Native natural enemies as biocontrol agents

Paula M. Shrewsbury, Rebeccah Waterworth, Alina Avanesyan, Maddie Potter, Department of Entomology, UMD; Jim Walgenbach, Emily Ogburn, Entomology and Plant Pathology, NCSU; Glynn Tillman, USDA ARS, Tifton, GA

Funding

USDA United States Department of Agriculture National Institute of Food and Agriculture

Specialty Crop Research Initiative

Collaborating Institutions

ARS · NC State University · PennState · OSU Oregon State · University of Maryland · University of Georgia · Washington State University · Northeastern IPM Center · Cornell University · Utah State University · Rutgers University · The Ohio State University · University of Kentucky · UC Davis · University of Minnesota · VirginiaTech · Berkeley · Michigan State University · UC Riverside

This material is based upon work that is supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, Specialty Crop Research Initiative under award number 2016-51181-25409.

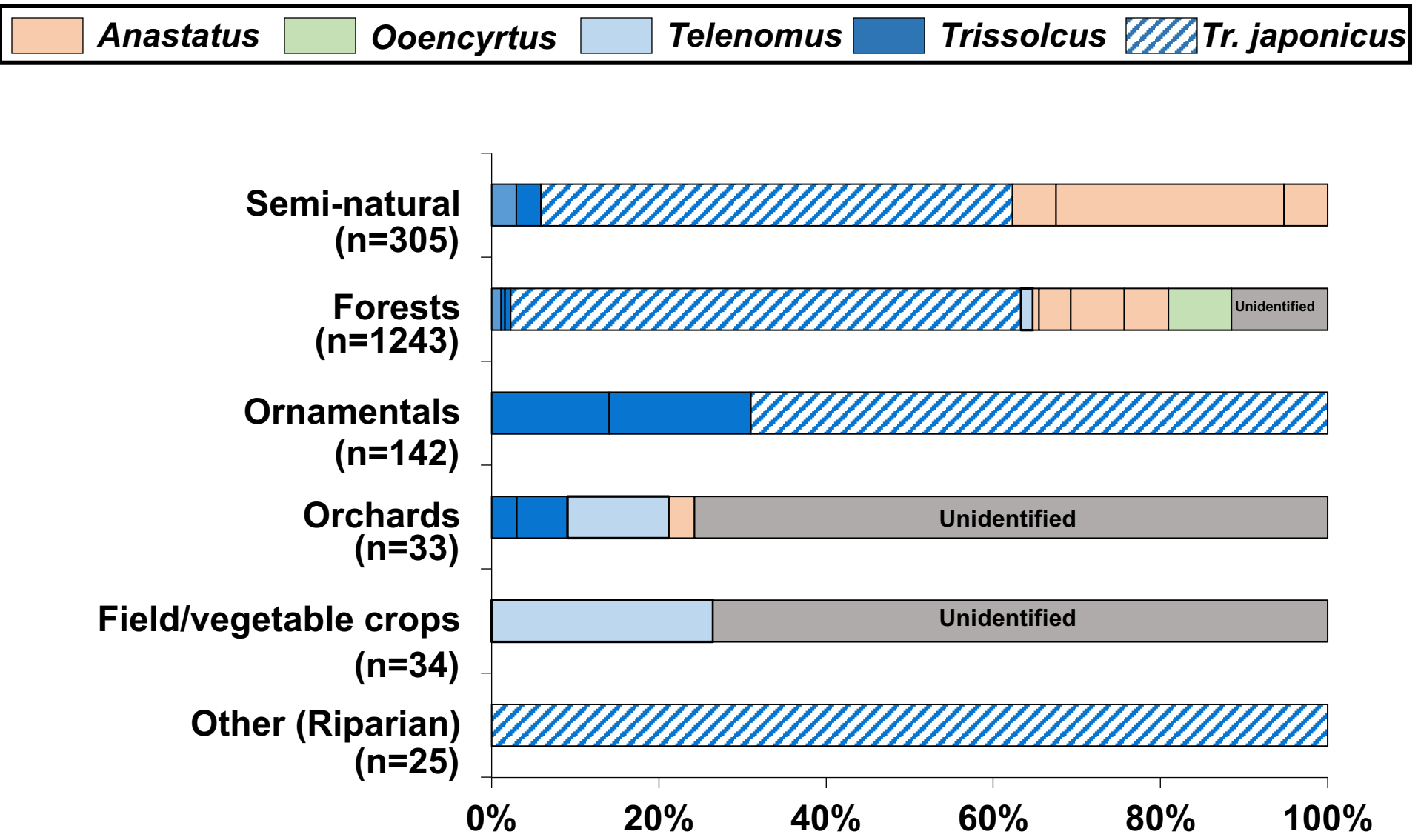
Natural Enemies: Variation Among Regions and Habitats (identity and impact) – 2017, 2018

Region	State (years)	Collaborators
Mid-Atlantic	Maryland (2017/18)	Paula Shrewsbury, Rebeccah Waterworth
	Delaware (2017/18)	Kim Hoelmer, Kathy Tatman
	Virginia (2017)	Chris Bergh, Nicole Quinn
	Pennsylvania (2017)	Greg Krawczyk
Southeast	Kentucky (2017/18)	Ricardo Bessin, Lauren Fann
	North Carolina (2017/18)	Jim Walgenbach, Emily Ogburn
Pacific NW	Oregon (2017/18)	Nik Wiman, Heather Andrews, David Lowenstein
	Oregon (2017*/18)	Jana Lee, Hanna McIntosh, Gracie Galindo
	Washington State (2017/18)	Betsy Beers, Joshua Milne
West	Utah (2017/18)	Diane Alston, Cody Holthouse, Zach Schumm
Great Lakes	Ohio (2017*/18)	Celeste Welty, Kristina Fox Vik
	Wisconsin (2018)	Janet van Zoeren, Christelle Guedot

Habitat categories and types

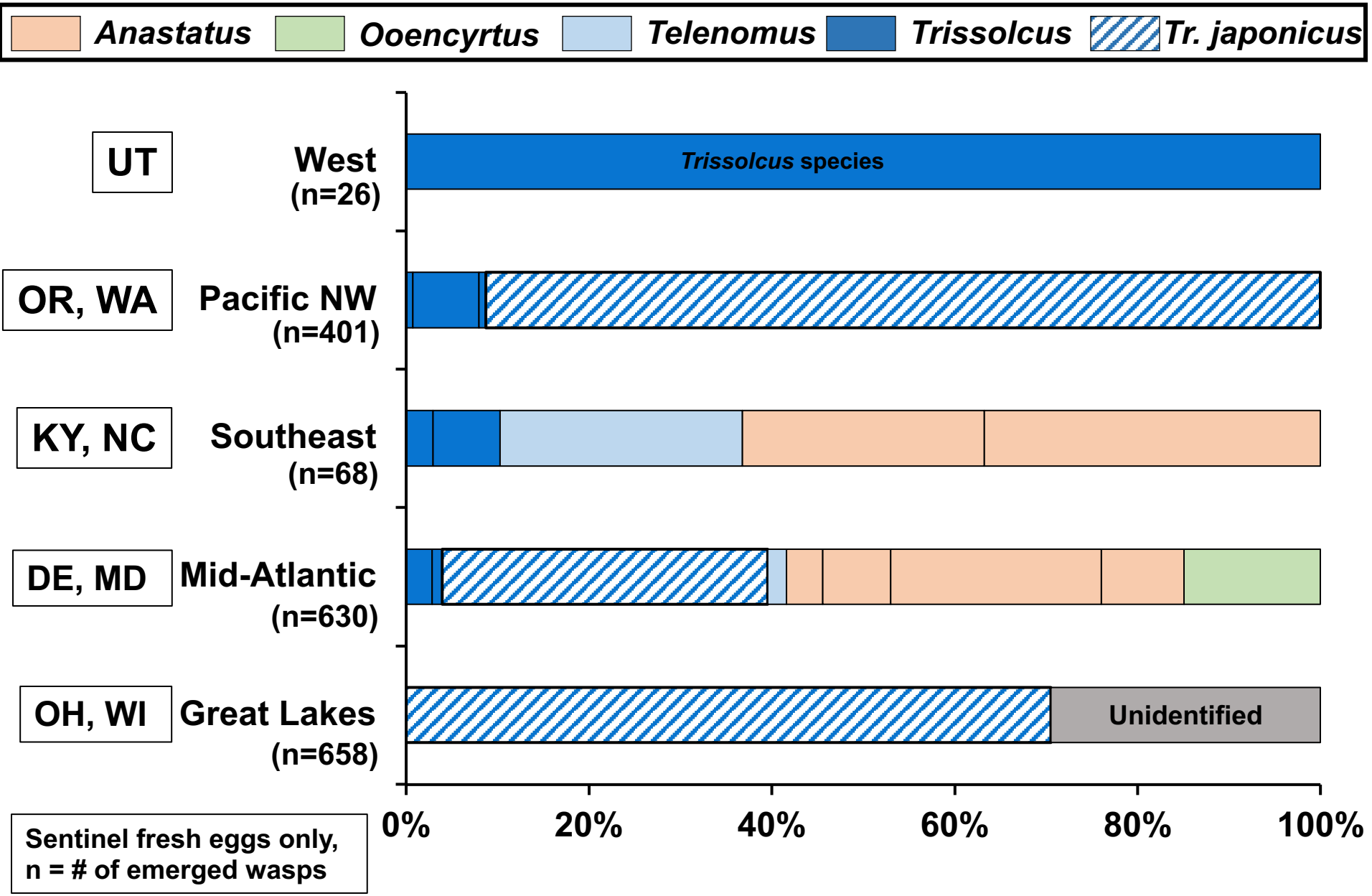
Habitat Category:	Habitat Type:
1. Forests	1. Wooded edges
2. Orchards	2. Apple, peach, pear, hazelnut
3. Ornamentals	3. Nurseries, urban landscapes
4. Field/vegetable crops	4. Corn, soybean, peppers
5. Semi-natural	5. Campuses, parks, arboretum
6. Mixed / other	6. Riparian

Percentage of parasitoid species by habitat category (2018)



Sentinel fresh eggs only,
n = # of emerged wasps

Percentage of parasitoid species by region (2018)



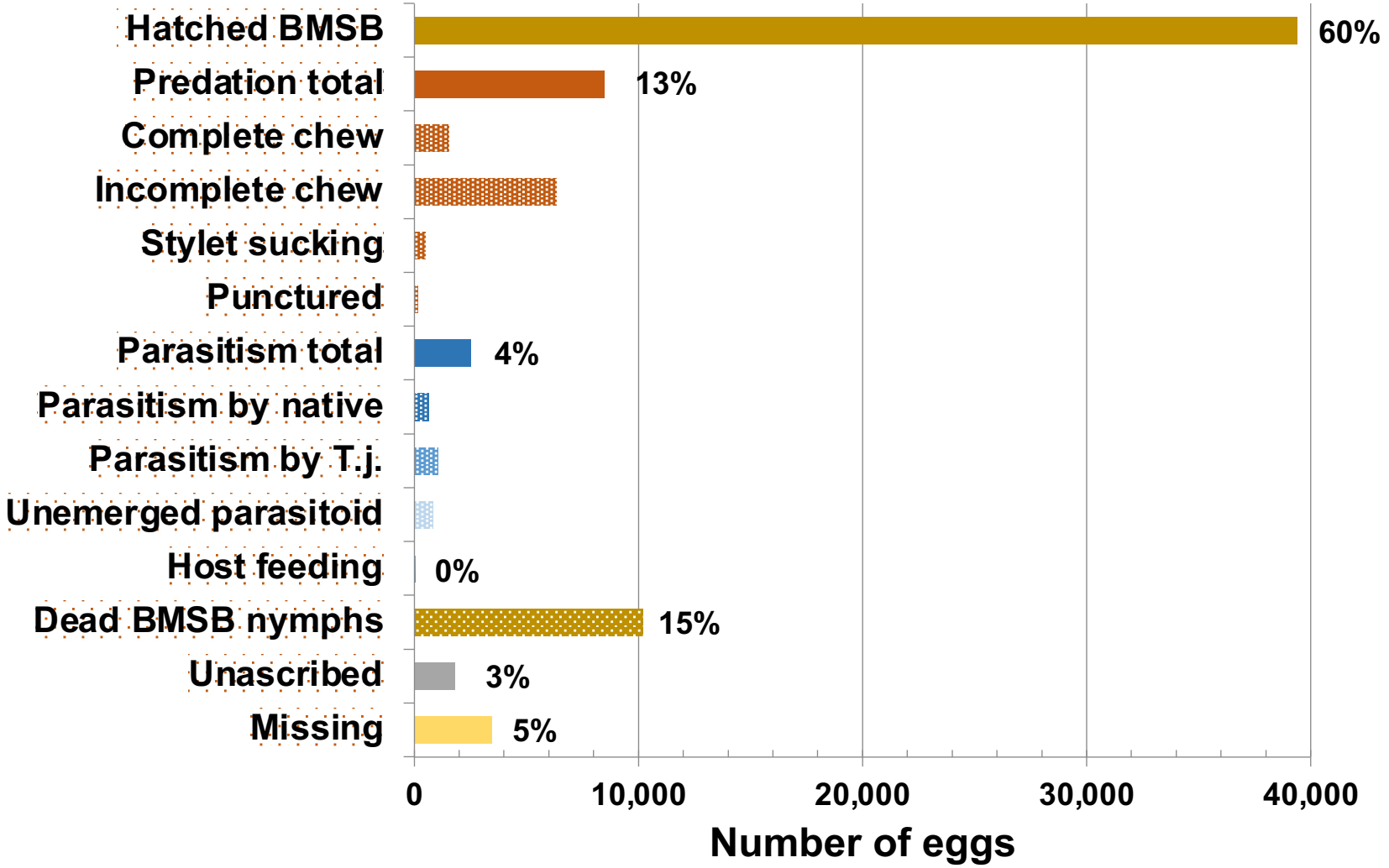
Conclusions

Parasitoid taxa

- **Habitat**
  - **Certain parasitoid species are more prevalent in specific habitats (2017 and 2018)**
    - ***Anastatus* and *Trissolcus* are arboreal**
      - ***Anastatus* in semi-natural and forests, to lesser extent orchards, ornamentals**
      - ***Trissolcus* in all habitats except veg / field crops**
    - ***Telenomus* (2017, 2018) in veg / field crop, orchards, forests**
    - ***Ooencyrtus* (2018) in veg / field crops, forests**
  - **Patterns similar in 2017 and 2018, but greater abundance of *Tr. Japonicus* in 2018**

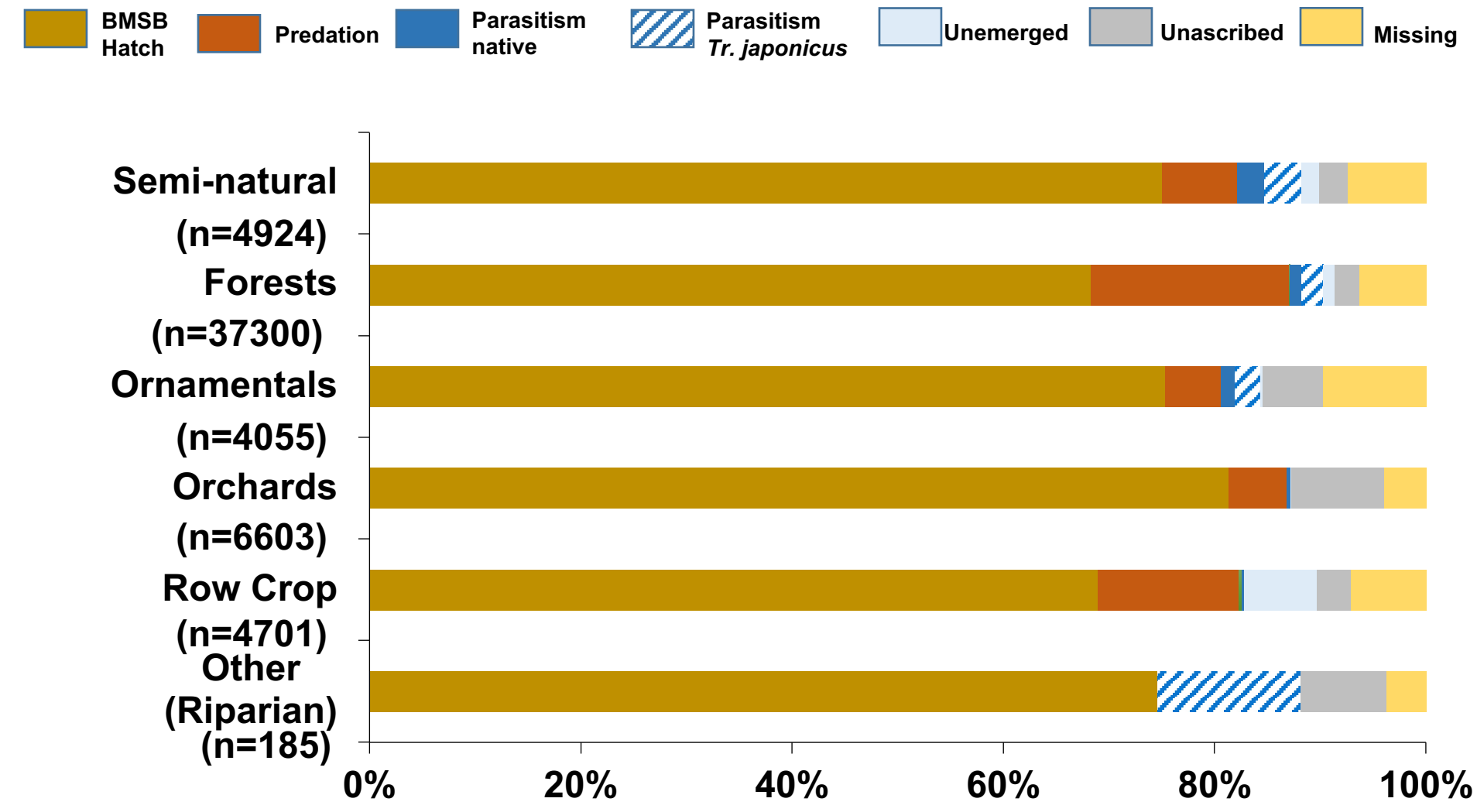
- **Region**
  - **Certain parasitoid species were only found in specific regions**
  - ***Anastatus* and *Telenomus* only found in mid-Atlantic and SE**
  - ***Trissolcus* in all 5 regions (only native in SE, only *Tr. japonicus* in Great Lakes**
  - **Mid-Atlantic had the greatest diversity of parasitoid species**

Egg fate – pooled across region and habitat (2018)



Sentinel fresh eggs only
(from 2,729 egg masses total)

Egg fate by habitat, pooled across regions (2018)



Sentinel fresh eggs only,
n = # of eggs

Conclusions

Impact by parasitoids and predators

- **Overall, there was low impact of parasitoids (4%) and predators (13%)**

- **Habitat**
  - **Predation was greatest in forests (wooded areas), followed row crops**
  - **Parasitism was similar for semi-natural, forests, and ornamentals**
  - **Parasitism was lowest in row crops and orchards**

Biological Control 145 (2020) 104247

Contents lists available at ScienceDirect

Biological Control

journal homepage: www.elsevier.com/locate/ybcon

Parasitism and predation of sentinel eggs of the invasive brown marmorated stink bug, *Halyomorpha halys* (Stål) (Hemiptera: Pentatomidae), in the southeastern US

Glynn Tillman[a,*], Michael Toews[b], Brett Blaauw[c], Ashfaq Sial[c], Ted Cottrell[d], Elijah Talamas[e], David Buntin[f], Shimat Joseph[f], Rammohan Balusu[g], Henry Fadamiro[g], Sriyanka Lahiri[h], Dilani Patel[c]

[a] United States Department of Agriculture, Agricultural Research Service, Crop Protection & Management Research Laboratory, PO Box 748, Tifton, GA, USA
[b] Department of Entomology, University of Georgia, Tifton, GA, USA
[c] Department of Entomology, University of Georgia, Athens, GA, USA
[d] United States Department of Agriculture, Agricultural Research Service, Southeastern Fruit & Nut Tree Research Laboratory, Byron, GA, USA
[e] Florida Department of Agriculture and Consumer Services, Florida State Collection of Arthropods, Gainesville, FL, USA
[f] Department of Entomology, University of Georgia, Griffin, GA, USA
[g] Department of Entomology and Plant Pathology, Auburn University, Auburn, AL, USA
[h] Department of Entomology and Nematology, University of Florida, Wimauma, FL, USA

Highlights: Predation and Parasitism of BMSB Eggs in Georgia and Alabama

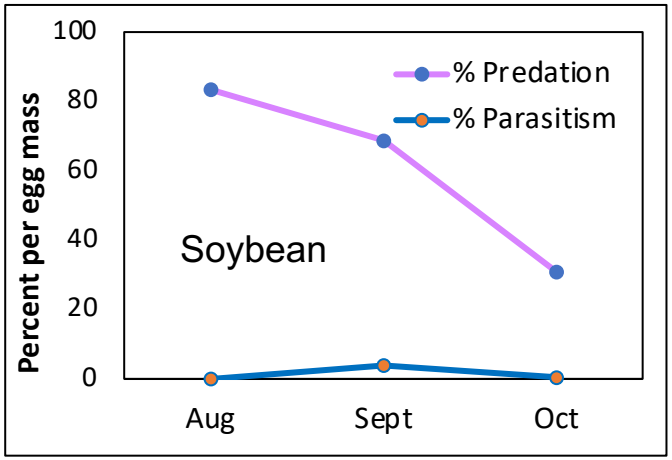
	Frequency (%) by habitat for a species				
Parasitoid species	Woodland	Orchard	Vegetable	Row crop	Vineyard
Anastatus reduvii	55.3	43.7	.	0.5	0.5
Anastatus mirabilis	75.0	25.0	.	.	.
Trissolcus brochymenae	56.2	37.5	1.6	1.6	3.1
Trissolcus euschisti	43.3	52.2	.	1.5	3.0
Trissolcus edessae	10.8	59.5	.	5.4	24.3
Ooencyrtus sp.	25.2	35.5	33.7	5.1	1.1
Telenomus podisi	21.8	33.3	20.3	14.5	10.1
Trissolcus solocis	25.0	37.5	.	37.5	.
Trissolcus basalis	.	.	86.7	13.3	.
Gyron obesum	.	7.1	85.8	7.1	.

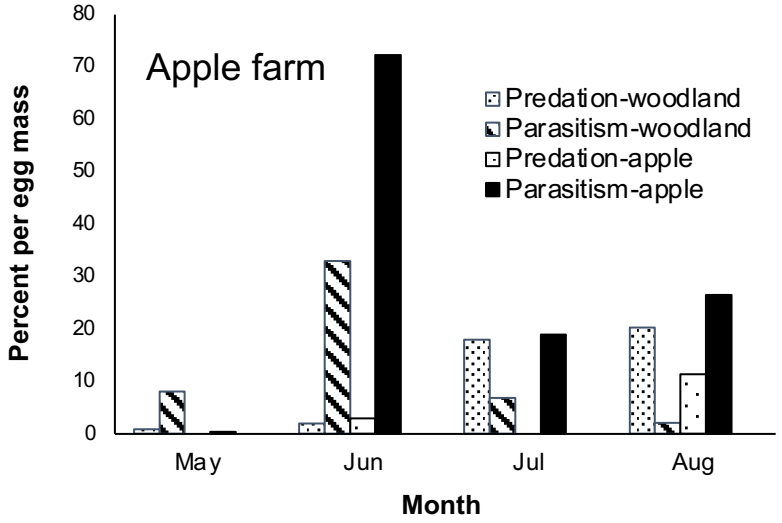
- Ten primary parasitoid species, two new records - *T. basalis* and *T. solocis*, emerged from BMSB egg masses in woodlands and crops.
- Prevalence of parasitoid species emerging from egg masses was mainly habitat specific. For example, *Anastatus* spp., *T. brochymenae*, and *T. euschisti* were the most prevalent species in woodland and orchard habitats.

Tillman et al. 2020. Biological Control. 145: 104247.

Highlights: Predation and Parasitism of BMSB Eggs in Georgia and Alabama

- Predation and parasitism rates varied by habitat and site.
- Predation, though, consistently reached very high levels in soybean and cotton.
- Highest rates of parasitism occurred in orchards, and “woody” parasitoid species parasitized BMSB sentinel egg masses in both woodland and orchard habitats. For example, peak parasitism in apple was 72.3% at a site in 2017.





Tillman et al. 2020. Biological Control. 145: 104247.

Tr. euschisti
Elijah Talamas

Highlights: Predation and Parasitism of BMSB Eggs in Georgia and Alabama

- Using sentinel eggs can result in overestimating predation or underestimating parasitism
- Examine natural eggs if possible.

		Natural egg masses		Sentinel egg masses	
Year	**Crop**	**% Predation**	**% Parasitism**	**% Predation**	**% Parasitism**
2019	Soybean	29.8	26.7	53.6	12.3

From: Tillman et al. 2020. Biological Control. 145: 104247

Parasitism of BMSB Eggs in Maryland

		Natural egg masses	Sentinel egg masses
Year	**Crop**	**% Parasitism**	**% Parasitism**
2012	Ornamental trees	28.4	4.6
2013	Ornamental trees	55.3	0.8

From: Jones, A.L.*, D.E. Jennings**, C.R.R. Hooks, and P.M. Shrewsbury◊. 2014. Sentinel eggs underestimate rates of parasitism of the exotic brown marmorated stink bug, *Halyomorpha halys*. Biological Control, 78, 61-66. DOI: 10.1016/j.biocontrol.2014.07.011.

Anastatus reduvii Augmentative Release project

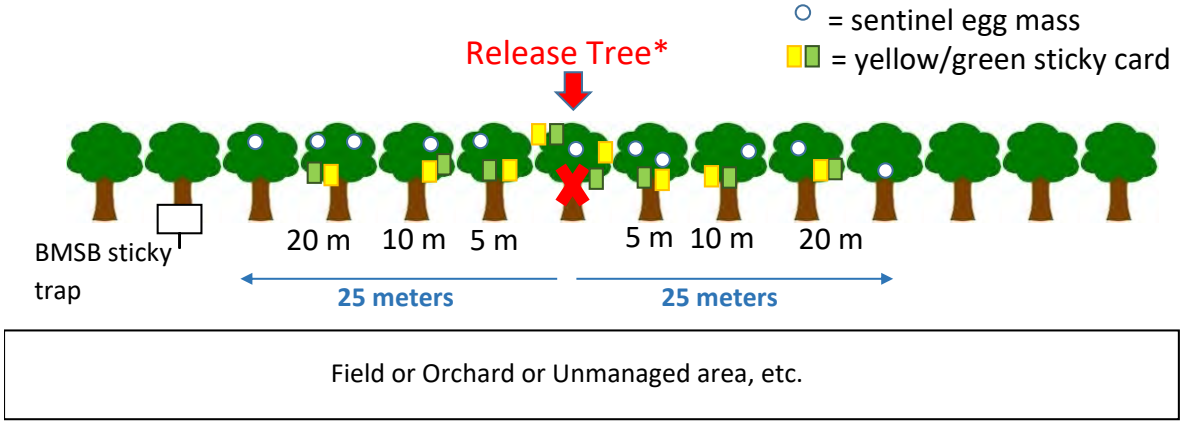
- In many field studies, most prevalent and abundant parasitoid to emerge from sentinel BMSB eggs deployed in arboreal habitats
- Objective: Examine the potential for augmentative release of *Anastatus reduvii* to increase parasitism rates of BMSB eggs
- North Carolina (Walgenbach and Ogburn) and Maryland (Shrewsbury and Avanesyan), will be a 2-3 year study

NC STATE UNIVERSITY

UNIVERSITY OF MARYLAND

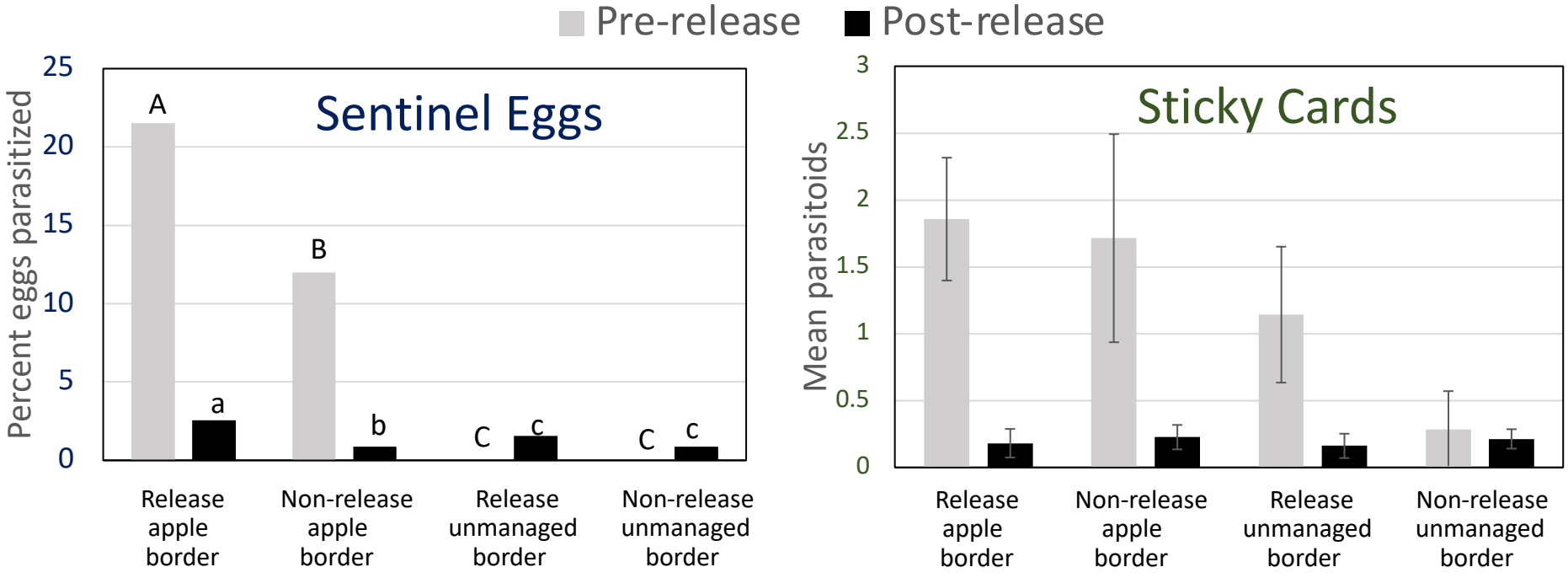
Study sites

- Two pairs of study sites in **wooded borders**:
  - Release sites
  - Non-release sites
- Monitor before & after release of parasitoids
  - Assess parasitoid community and activity using sentinel BMSB eggs, surveys for wild stink bug eggs, and yellow and green sticky cards



*Designated "Non-release" tree at non-release sites

NC 1st year results: all parasitoid species of BMSB



- Overall, pre-release total egg parasitism was higher than post-release. Likely due to seasonal variation in parasitoid activity.
- Significant differences among locations for both pre- and post-release

- Overall, pre-release sticky cards captured significantly more total parasitoids than post-release. Likely due to seasonal variation.
- No significant differences among locations pre- or post- release

*number of *A. reduvii* were low this first year

Goal: Elucidate measures to increase the biological control impact of native *Anastatus reduvii* on BMSB

Objectives:

1. **Identify alternative in-season and overwintering insect egg hosts of *A. reduvii***
2. **Identify host plants on which *A. reduvii* are most commonly associated**

UNIVERSITY OF MARYLAND

Alternative Hosts - Citizen Science Project

- Recruiting from 5 MD County Master Gardener groups
- Volunteers collect any and all insect eggs March 2021-August 2021
- Volunteers ship eggs to Shrewsbury lab
- ID eggs and what emerges, and host plants eggs are from

Anastatus reduvii Insect Egg Hosts

Host Common Name	Order	Family	Genus	Species	Citation(s)
Green stink bug	Hemiptera	Pentatomidae	*Chinavia*	*hilaris*	Krombein, 1979; Potter and Shrewsbury, unpubl.
Brown stink bug	Hemiptera	Pentatomidae	*Euschistus*	*servus*	Tillman and Cottrell, 2016; Potter and Shrewsbury, unpubl.
Brown marmorated stink bug	Hemiptera	Pentatomidae	*Halyomorpha*	*halys*	Herlihy, et al., 2016; Potter and Shrewsbury, unpubl.
Squash bug	Hemiptera	Coreidae	*Anasa*	*tristis*	Krombein, 1979.
Leaf-footed bug*	Hemiptera	Coreidae	*Leptoglossus* sp.		Mitchell and Mitchell, 1986; Potter and Shrewsbury, unpubl.
Wheel bug	Hemiptera	Reduviidae	*Arilus*	*cristatus*	Krombein, 1979; Potter and Shrewsbury, unpubl.
Shieldbacked pine seed bug	Hemiptera	Scutelleridae	*Tetyra*	*bipunctata*	Krombein, 1979.
Salt marsh moth	Lepidoptera	Erebidae	*Estigmene*	*acrea*	Krombein, 1979.
Oakworm moth	Lepidoptera	Saturniidae	*Anisota* sp.		Burks, 1967.
Orange-striped oakworm	Lepidoptera	Saturniidae	*Anisota*	*senatoria*	Krombein, 1979; Potter and Shrewsbury, unpubl.
Polyphemus moth	Lepidoptera	Saturniidae	*Antheraea*	*polyphemus*	Krombein, 1979; Potter and Shrewsbury, unpubl.
Carolina mantis*	Mantodea	Mantidae	*Stagmomantis*	*carolina*	Potter and Shrewsbury, unpubl.
Owlfly	Neuroptera	Ascalaphidae	*Ululodes* sp.		Burks, 1967.
Bush crickets / katydids	Orthoptera	Tettigoniidae	*Microcentrum* sp.		Krombein, 1979.

***new record of *A. reduvii* emerging from this egg host**

Host Plants- Meta-analysis

- **Current and previous Shrewsbury lab data, and related literature**
- **Summarize *A. reduvii* associations with different host plants**
- **Determine correlations with different host plants and host plant features**

Anastatus reduvii Host Plants

*Shrewsbury lab preliminary data

Common Name	Genus	Species	Cultivar
Red Sunset® Maple	*Acer*	*rubrum*	'Franksred'
Legacy Sugar Maple	*Acer*	*saccharum*	'Legacy'
Tree of Heaven	*Ailanthus*	*altissima*	
Hackberry	*Celtis*	*occidentalis*	
Eastern Red Bud	*Cercis*	*canadensis*	
Tulip Poplar	*Liriodendron*	*tulipifera*	
Inkberry	*Llex*	*glabra*	
Magnolia	*Magnolia sp.*		
Mulberry	*Morus sp.*		
Kwanzan / Ornamental Cherry	*Prunus*	*serrulate*	'Kwanzan'
White Oak	*Quercus*	*alba*	
Swamp White Oak	*Quercus*	*bicolor*	
Scarlet Oak	*Quercus*	*coccinea*	
Black Locust	*Robinia*	*pseudoacacia*	
Great Wall™ Lilac	*Syringa*	*pekinensis*	'WFH2'
Beijing Gold Pekin Lilac	*Syringa*	*pekinensis*	'Zang Zhiming'
Littleleaf Linden	*Tilia*	*cordata*	
American Elm	*Ulmus*	*americana*	'Princeton'
Chinese Elm	*Ulmus*	*parviflora*	'Patriot'

Interspecific and intraspecific interactions of native *Anastatus reduvii*, an egg parasitoid of the brown marmorated stink bug (BMSB), *Halyomorpha halys* Stål (Hemiptera: Pentatomidae)

See presentation at the Eastern Branch ESA meeting
(by Alina Avanesyan et al.; available starting March 22nd

Main objective:

To investigate th
reduvii in the pr
another *A. reduv*
presence of *Tris*
of BMSB in Asi

We specifically focused on the following:

- Time spent by *A. reduvii* ON and OFF the egg mass
- Various behavior performed by *A. reduvii* ON and OFF the egg mass and its changes in the presence of other parasitoids
- Effect of host-feeding and probing/ovipositing, performed by *A. reduvii,* on the BMSB egg fate

UNIVERSITY OF MARYLAND

Outlook for native natural enemies as biological control agents for BMSB

- Levels of predation and parasitism vary by habitat type
- Arboreal habitats tend to have greater rates of parasitism
- Row and vegetable crops, and wood edges tend to have greater levels of predation
- However, overall the impact of parasitoids and predators is low

- Identification and implementation of practices to increase biological control impacts are necessary
  - Augmentative releases of parasitoids
  - Habitat modifications targeting dominant natural enemy species for various habitat types (ex. incorporating plants that provide alternative hosts or resources)
  - Use of low risk pesticides

Thank You

It’s time for a few polling questions