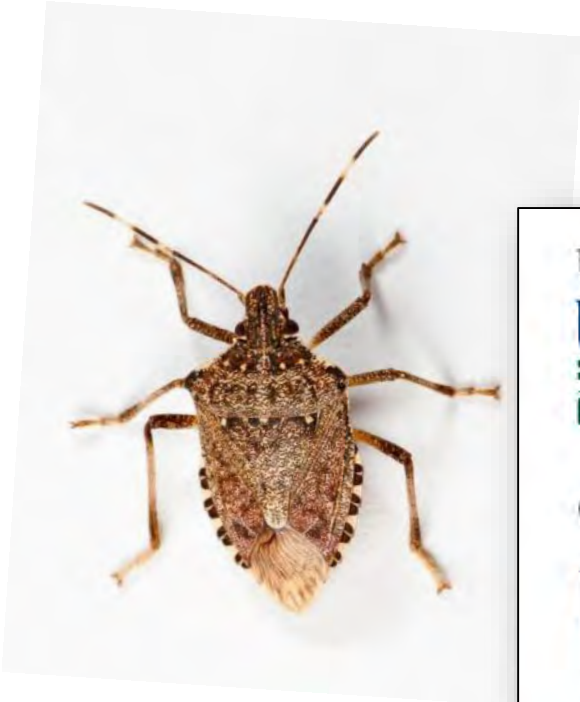


# Subobjectives 2.2.5. Asian Natural Enemies



Funding



United States  
Department of  
Agriculture

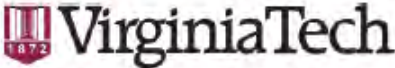
National Institute  
of Food and  
Agriculture

Specialty Crop Research Initiative  
Grant #2011-01413-30937

Collaborating Institutions



Cornell University



# Host Range Evaluations– A team effort to fast-track the evaluation process

## Funding for Host Range Evaluations:

Farm Bill funding (APHIS PPQ)

NIFA SCRI multi-institution BMSB grant

## Collaborators:

USDA-ARS (Newark, DE & EBCL, France)

University of Delaware (D. Tallamy)

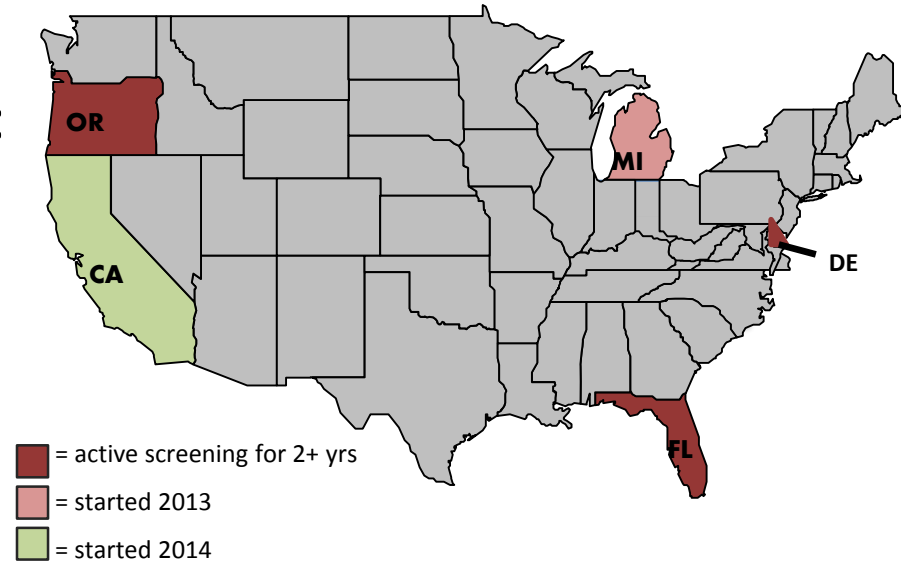
Florida Dept. Agriculture & Consumer Services, Division of Plant Industry (T. Smith)

MSU – Michigan State University – Department of Entomology (E. Delfosse)

Oregon Department of Agriculture (H. Rogg)

Oregon State University – Department of Horticulture (V. Walton, P. Shearer)

University of California, Riverside & CDFA (M. Hoddle, C. Pickett)





# Asian *Trissolcus* spp.



**30+ parasitoid populations at ARS BIIR**  
maintained for host range and efficacy testing

China:     ***Trissolcus japonicus (halyomorphae)***  
                  (Beijing 2007, Beijing 2009, Nanjing 2009)

Japan:     ***Trissolcus mitsukurii*** (Tsukuba 2007)  
                  ***Trissolcus japonicus (plautiae)*** (Tsukuba 2007, 2012)  
                  ***Trissolcus cultratus (near flavipes)*** (Tsukuba 2007, 2012)  
                  ***Trissolcus itoi*** (Tsukuba 2012)

S. Korea:   ***Trissolcus japonicus (plautiae)*** (Seoul 2009, 2010)

# The potential biological control agent - *Trissolcus japonicus*


**Quarantine population tested:** Originally recovered from the Beijing area from *Halyomorpha halys* egg masses

- **Solitary egg parasitoid** of Pentatomidae
- **Short development time**
- **~ 10 generations/year**
- **Female-biased sex ratio**
- **High parasitism rates in *Trissolcus japonicus*** compared to other *Trissolcus spp.* reported in Asia

**Disclaimer: The Data Presented in this slide are Preliminary Data !**

## Host Range Evaluations: Progress

62 non-target host species have been tested nationwide so far



22 species  
completed

40 species in progress

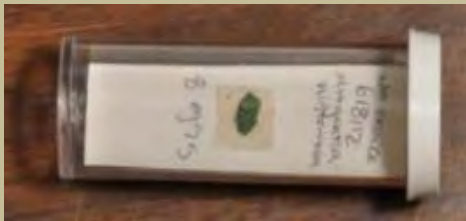
**Disclaimer: The Data Presented in this slide are Preliminary Data !**



# No-choice Screening



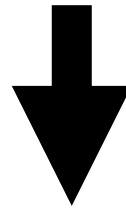
Single egg mass of non-target species:



Followed by a BMSB control for an additional 24h:



**no attack  
of non-  
target**



**no  
further  
testing  
required**

### Pentatomidae

| Genus                 | Species                |
|-----------------------|------------------------|
| <i>Alcaeorhynchus</i> | <i>grandis</i>         |
| <i>Brochymena</i>     | <i>quadripustulata</i> |
| <i>Coenus</i>         | <i>delius</i>          |
| <i>Cosmopepla</i>     | <i>lintneriana</i>     |
| <i>Edessa</i>         | <i>bifida</i>          |
| <i>Euschistus</i>     | <i>ictericus</i>       |
| <i>Euschistus</i>     | <i>quadrator</i>       |
| <i>Homaemus</i>       | <i>proteus</i>         |
| <i>Loxa</i>           | <i>viridis</i>         |
| <i>Mormidea</i>       | <i>lugens</i>          |
| <i>Mormidea</i>       | <i>pama</i>            |
| <i>Nezara</i>         | <i>viridula</i>        |
| <i>Oebalus</i>        | <i>pugnax</i>          |
| <i>Perillus</i>       | <i>strigipes</i>       |
| <i>Piezodorus</i>     | <i>guildinii</i>       |
| <i>Proxys</i>         | <i>punctulatus</i>     |

### Non-Pentatomidae

| Genus              | Species          | Family        |
|--------------------|------------------|---------------|
| <i>Corimelaena</i> | <i>lateralis</i> | Thyreocoridae |
| <i>Corimelaena</i> | <i>pulicaria</i> | Thyreocoridae |
| <i>Eurygaster</i>  | <i>alternata</i> | Scutelleridae |
| <i>Homaemus</i>    | <i>proteus</i>   | Scutelleridae |
| <i>Megacopta</i>   | <i>cribraria</i> | Plataspidae   |
| <i>Sehirus</i>     | <i>cinctus</i>   | Cydnidae      |

**Disclaimer: The Data Presented in this slide are Preliminary Data !**



# Choice Screening

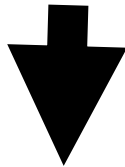
## Pentatomidae

| Genus                | Species              |
|----------------------|----------------------|
| <i>Amaurochrous</i>  | <i>cinctipes</i>     |
| <i>Banasa</i>        | <i>euchlora</i>      |
| <i>Banasa</i>        | <i>dimiata</i>       |
| <i>Chinavia</i>      | <i>hilaris</i>       |
| <i>Chinavia</i>      | <i>marginata</i>     |
| <i>Chlorochroa</i>   | <i>ligata</i>        |
| <i>Chlorochroa</i>   | <i>uhleri</i>        |
| <i>Edessa</i>        | <i>florida</i>       |
| <i>Euschistus</i>    | <i>conspersus</i>    |
| <i>Euschistus</i>    | <i>servus</i>        |
| <i>Euschistus</i>    | <i>tristigmus</i>    |
| <i>Euschistus</i>    | <i>variolarius</i>   |
| <i>Euthyrhynchus</i> | <i>floridanus</i>    |
| <i>Holcostethus</i>  | <i>abbreviatus</i>   |
| <i>Holcostethus</i>  | <i>limbolarius</i>   |
| <i>Loxa</i>          | <i>flavicollis</i>   |
| <i>Murgantia</i>     | <i>histrionica</i>   |
| <i>Neottiglossa</i>  | <i>undata</i>        |
| <i>Perillus</i>      | <i>bioculatus</i>    |
| <i>Podisus</i>       | <i>maculiventris</i> |
| <i>Stiretrus</i>     | <i>anchorago</i>     |
| <i>Thyanta</i>       | <i>custator</i>      |



B. T. Cutting

When attack of non-target hosts observed



One egg mass each of target and non-target species together :

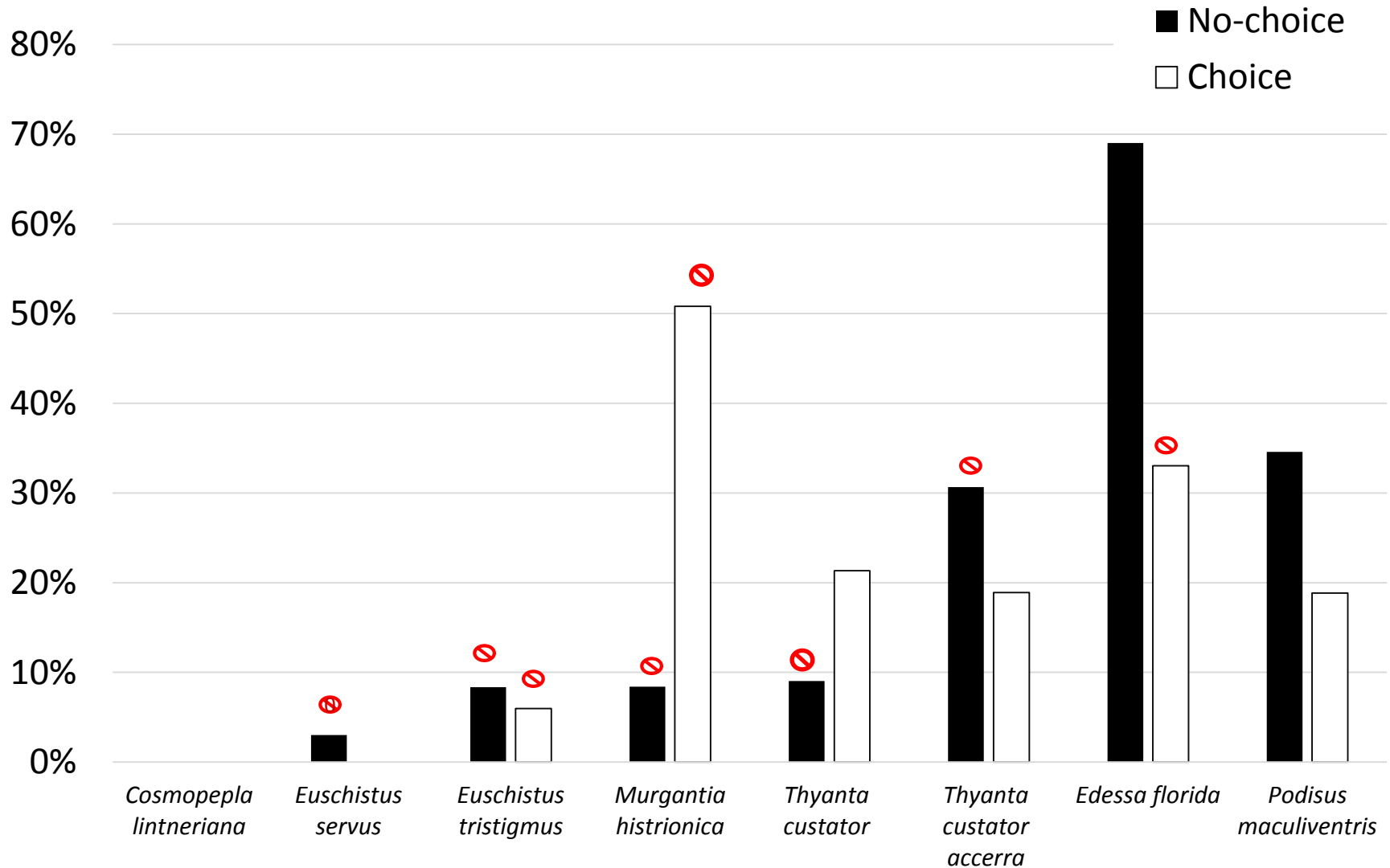


## Non-Pentatomidae

| Genus               | Species        | Family               |
|---------------------|----------------|----------------------|
| <i>Orsilochides</i> | <i>guttata</i> | <i>Scutelleridae</i> |

**Disclaimer: The Data Presented in this slide are Preliminary Data !**

Fate of Non-target Egg mass - No-choice vs. Choice Test



⊘ = no live offspring



# A Closer Look at Host Choice Behavior in *T. japonicus*

## Influence of arena



- **Size**
  - 10 dram
  - 100 dram
  - 500 dram
  - 1000 dram
  - 2000 dram
- **Complexity**
  - Choice tests on plants

## Role of parasitoid physiology & experience



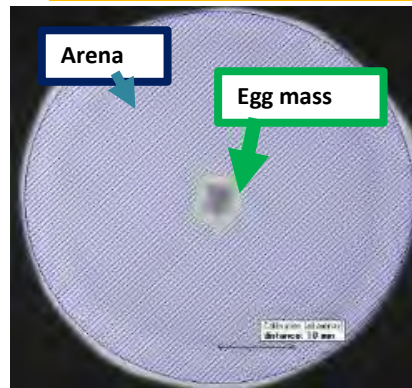
- Parental experience
- Parental physiology
- Effect of host choice on offspring physiology & behavior

## Influence of time of exposure



- 1 h
- 4 h
- 6 h
- 24 h

## Behavioral observations



- Searching behavior
- Oviposition behavior
- Host choice
- ...

## Olfactometer Studies (FL, MI)



# Ecological Host Range of *T. japonicus* in Asia – K.A. Hoelmer



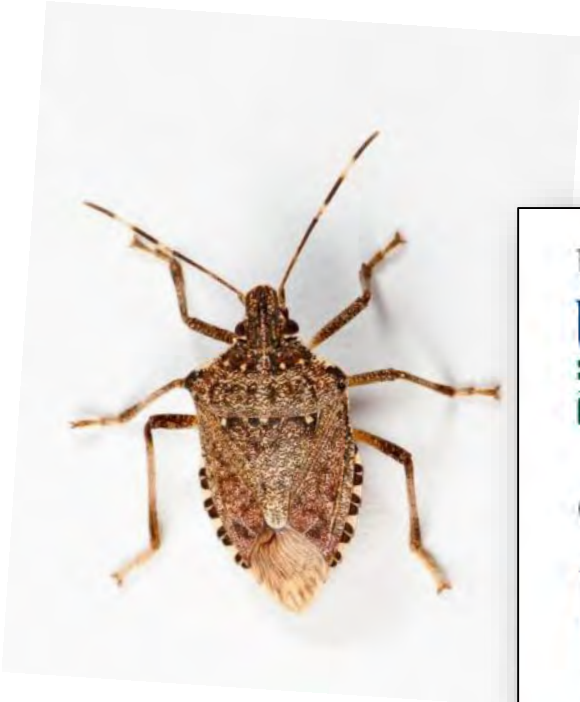


Study the ecological host range of *Trissolcus japonicus* in Asia – Tim Haye (CABI)

# Summary

- Classic host range tests:
  - with *T. japonicus* are almost completed
  - tests with additional populations and/or species have begun (DE – 13 populations/species; FL – *T. cultratus*)
  - results show that *T. japonicus* is oligophagous under laboratory conditions AND non-target species are often less-preferred and/or less-suitable than BMSB
- Additional choice test experiments designed to resemble more natural conditions have been initiated ( most regional collaborators)
- Field studies in Asia will be continued to determine *Trissolcus*' realized (ecological) host range

# Subobjective 2.2.6. Native Natural Enemies



### Funding



United States  
Department of  
Agriculture

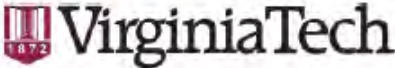
National Institute  
of Food and  
Agriculture

Specialty Crop Research Initiative  
Grant #2011-01413-30937

### Collaborating Institutions



Cornell University



## Surveys to assess BMSB parasitism by native species and habitat diversity

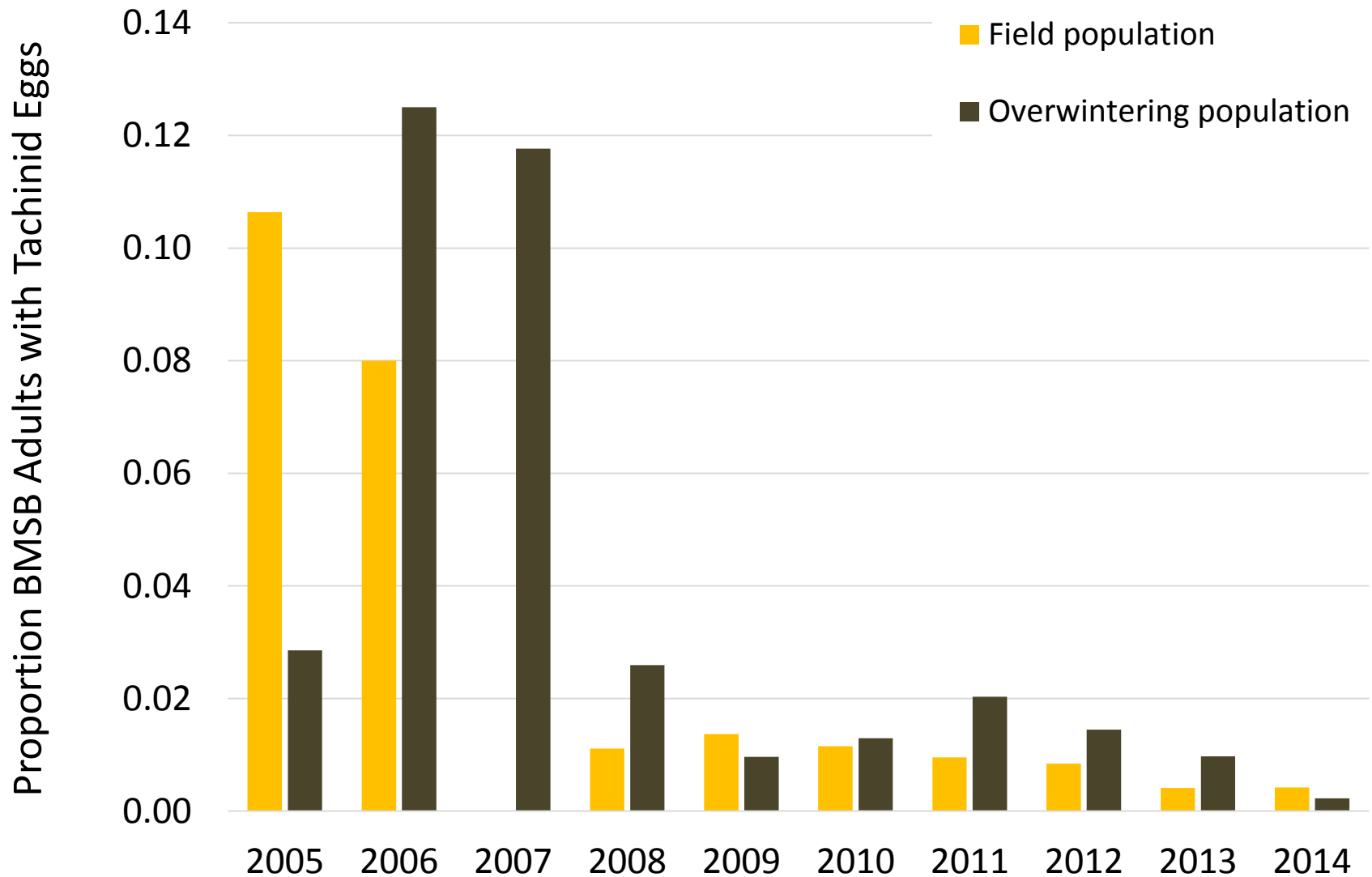
- North Carolina
- Delaware
- Maryland
- Oregon
- Pennsylvania
- Virginia

**Overall results: Native parasitoids have variable levels of activity but are not as effective in regulating BMSB populations in US as we would like**

# B SMB Predators and Parasitoids - Summary

| Order       | Family (subfamily if applicable) | Species                       | <i>H. halys</i> Life stages | Locality   |
|-------------|----------------------------------|-------------------------------|-----------------------------|------------|
| Araneae     | Arachnida                        |                               | Eggs, Nymphs, Adults        | MD, OR, PA |
| Coleoptera  | Coccinellidae                    | <i>Harmonia axyridis</i>      | Eggs                        | PA         |
| Dermaptera  | Forficulidae                     |                               | Eggs                        | PA         |
| Diptera     | Tachinidae                       | <i>Trichopoda pennipes</i>    | Adult, Late instars         | PA         |
| Hemiptera   | Anthocoridae                     | <i>Orius sp.</i>              | Eggs                        | MD         |
|             | Geocoridae                       | <i>Geocoris sp.</i>           | Eggs, Nymphs                | MD, OR, PA |
|             | Reduviidae                       | <i>Arilus cristatus</i>       | Eggs, Nymphs, Adults        | MD, OR, PA |
| Hymenoptera | Crabronidae                      | <i>Astata unicolor</i>        | Adults, Late instars        | PA         |
|             |                                  | <i>Astata bicolor</i>         | Late instars                | OR         |
|             |                                  | <i>Bicyrtes quadrafaciata</i> | Late instars                | PA         |
|             | Encyrtidae                       | <i>Ooencyrtus sp.</i>         | Eggs                        | DE, MD     |
|             | Eupelmidae                       | <i>Anastatus mirabilis</i>    | Eggs                        | DE, MD     |
|             |                                  | <i>Anastatus pearsalli</i>    | Eggs                        | DE, MD, PA |
|             |                                  | <i>Anastatus reduvii</i>      | Eggs                        | DE, MD, VA |
|             | Platygastridae (Scelioninae)     | <i>Gryon obesum</i>           | Eggs                        | MD         |
|             | Platygastridae (Telenominae)     | <i>Telenomus podisi</i>       | Eggs                        | MD, PA     |
|             |                                  | <i>Telenomus utahensis</i>    | Eggs                        | VA         |
|             |                                  | <i>Trissolcus brochymenae</i> | Eggs                        | DE, MD, VA |
|             |                                  | <i>Trissolcus edessae</i>     | Eggs                        | DE, MD, VA |
|             |                                  | <i>Trissolcus euschisti</i>   | Eggs                        | DE, MD, OR |
|             |                                  | <i>Trissolcus thyantae</i>    | Eggs                        | VA         |
|             |                                  | <i>Trissolcus utahensis</i>   | Eggs                        | OR         |
| Mantodea    | Mantidae                         | <i>Tenodera sinensis</i>      | Nymphs, Adults              | MD         |
| Neuroptera  | Chrysopidae                      | unidentified larvae           | Eggs, Early nymphs          | MD, OR, PA |

# DE (K. Hoelmer) – BMSB parasitism by Tachinidae (Diptera)





# Native Parasitism & Predation - Sentinel Egg mass Protocol

## In the field:



Sentinel EM clipped to leaf

Or

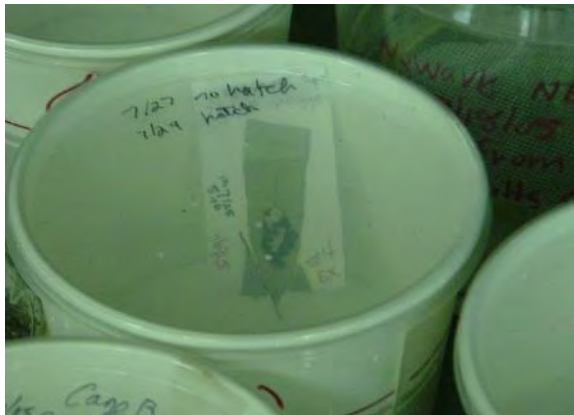


Sentinel EM sewn to leaf

➔ *Fresh egg masses  
or Frozen*

➔ *2-4d exposure  
in the field*

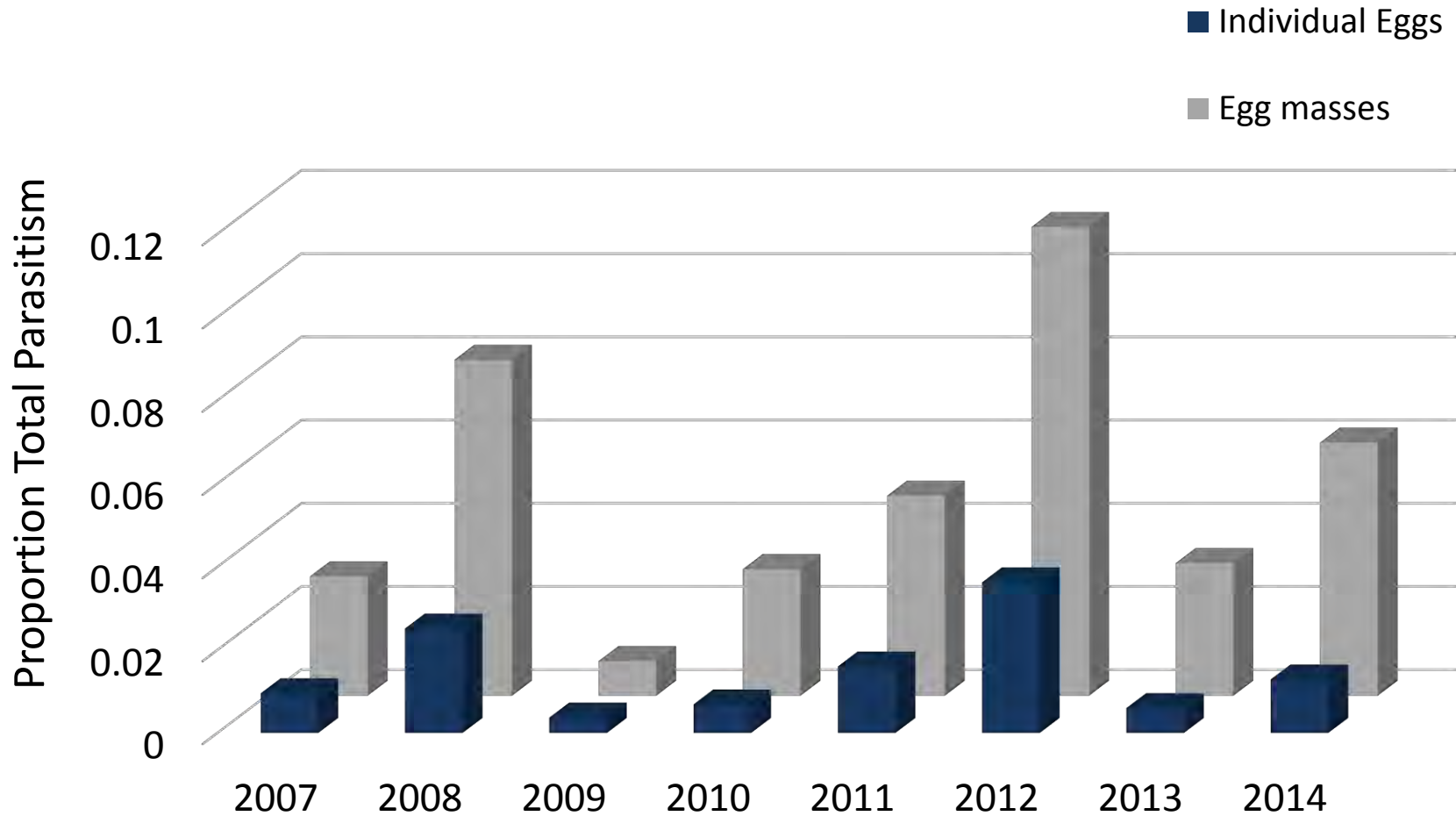
## Back in the lab:



*Record the following:*

- Parasitism rate
- Egg parasitoid species composition
- Classification of egg mass status  
(**Hatched**, **Missing**, **Unknown**,  
**Parasitized**, **Chewing Predators**, **Sucking  
Predators**, **General Predation**)

# DE (K. Hoelmer) – Sentinel Egg Mass Parasitism



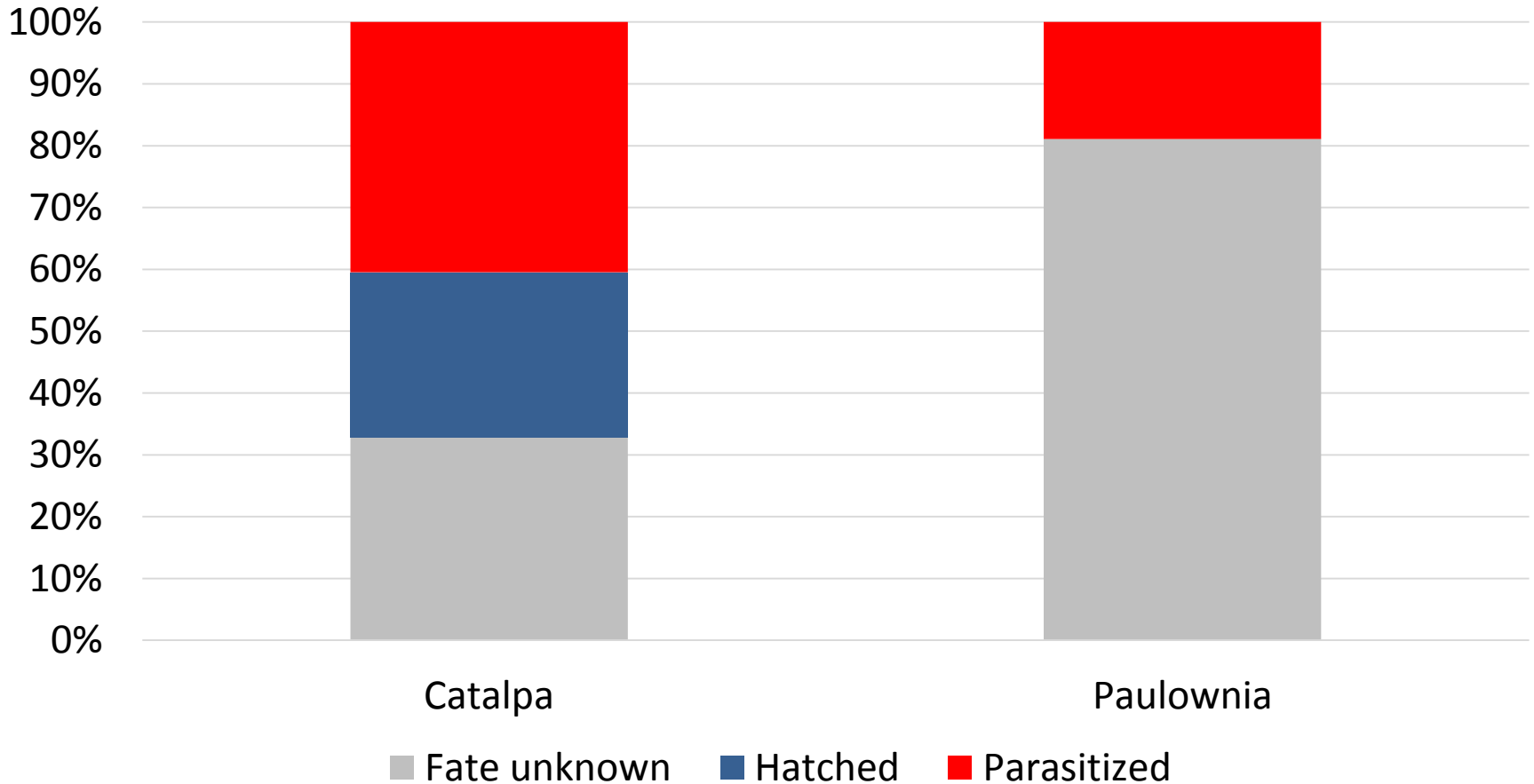
# OR (Jana Lee): Natural enemies in ornamentals



- Frozen sentinel eggs were exposed for 1 wk with/without cages.
- *Trissolcus euschistii* and *Telenomus utahensis* were found.
- June, July, August, Sept trials with 4 sites/host, 125 egg clutches.
- **Low parasitism compared to 2013 (3-35% of clutches)**

|               | % clutches para.<br>by <i>T. euschistii</i> | % eggs w/in clutch<br>para. | % clutches<br>pierced/chewed |
|---------------|---|-----------------------------|------------------------------|
| Cherry laurel | 0%  |                             | 63%                          |
| English holly | 6%  | 50%                         | 50%                          |
| Oregon grape  | 1%  | 18%                         | 40%                          |
| Red maple     | 1%  | 1%                          | 50%                          |

## VA (T. Kuhar) : Fate of Sentinel Egg masses on Different Hosts - 2014



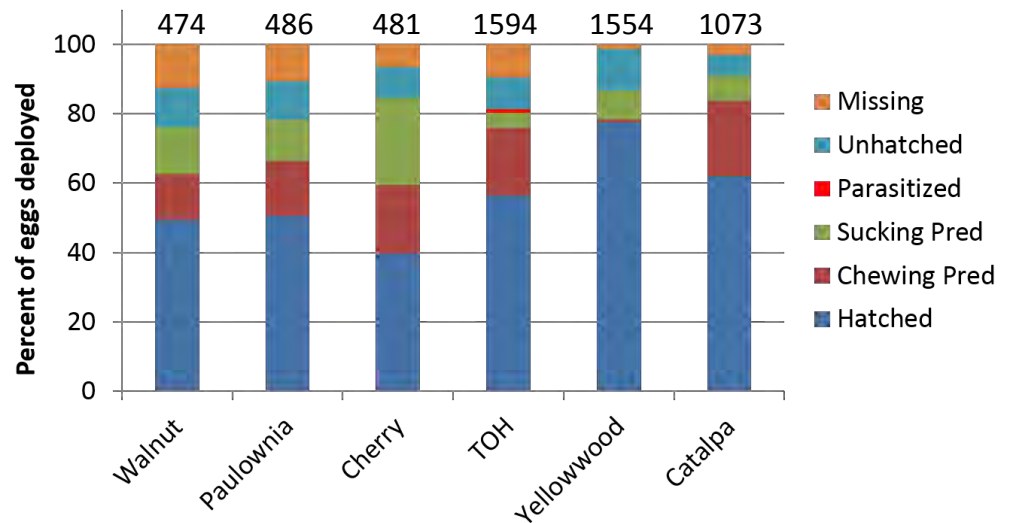
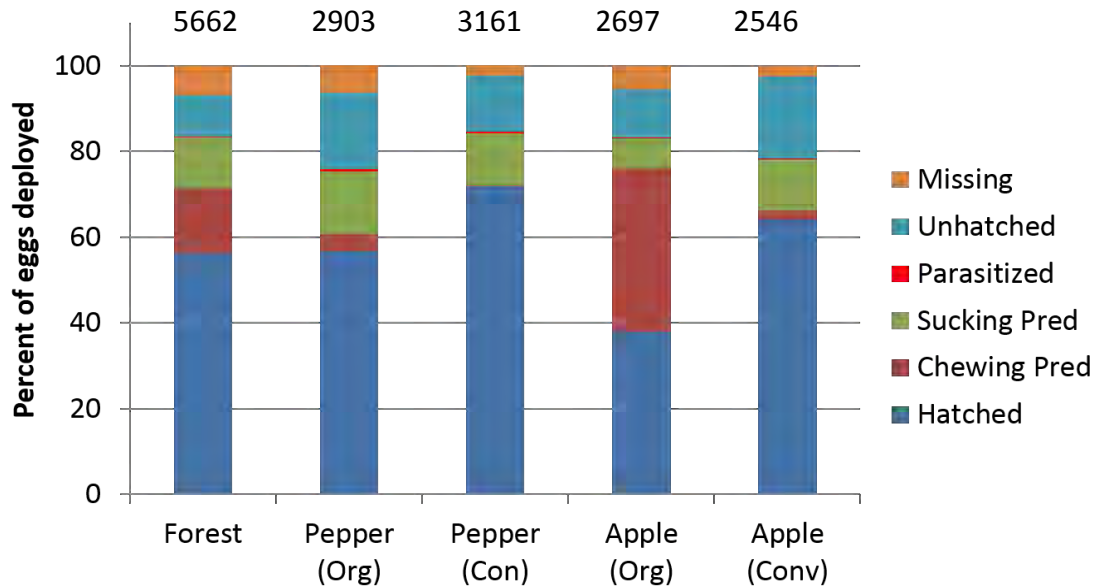
### **2014 - Species diversity and dominance:**

*Anastatus pearsalli* > *Anastatus* sp. (males only) > *Trissolcus brochymenae*

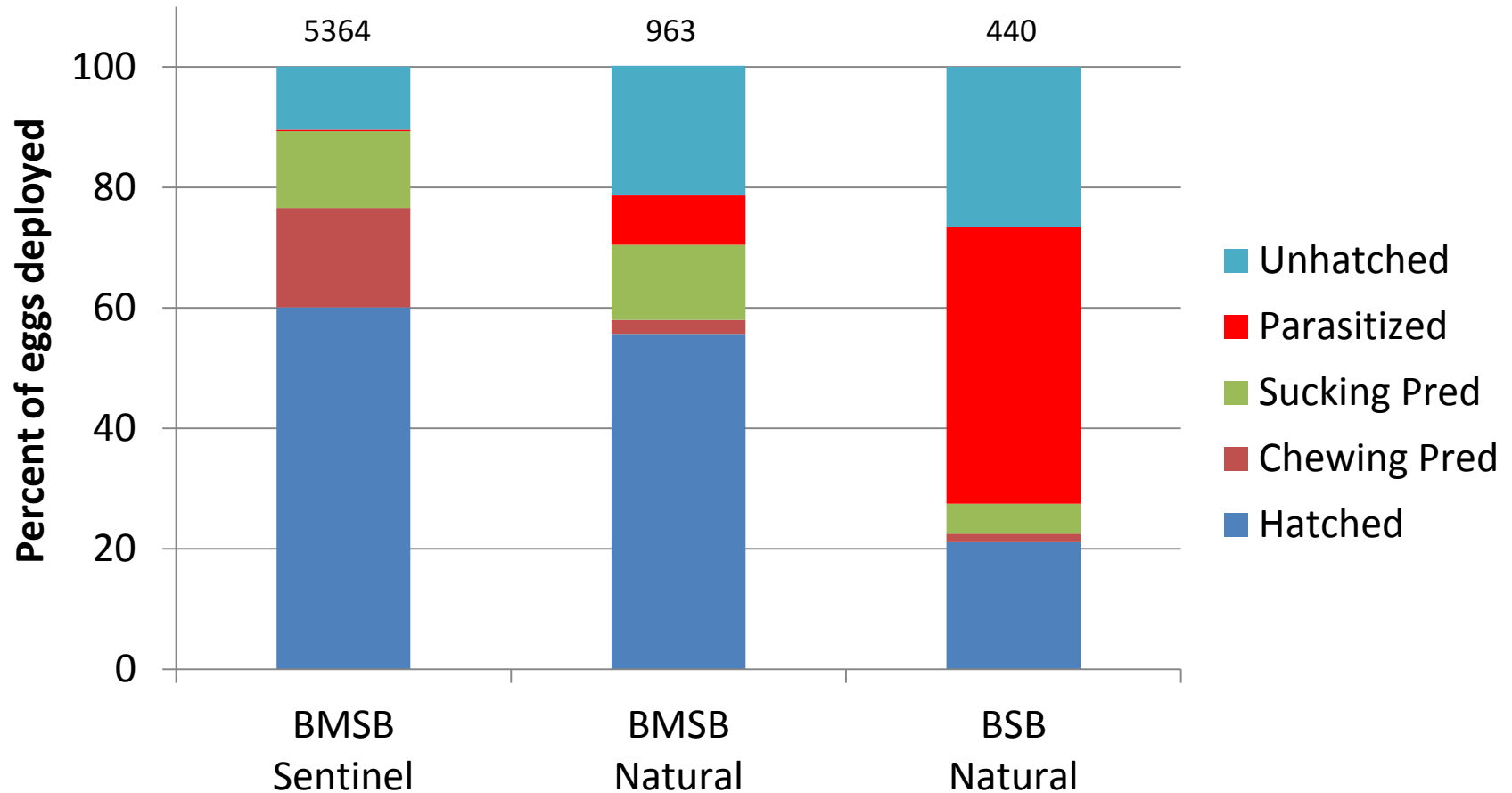
### **2013 - Species diversity and dominance:**

*Anastatus redivii* > *Trissolcus brochymenae* > *Telenomus podisi* > *Trissolcus euschisti*

# NC (J. Walgenbach): Fate of BMSB Sentinel Eggs in Different North Carolina Habitats



# Fate of Sentinel and Naturally Laid BMSB and Brown Stink Bug (BSB) Eggs in NC Forest Habitat





# Sentinel eggs underestimate rates of parasitism of the exotic brown marmorated stink bug, *Halyomorpha halys*



**Paula Shrewsbury,**  
**Ashley Jones, Michael Raupp,**  
**Cerruti Hooks, David Jennings**  
Department of Entomology,  
University of Maryland, USA

**BMSB SCRI**  
**December 2014**

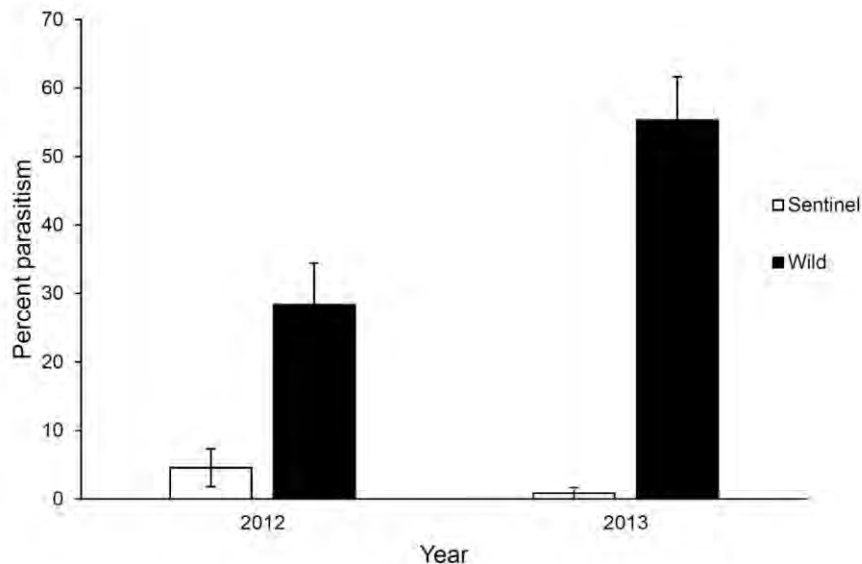
A.L. Jones, D.E. Jennings, C.R.R. Hooks, P.M. Shrewsbury, 2014. Sentinel eggs underestimate rates of parasitism of the exotic brown marmorated stink bug, *Halyomorpha halys*. *Biological Control*, 78: 61-66.



# Sentinel vs Wild Egg Masses

- **Summary**

- Wild egg masses had higher parasitism, parasitoid abundance and species richness
- *Anastatus reduvii* was the most common parasitoid species overall
- Sentinel egg masses underestimated parasitoid communities and impact in MD nurseries
- Wild egg masses should be used for estimating biological control impacts



**Table 1**

Total numbers of parasitoids collected from sentinel (laboratory-laid) and wild (naturally field-laid) brown marmorated stink bug egg masses by species.

| Family         | Species                         | Origin of eggs |      |
|----------------|---------------------------------|----------------|------|
|                |                                 | Sentinel       | Wild |
| Eupelmidae     | <i>Anastatus reduvii</i> ♀      | 13             | 636  |
|                | <i>Anastatus mirabilis</i> ♀    | 0              | 14   |
|                | <i>Anastatus pearsalli</i> ♀    | 19             | 90   |
|                | <i>Anastatus</i> spp. ♂         | 4              | 143  |
| Platygastridae | <i>Telenomus podisi</i> ♂       | 5              | 4    |
|                | <i>Telenomus</i> spp. ♂         | 1              | 1    |
|                | <i>Trissolcus brochymenae</i> ♀ | 0              | 1    |



# Biological Control Objectives for the SCRI Renewal

## Collaborators:

Paula Shrewsbury, Dept. of Entomology, UMD

Kim Hoelmer, Christine Dieckhoff – USDA-ARS & UD

**Overall obj.** - To predict potential impacts of release of exotic egg parasitoids on native parasitoids and BMSB survival

**Obj. 1** - To test interactions between exotic parasitoids and native parasitoid species on parasitism rates and BMSB mortality in laboratory experiments

- Additive
- Antagonistic
- Synergistic

**Obj. 2** - To link behavioral observations of adult parasitoids to egg fate



# Thank you for your attention!



Photo: Steve Valley