations of BMSB captures throughout the season and on-demand viewing by agricultural producers.

‘Passive Trapping’ System Development: In the spring of 2013 we are planning to deploy a ‘Passive Trapping’ system for the BMSB. We recently employed the use of high intensity lights covered with insecticide treated netting to capture adult BMSB along the edge of orchard. This provided a fast, very effective method of discerning the population density and composition of the stink bug complex. However, the use of 15’ netted strips along the edge and interior of the orchard without the use of attractants will provide data on the movement of the insect into and throughout the orchard, to assist us in providing management decisions for producers as BMSB migration begins.

Trap Cropping: We will continue studying the efficacy of injected and implant insecticide applications to the non-native tree, Tree of Heaven, Ailanthus altissima, for use as a trap crop. We plan to incorporate lures to the trees to draw BMSB into trees for greater attractiveness and population reduction. Ultimately, our goal in this project is to reduce the population of the invasive brown marmorated stink bug along agricultural crop borders where risk from this insect is greatest, while reducing the need for late season insecticide use to manage the BMSB.

Trap and Kill Strategies: In addition to trap crop studies, we will incorporate high intensity lighting and pheromone lures, established along the orchard perimeter, to pull insects from the crop, exposing them to large surface areas of insecticide treated netting for population reduction assessments.

Literature Cited

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