2.2.6 Native Natural Enemies of BMSB

Biological Control Team Participants and Participating Institutions:

University of Maryland – Cerruti Hooks (co-coordinator), **Paula Shrewsbury**

USDA ARS BIIR Delaware – Kim Hoelmer (co-coordinator), Christine Dieckhoff

Penn. State University – David Biddinger, John Tooker

USDA ARS Horticultural Crops Research Lab, Corvalis, Oregon – Jana Lee

Oregon State University – Peter Shearer, Nik Wiman

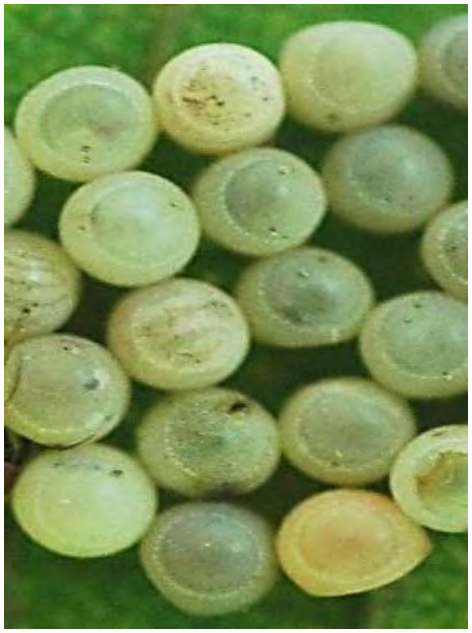
North Carolina State Univ. – Jim Walgenbach

Many graduate students, post docs, techs, stakeholders

Biological Control – U.S.

- **1st step before developing a biological control strategy:**
  - **Determine baseline data on native natural enemy activity**
- **Implement biological control approach**
  - **Conservation**
  - **Augmentation**
  - **Classical**

Biological Control
Ornamentals - MD



Main Objective

- Survey and identify native natural enemy activity in ornamental systems
  - BMSB egg mortality
  - Parasitoid complex and parasitism rates
  - Predator complex

Egg Mortality and Parasitoids: Methods

- Sampled three nurseries at regular intervals from late May through September 2012 and 2013


Photo by Steve Black


Photo by Ruppert Nurseries

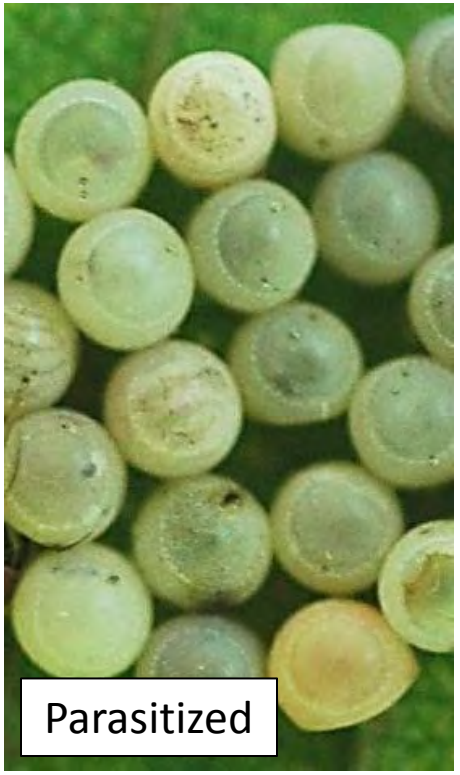
Egg Mortality and Parasitoids: Methods

- Visual searches of foliage on *Acer*, *Prunus*, and *Ulmus* for:
  - BMSB egg masses (natural)
  - Natural enemy activity

- Egg masses flagged and left in field for set time interval
  - Brought back to lab and monitored for mortality factors and parasitoid emergence
  - Growth chamber (25^{o}C, 16L : 8D)

No mortality

Mortality factors



No mortality

Mortality factors


Newly laid

2012: 897 egg masses; 24,124 eggs

2013: 1,208 egg masses: 32,076 eggs


Newly hatched


Hatched


Chewing predation


Parasitized

Percent BMSB Egg Mortality

Percent Egg Mortality

100
90
80
70
60
50
40
30
20
10
0

May 4 | June 1 | June 2 | June 3 | June 4 | July 1 | July 2 | July 3 | July 4 | Aug. 1 | Aug. 2 | Aug. 3 | Aug. 4 | Sept. 1 | Sept.2

Sampling Week

2012

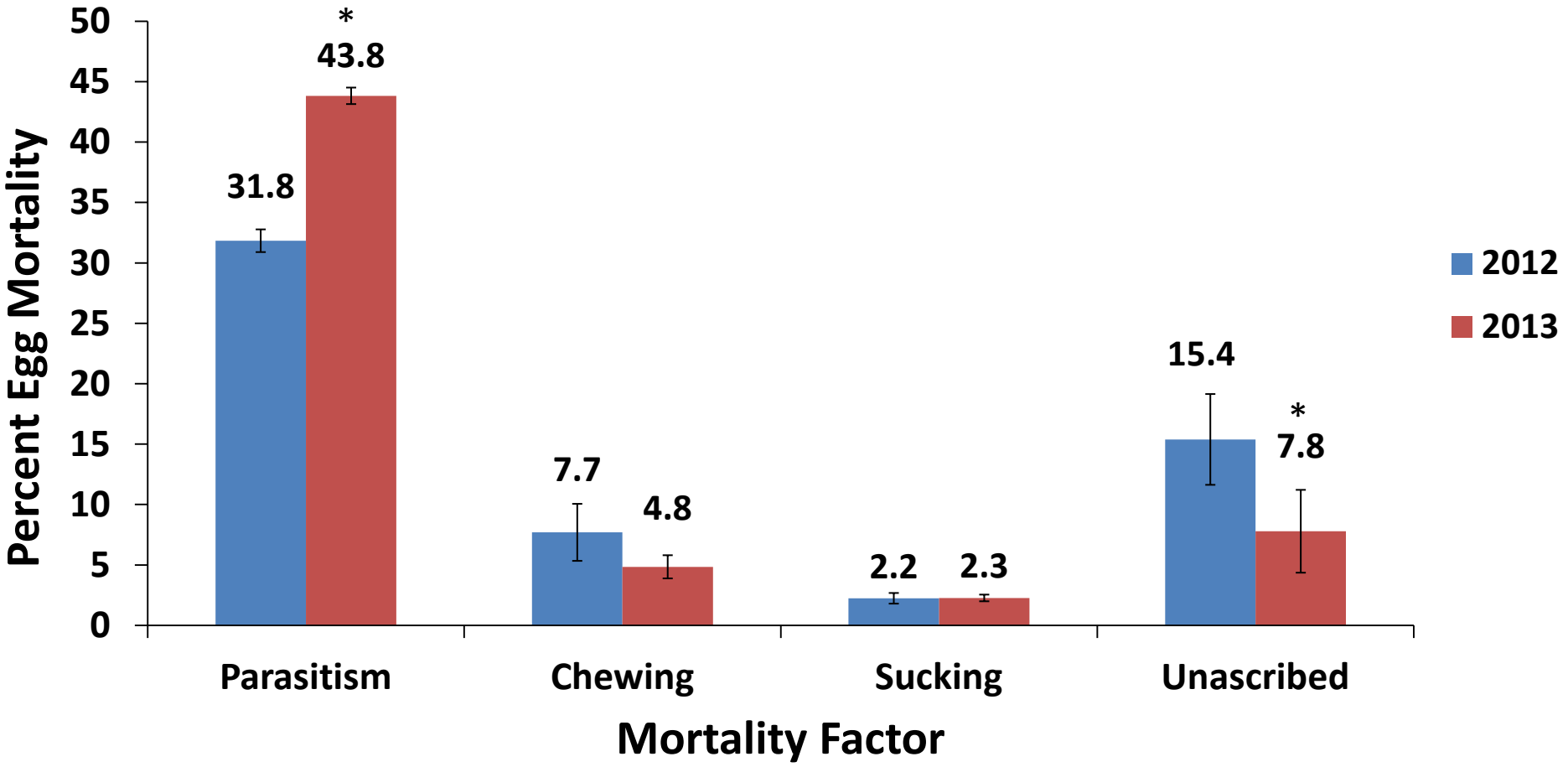
$R^2 = 0.8719$

2013

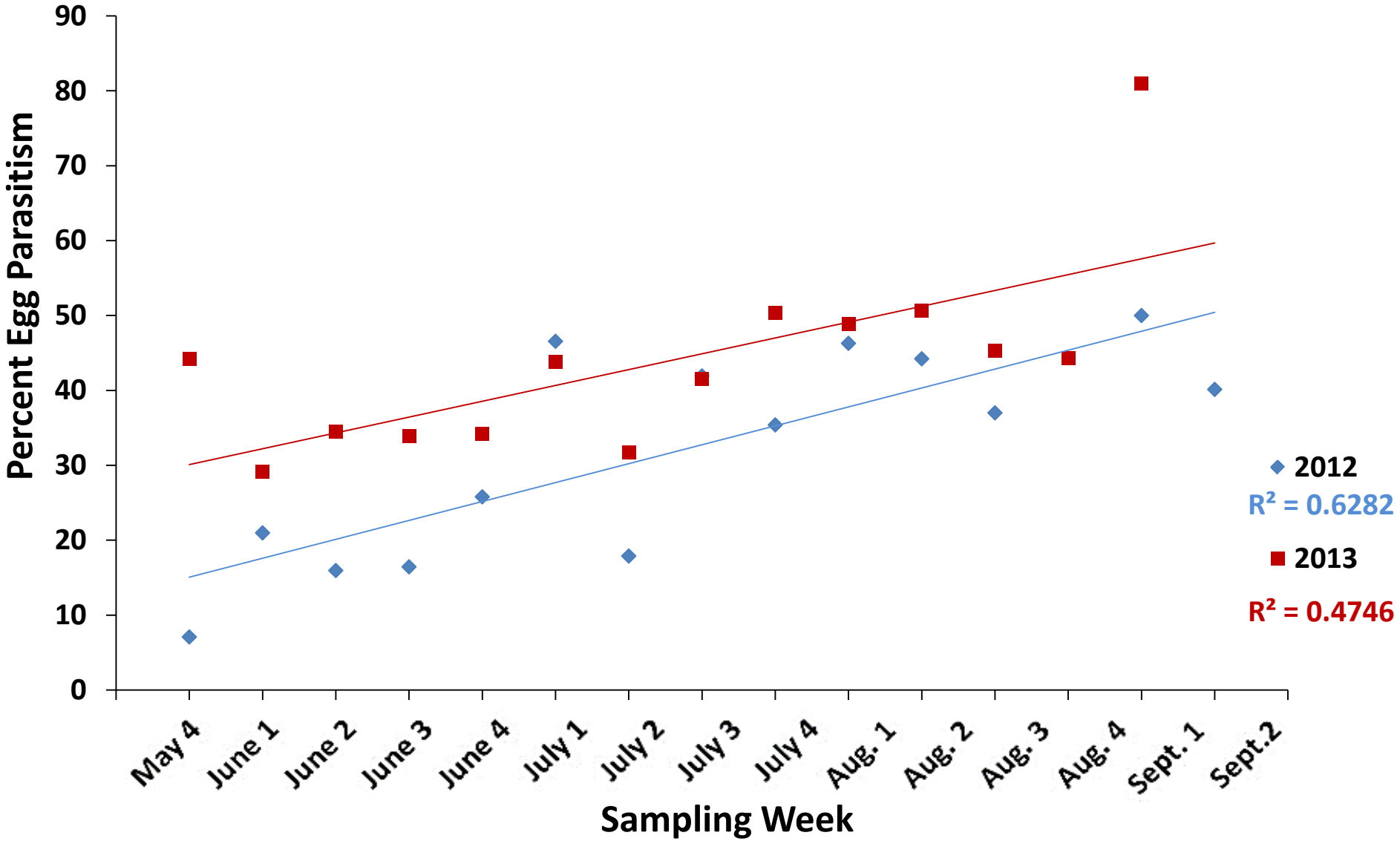
$R^2 = 0.6209$

BMSB Egg Mortality Factors

Total Mortality ~ 58%

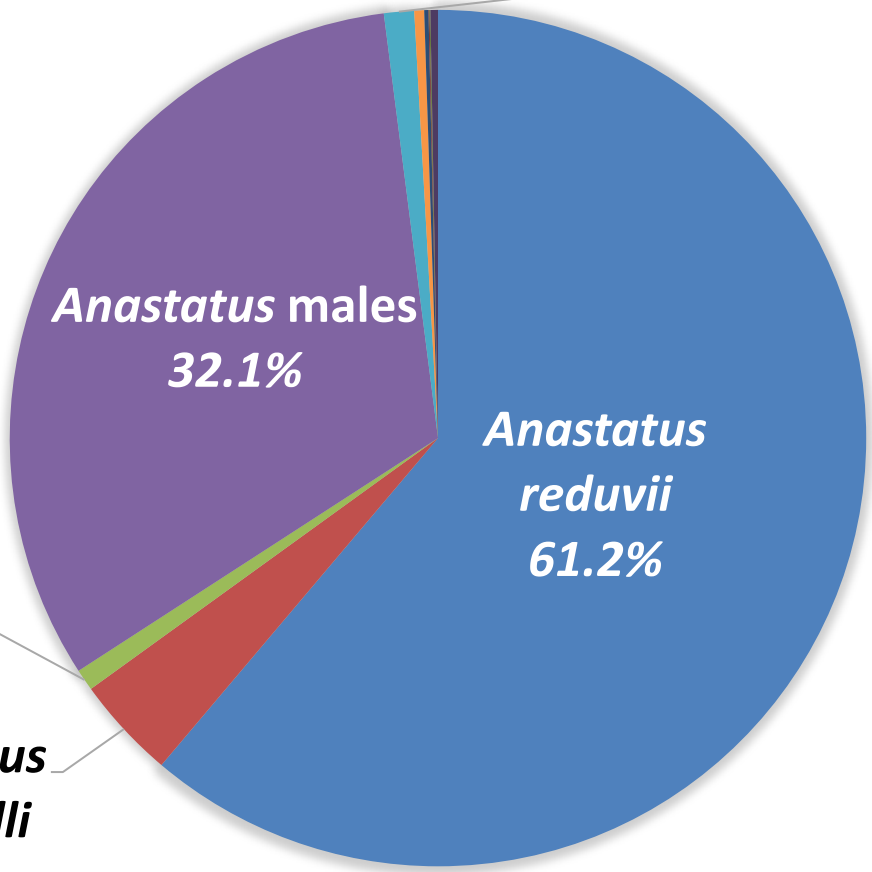


Percent BMSB Egg Parasitism



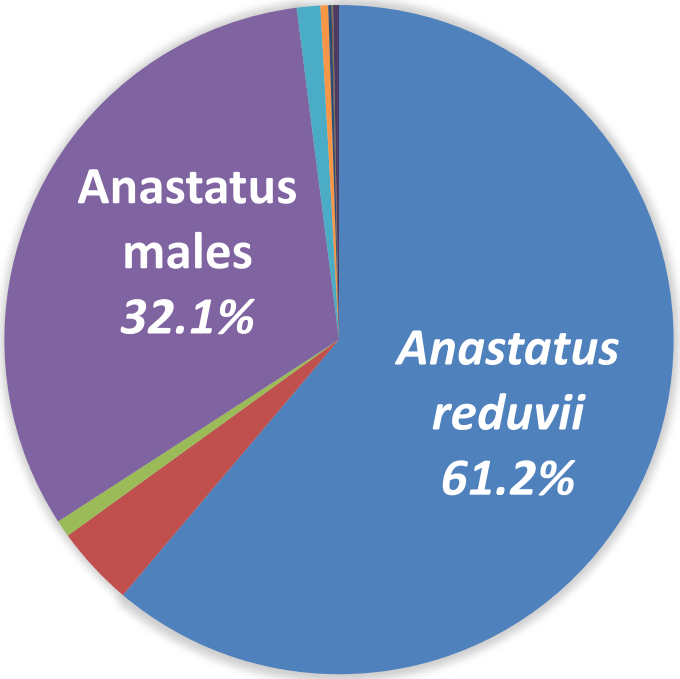
2012: 5,638 parasitoids

2012



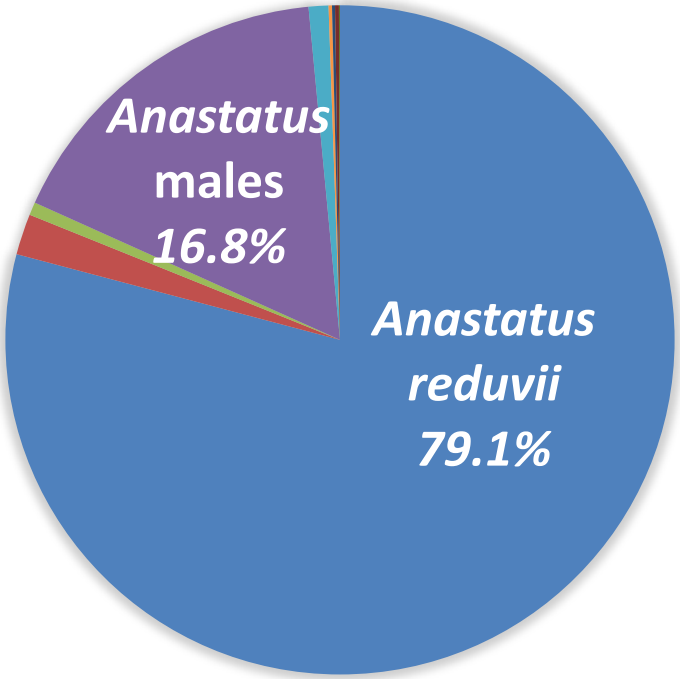
Anastatus total: 98%

2012



5,638 parasitoids

2013



9,719 parasitoids

Anastatus reduvii (Eupelmidae)

Anastatus pearsalli

Anastatus mirabilis

Conclusions:

- Egg mortality from all sources was approximately 58%
- Mortality increased throughout the season

- Native parasitoids are attacking BMSB eggs
- Higher rates of parasitism in year 2
  - 31.8% in 2012
  - 43.8% in 2013

- *Anastatus reduvii* was the most abundant

Predators observed per tree

	2011	2012
Wheel bugs (nymphs and adults)	0.019	0.082
Lacewing larvae	0	0.072
Spined soldier bugs	0.002	0
Praying mantids (nymphs and adults)	0.010	0.002
Jumping spiders	0.068	0.108
Crab spiders	0.008	0.060
Orb weaver spiders	0.089	0.308

Predator Feeding Trials: Methods

- Predators tested:
  - **Field collected**:
    - *Arilus cristatus* – wheel bug
    - *Harmonia axyridis* - multicolored Asian lady beetle
    - *Brochymena quadripustulata* - rough stink bug
    - *Phidippus audax* - daring jumping spider
  - **Commercially ordered**:
    - *Chrysoperla rufilabris* – green lacewing
    - *Orius insidiosus* - minute pirate bug
    - *Hippodamia convergens* - convergent lady beetle

Conclusions:

- Field surveys suggested that predators may be tracking BMSB
- Most abundant predators observed:
  - Wheel bugs
  - Spiders

- Wheel bugs were most voracious predator
  - Consumed both adult and nymphal BMSB stages

- Low predation of eggs

Biological Control
Vegetables / Field Crops - MD

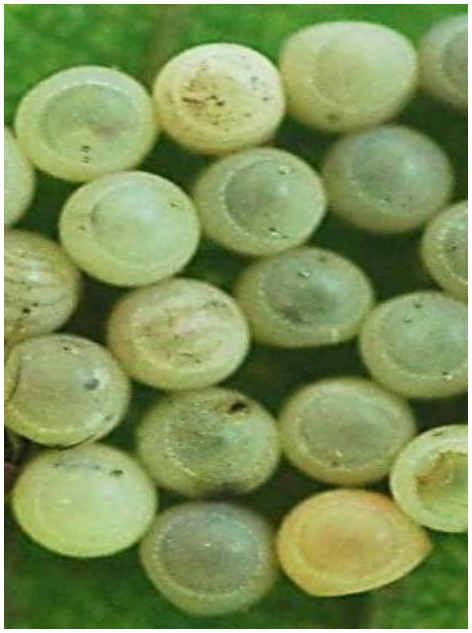


Table 1. Fate of stink bug egg masses found in organically grown corn and soybean plots in Keddysville, Maryland in 2013.

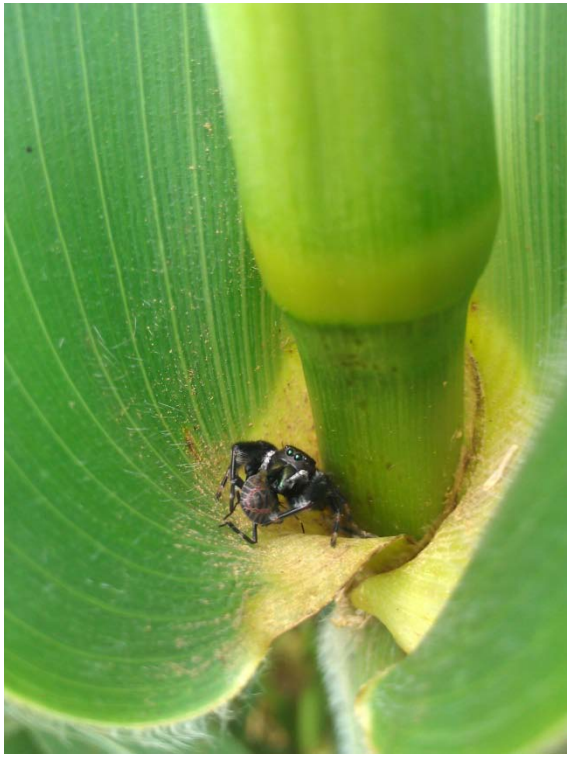
		Egg Category								
Crop	SB sp.	Total EM	Total eggs	Disappear	Chewed	Sunken	Parasitized	Unknown	Hatch	%Mort
Field corn	RSB	37	708	0	0	3	651	3	51	
	SSB	2	24	0	0	0	24	0	0	
	BMSB	72	1814	259	36	454	49	515	501	72%
	BSB	41	858	25	0	13	784	14	22	
Soybean	RSB	9	132	0	0	0	75	0	57	
	SSB	5	92	0	0	1	68	23	0	
	BMSB	102	2648	230	85	895	9	592	837	68%
	BSB	97	1596	0	15	66	1413	31	71	

Eggs monitored and or collected from July 30 through September 03.
Field consisted of plots of corn and soybean planted

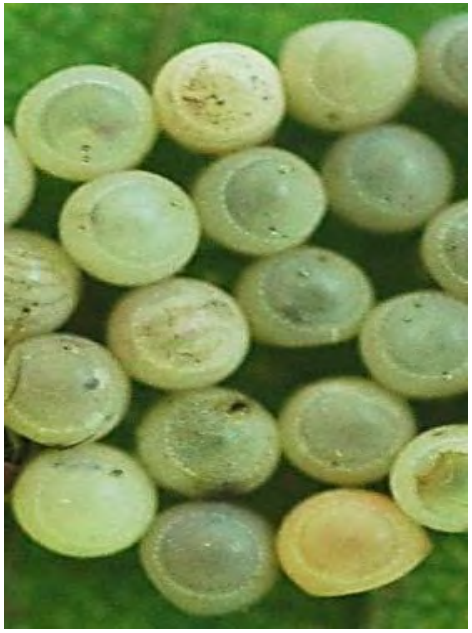
SB sp = Stink bug species, Rice stink bug, spined soldier bug, brown marmorated stink bug and brown stink bug.

Total = Total egg masses
Total eggs = Total number of eggs
Disappear = Eggs disappear from plant
Chewed = Chewing predator
Sunken = Sucking predator/sunken eggs
Hatch = Reached 1st instar stage
Unknown = Unknown/unascertained (eggs don't hatch but no evidence of natural enemy activity)

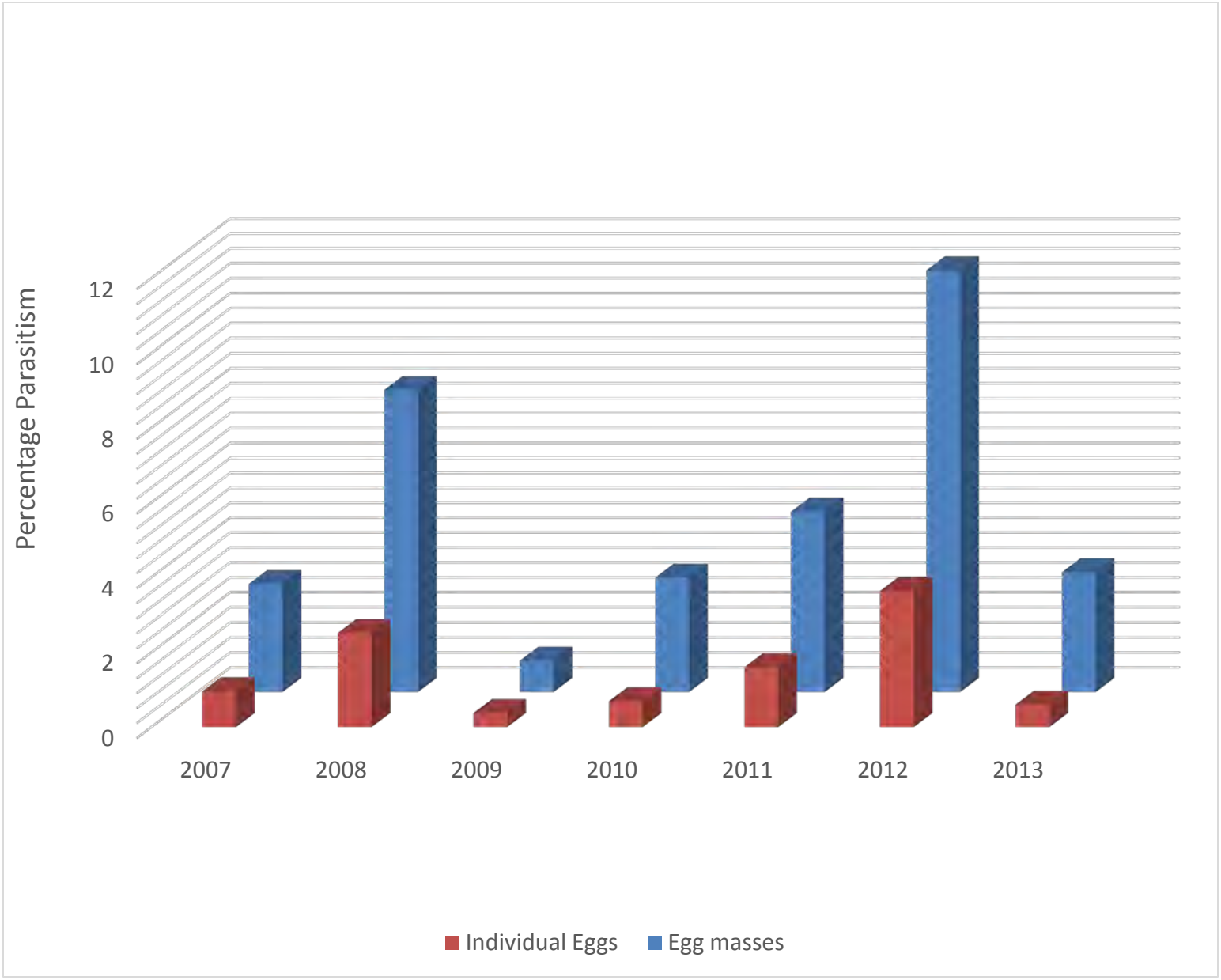
Low BMSB egg densities on vegetables in Clarksville, MD



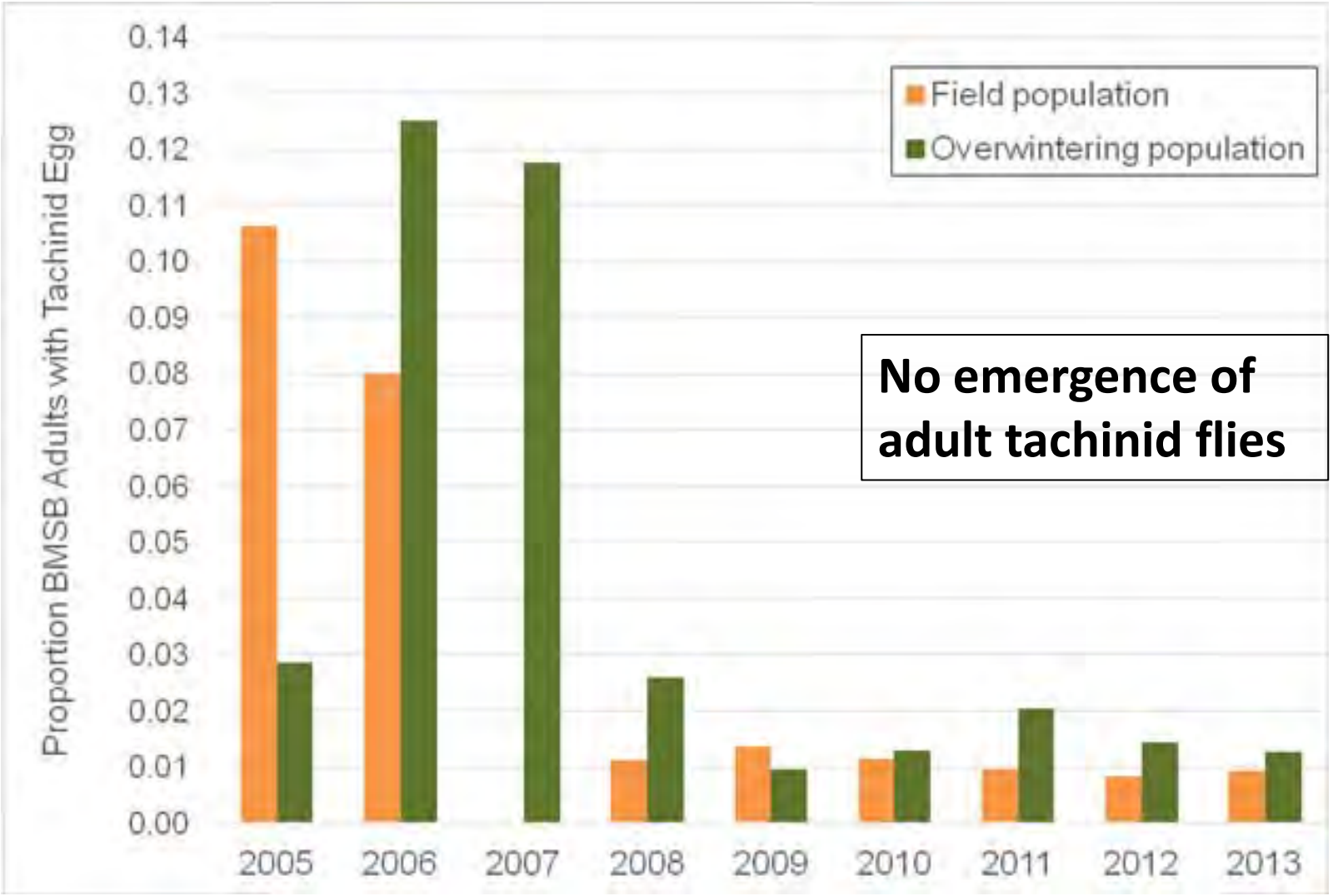
Biological Control
USDA ARS Newark, DE
Landscape trees / ornamentals



BMSB egg and egg mass parasitism in landscapes

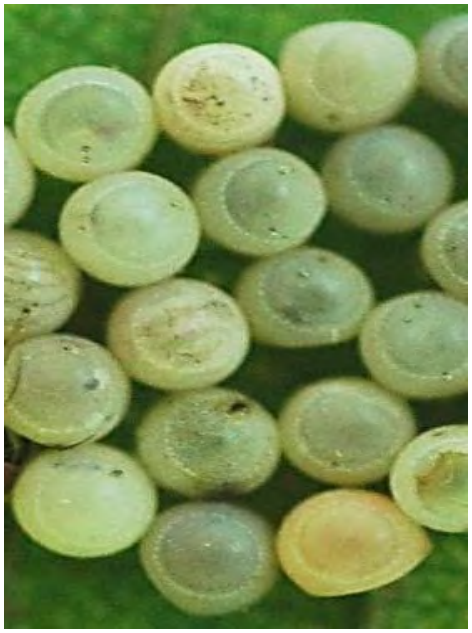


Adult BMSB with Tachinid Eggs deposited



2005 – 2007: low sample size
2011 – 2013: high sample size (5-10 K)

Biological Control
Ornamentals - OR



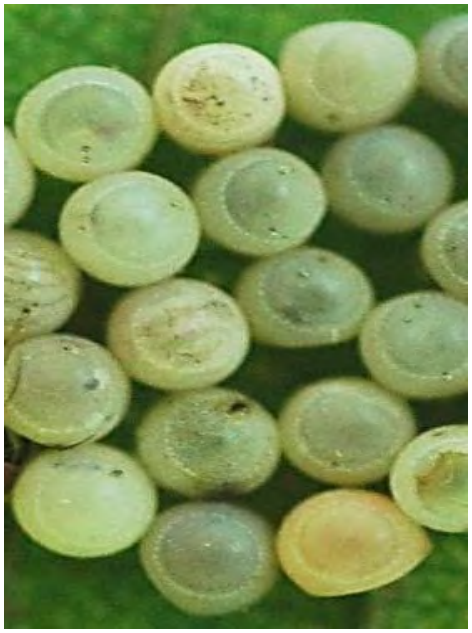
Natural enemies in Ornamentals

- Frozen sentinel eggs were exposed for 1 wk with/without cages.
- *Trissolcus* can easily go through the cage and parasitize eggs.
- June, July, August trials with 5 sites/host, 100 egg clutches total / month.

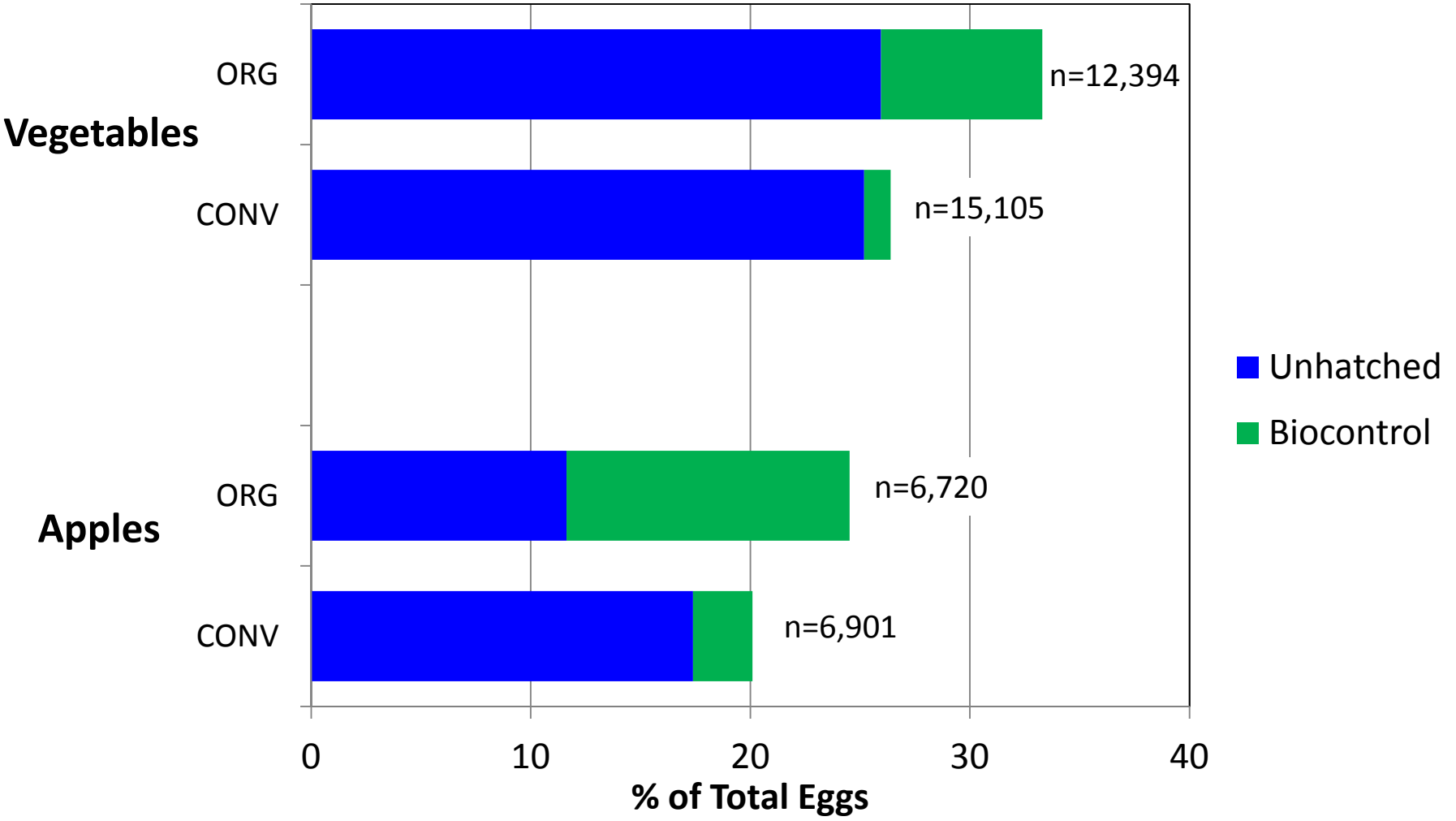
	% clutches para. by *T. euschistii*	% eggs w/in clutch para. *	% clutches pierced/chewed
Cherry laurel	15%	66.4%	35%
English holly	35%	55.2%	40%
Oregon grape	3.3%	100% (1 sample)	36.7%
Red maple	11.5%	52.3%	34.6%

* % from parasitized egg clutches only

Biological Control
Vegetables, Apples - NC



Fate of Healthy BMSB Sentinel Egg Masses in Different Agroecosystems



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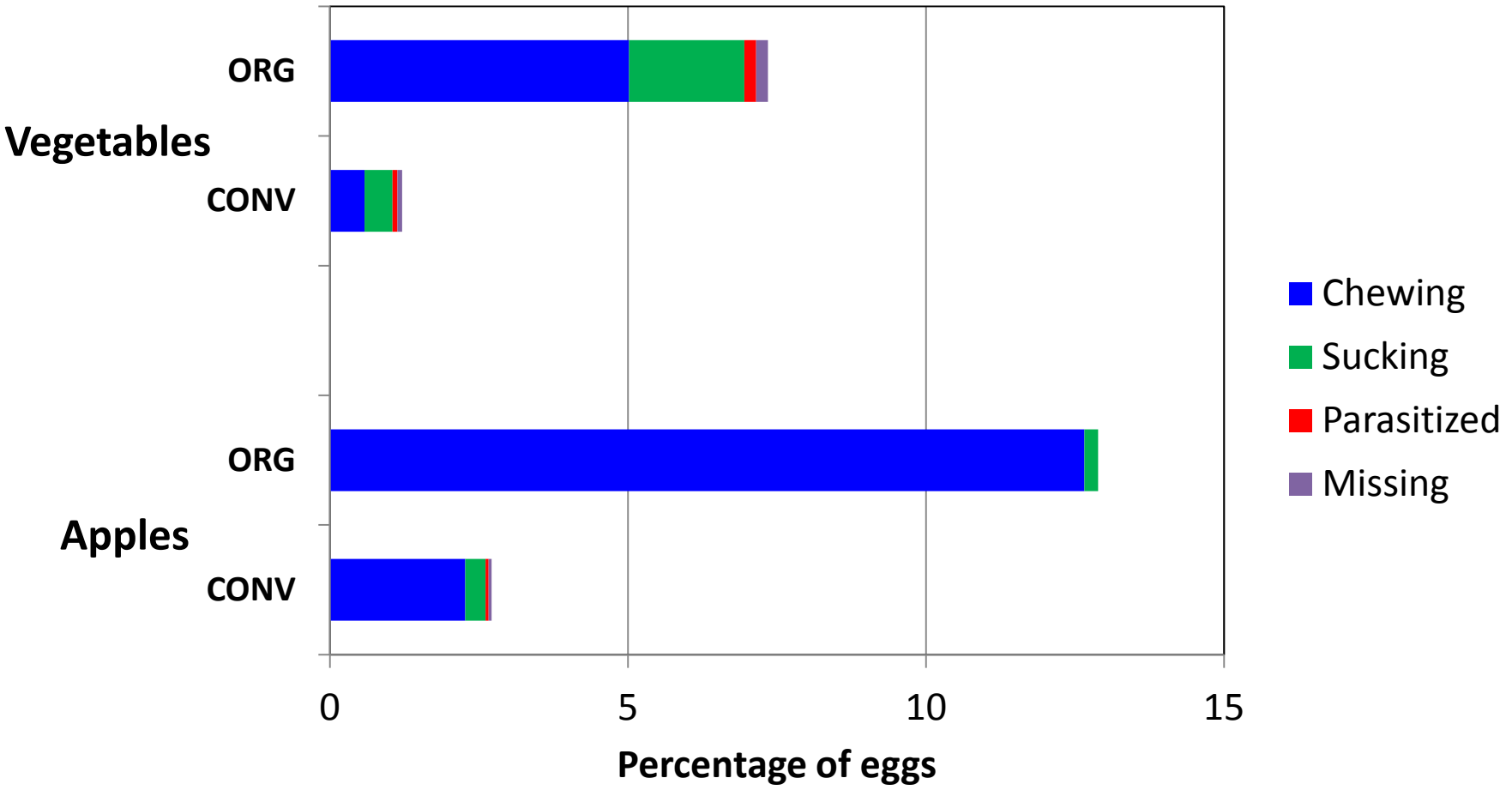
Fate of Sentinel BMSB Eggs in Conventional and Organic Crops



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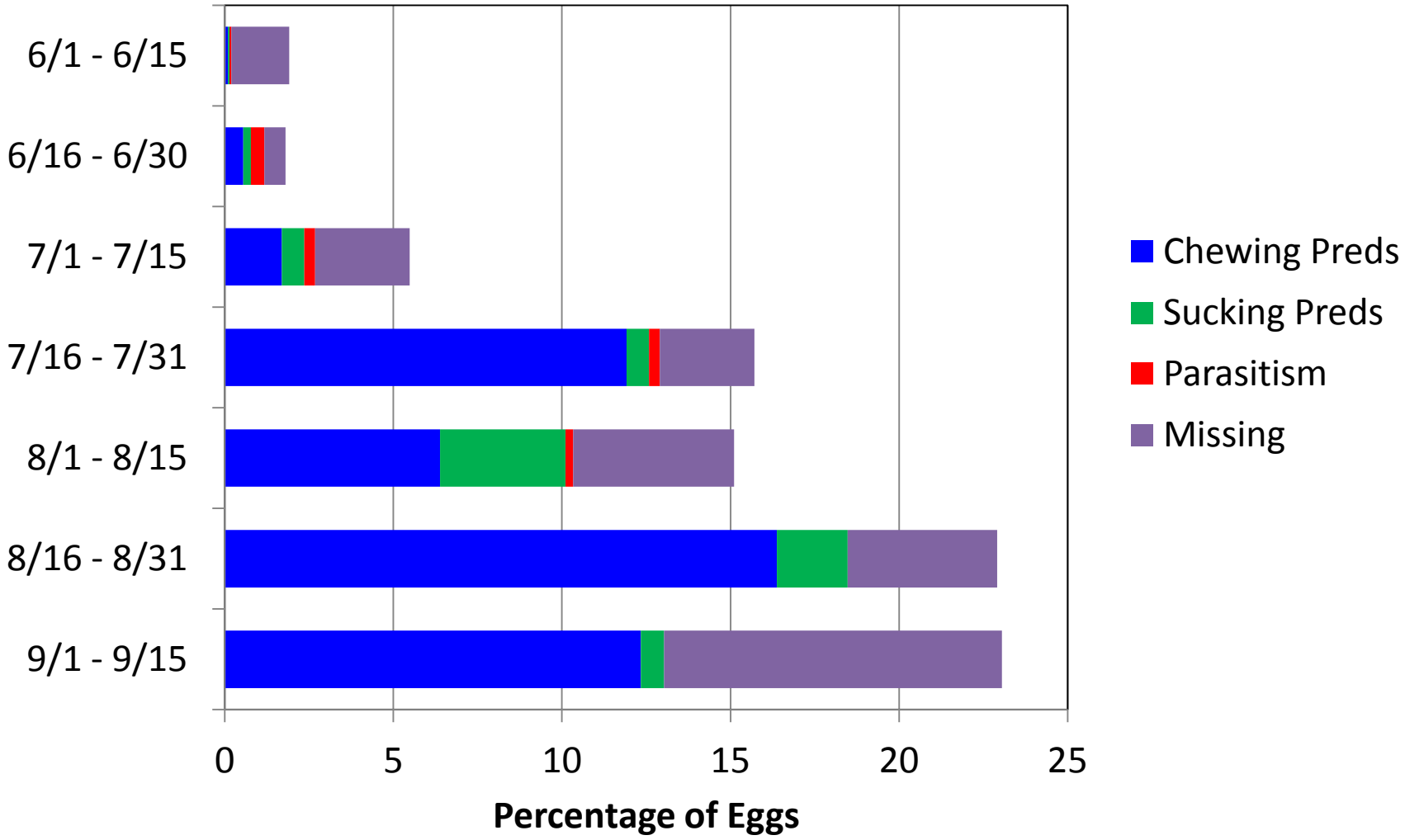
Fate of BMSB Sentinel Eggs vs. Time



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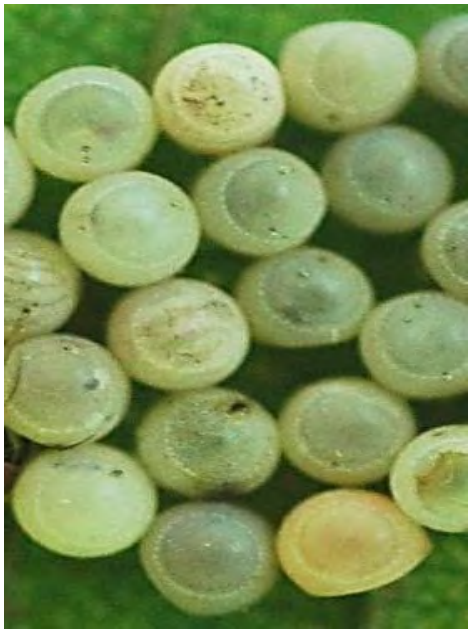
Biological Control
Tree Fruit - PA

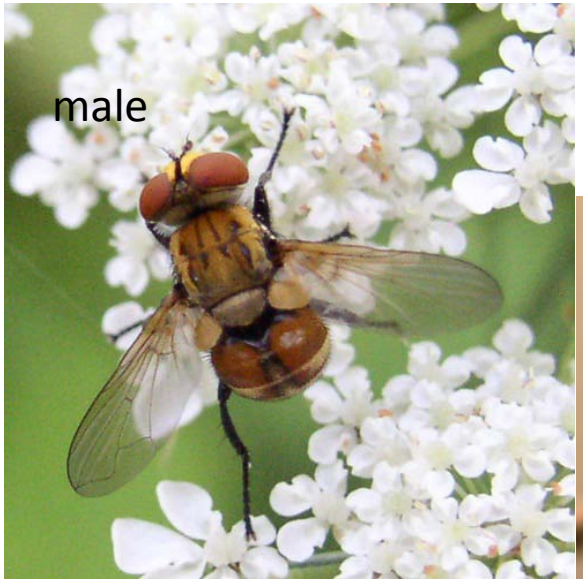


Gymnosoma sp.

***Trichopoda pennipes* July- Sept**
Adults attracted to golden rod, butterfly bush, & Queen Anne's Lace

Tachinid Parasitoids of Adult Stink Bugs

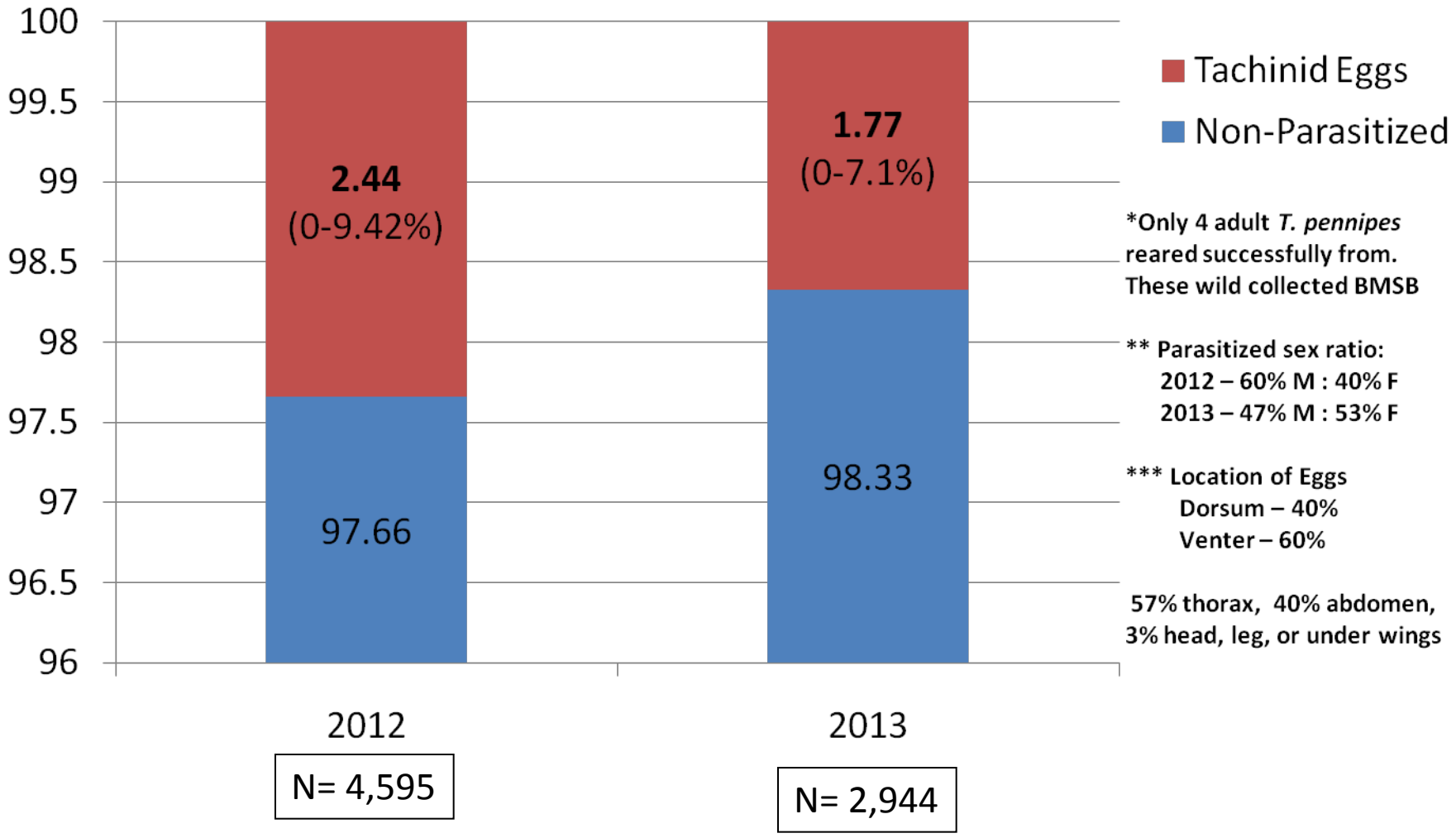
Gymnoclytia sp.



Trichopoda pennipes Egg

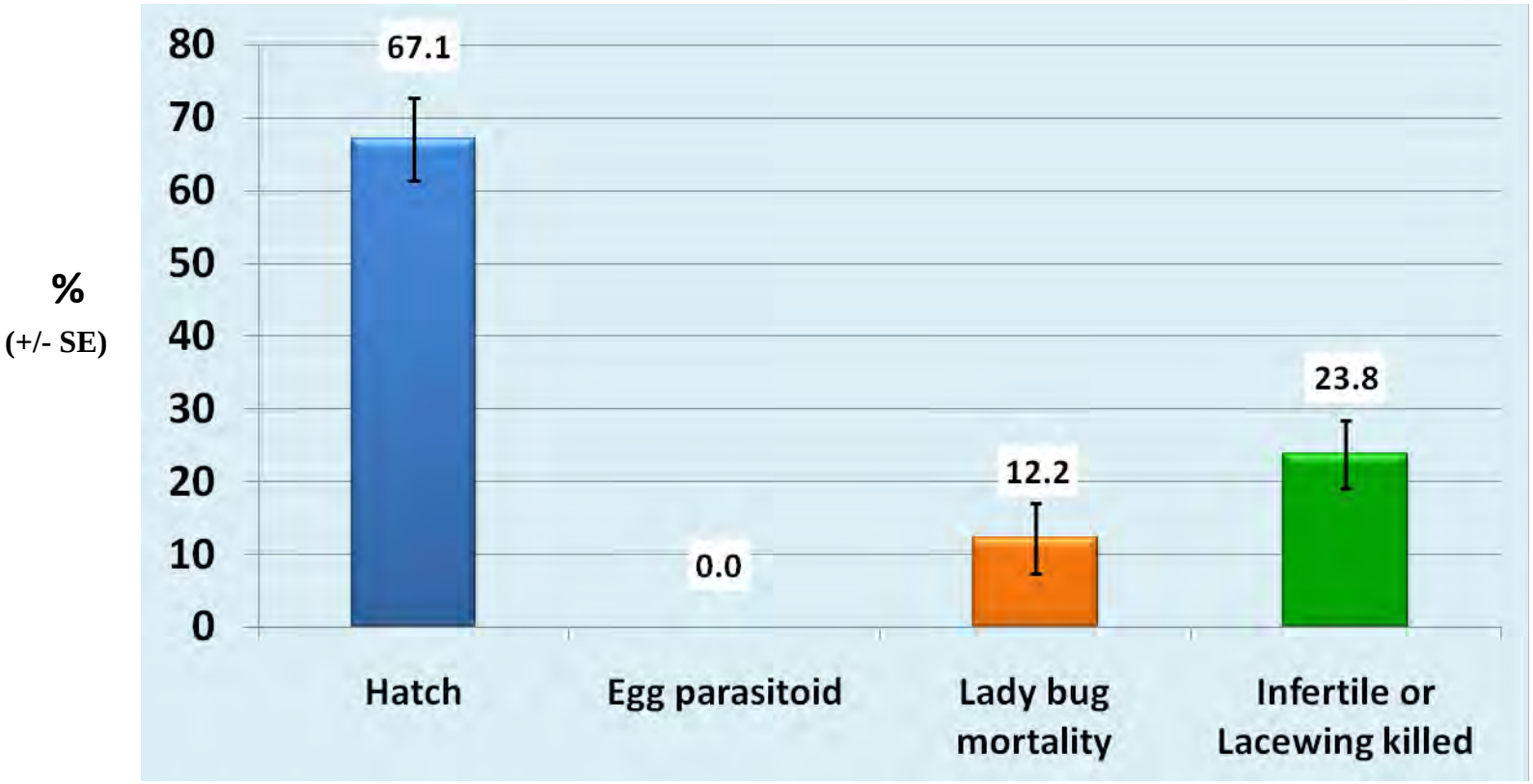
Trichopoda pennipes Egg

Fig. 2 BMSB Parasitism by *Trichopoda pennipes*

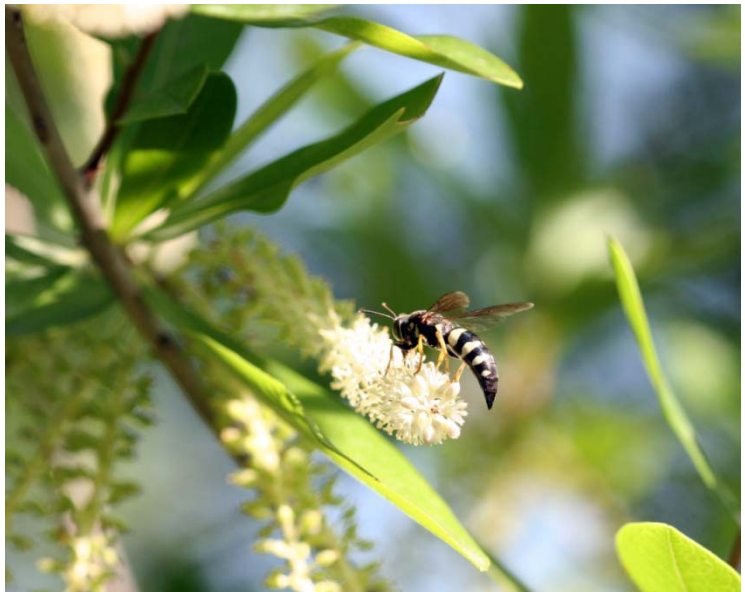


2011 BMSB Sentinel Egg Mass Trial

- 50 Egg masses placed along woods adjacent to two apple orchards in Adams County from May 7 – Aug 18 (6 dates)
- Egg masses from colony laid on bean leaves < 48 hours old
- Bean leaves with egg masses stapled to sassafras leaves for 48 hours
- Individual egg masses reared in petri dishes and held for one month
- Total # eggs/mass counted, # hatch, # dead eggs, # parasitoids, # eaten by predators



***Bicyrtes quadrifasciata* – Sand Wasp**



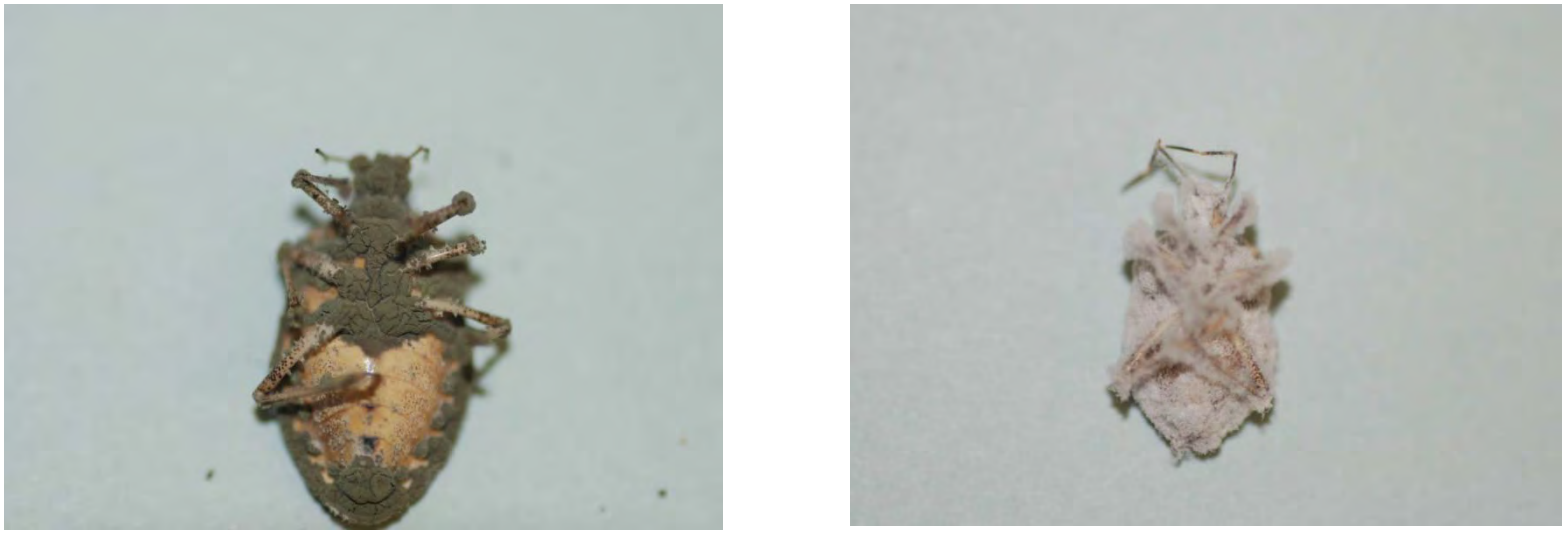
Crabronidae

***Astata unicolor* – adults from July- Sept**

Adults nectar at Bee Balm and other bee flowers

Effects of entomopathogenic fungi on brown marmorated stink bug

- **Evaluated 3 genera (*Metarhizium*, *Beauvaria*, and *Isaria*) and multiple strains of wild type fungi and measured days to kill and days to sporulation**
- **None appear to be consistently virulent to the level necessary to serve as a biological agent either as a formulated biological control or in an Attract and Kill method**
- **More recently pursuing transgenic fungal strains in an attempt to increase efficacy and bioassays being analysed**



BMSB infected with Metarhizium (left) and Isaria (right)

P. Shrewsbury, R. St. Leger, T. Pike, UMD

Progress Toward IPM Programs and Biological Control

Progress Toward IPM Programs and Biological Control

- Native natural enemies are attacking BMSB
- Egg parasitoids – ornamental systems
- Predators – field / vegetable crops; apples
- Low parasitoid activity in orchards (PA)

- Baseline data for future biological control programs
- Classical biological control
- Conservation of natural enemies
  - Habitat manipulation to provide resources (ex. Insectary plantings)
  - Smart selection / use of pesticides

- Long term, sustainable approach

Tracking the BMSB Video Series

StopBMSB.org

Biological Control

- http://www.stopbmsb.org/more-resources/video-series/?keywords=biological%20control