Distribution and impact of *Trissolcus japonicus* and status of petition to release quarantined populations

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Collaborating Institutions

NC STATE UNIVERSITY
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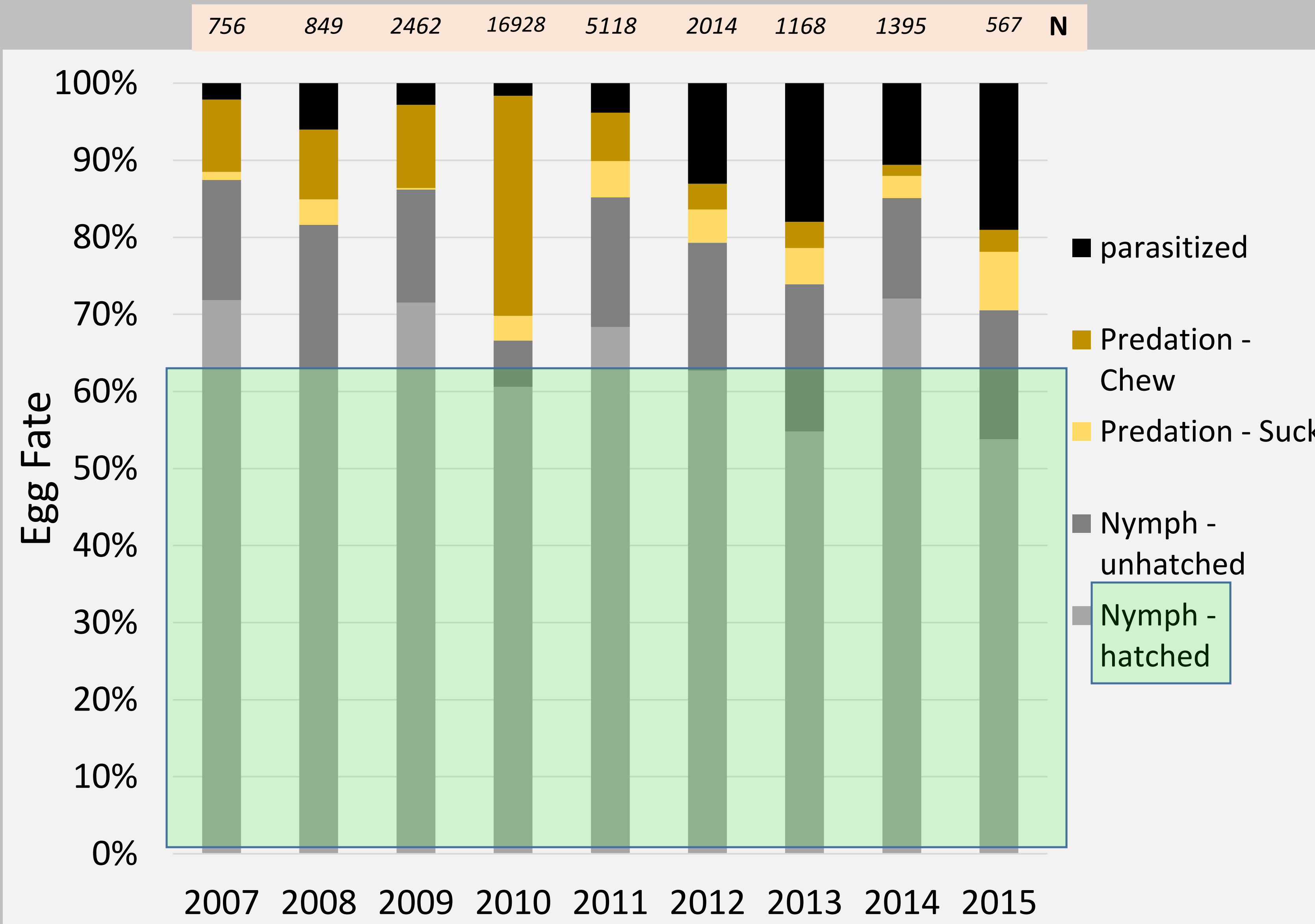
Delaware

Fate of naturally laid **BMSB** eggs

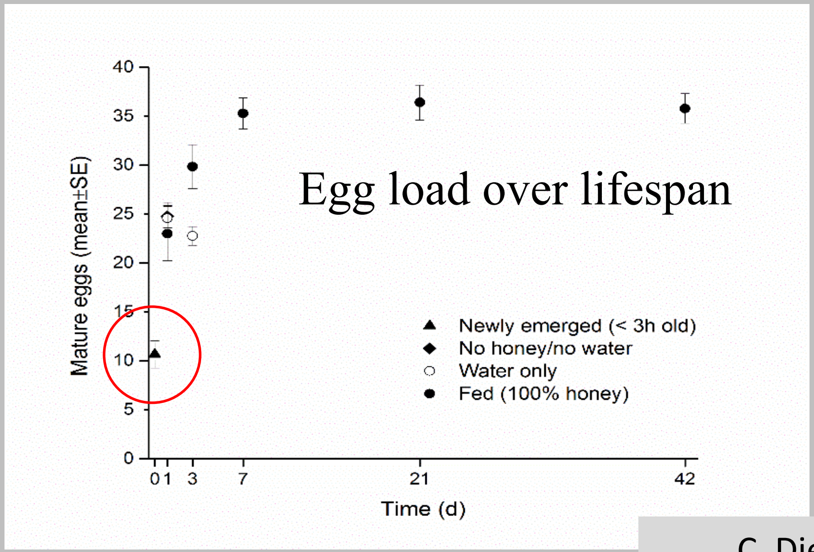


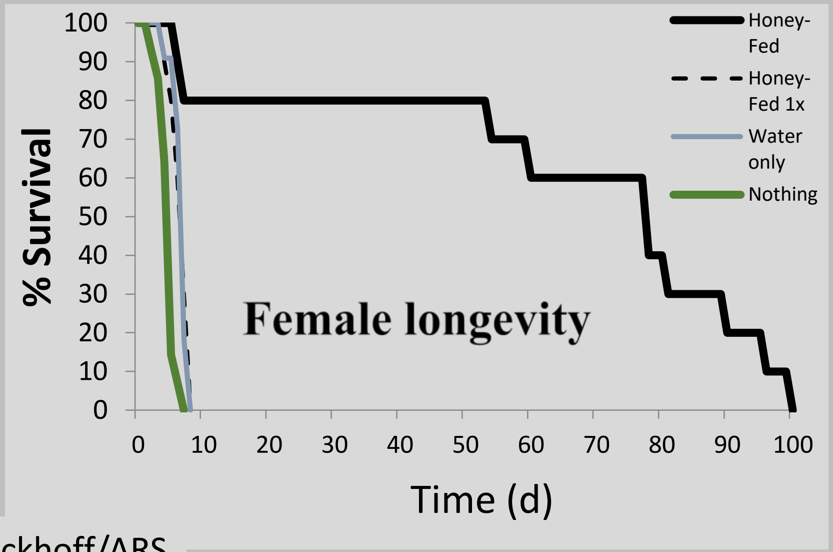
Trissolcus japonicus

"samurai wasp"

Trissolcus japonicus
(Hym.: Scelionidae)

- solitary egg parasitoid
- high % of eggs in mass attacked
- 2 - 3 weeks / generation
- multiple generations/season
- female-biased sex ratio
- 65 to 90% BMSB parasitism in Asia





C. Dieckhoff/ARS

Summary – *T. japonicus* in Asia:

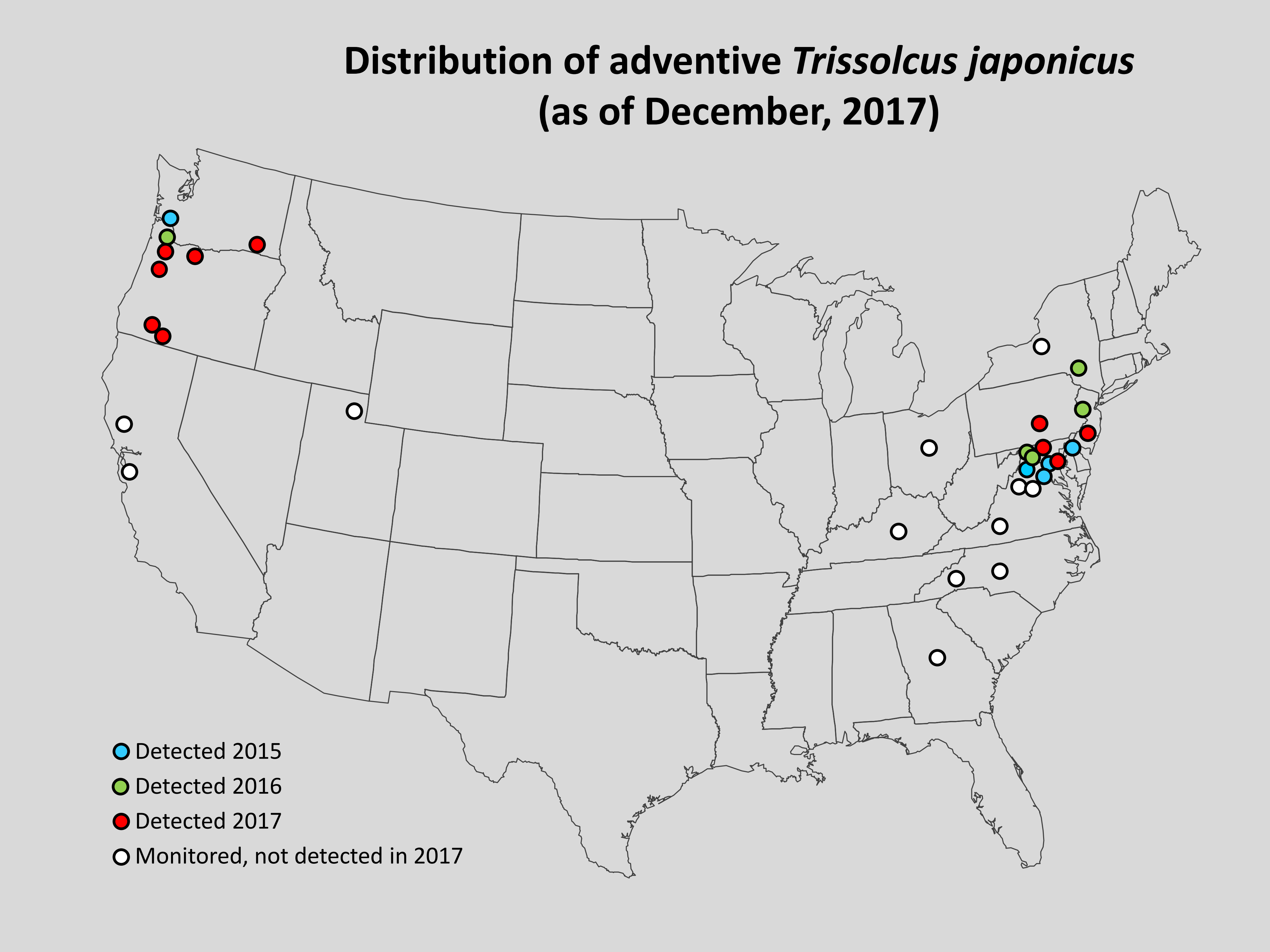
- *T. japonicus* is the dominant parasitoid species on BMSB throughout the season on different host plants
- Other species (e.g., *Anastatus, Ooencyrtus*, tachinid flies) are of minor importance in limiting BMSB
- Ecological host range of *T. japonicus* contains other species in these habitats*, e.g. Plautia* and *Dolycoris*
- *T. japonicus* is an oligophagous species, thus non-target attacks is likely of other stink bugs, risk-benefit analysis needed for classical biocontrol

Why is a Risk Assessment Needed?

NAPPO (and APHIS) Guidelines for Petitions for First Release of Arthropod Pest Biological Control Agents:

General Requirements

1. Proposed Action
2. Target Pest Information
3. Biological Control Agent Information
4. Host-Specificity Testing
5. Environmental and Economic Impacts of Proposed Release
6. Post-Release Monitoring


Distribution of adventive *Trissolcus japonicus*
(as of December, 2017)
Detected 2015
Detected 2016
Detected 2017
Monitored, not detected in 2017

Parasitized egg masses recovered from sentinel egg canopy transects

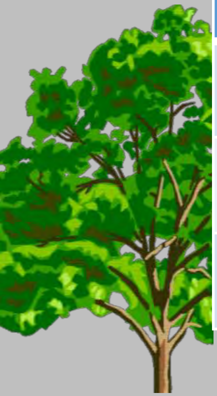
2016:

- 135 egg masses deployed
- 4.4% (n = 6) of egg masses parasitized
- 2.2% (n = 3) of egg masses parasitized by *T. japonicus* (mid and upper canopy)

2017:

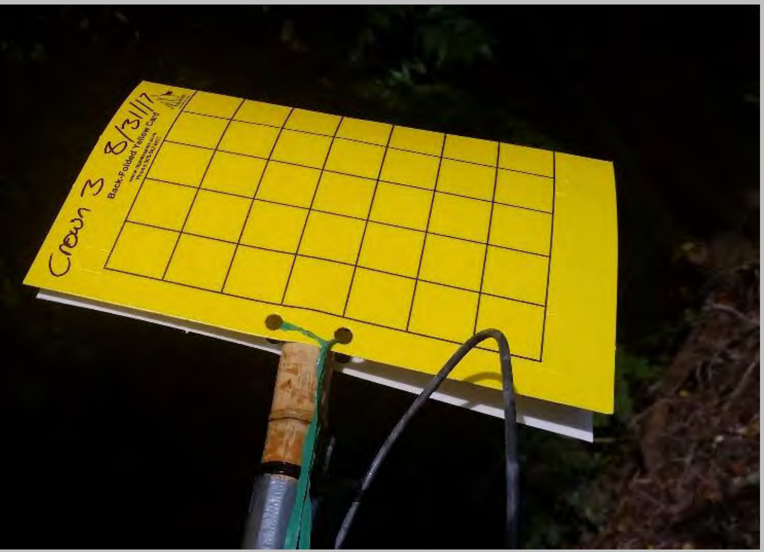
- 105 egg masses deployed
- 2.86% (n = 3) of egg masses parasitized
- 0.95% (n = 1) of egg masses parasitized by *T. japonicus* (upper-canopy)

Destructive Sampling in VA BMSB Egg Mass Locations (2016 & 2017)



Canopy Location	Total # egg masses 	# Egg masses yielding *T. japonicus* 	# Egg masses yielding other parasitoids 	# Egg masses previously parasitized 
Upper	13	3	0	0
Middle	**28**	**7**	**3**	**3**
Lower	10	0	0	1

Numerically, but not significantly, greater levels of parasitism at mid-canopy
(Fisher's exact test, df = 6; p=0.27)



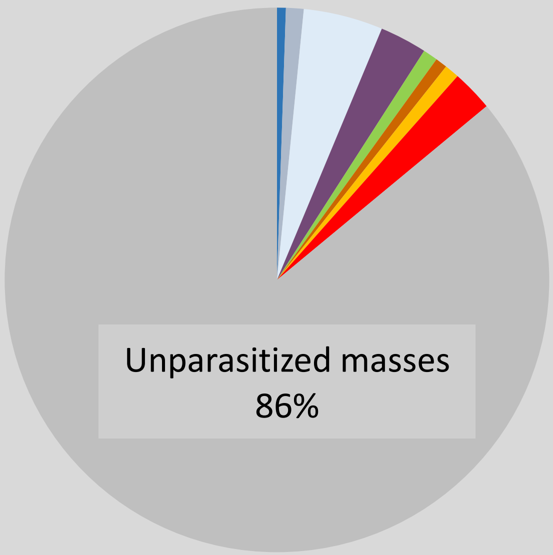
1. Assembly:
Sticky traps attached to 4.8m poles

2. Deployment:
At mid-canopy for 7 days

3. Processing:
Parasitoids removed and identified

BIIRU Newark 2017 Sentinel Egg masses (placed on foliage)

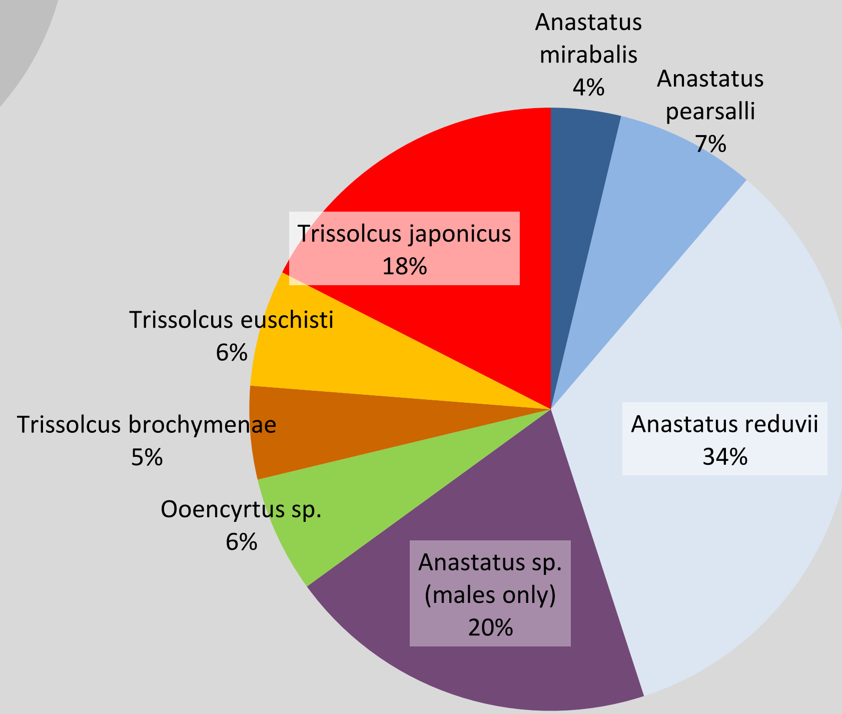
Egg mass fate



N placed = 572

N parasitized = 80 (14.0% of total)

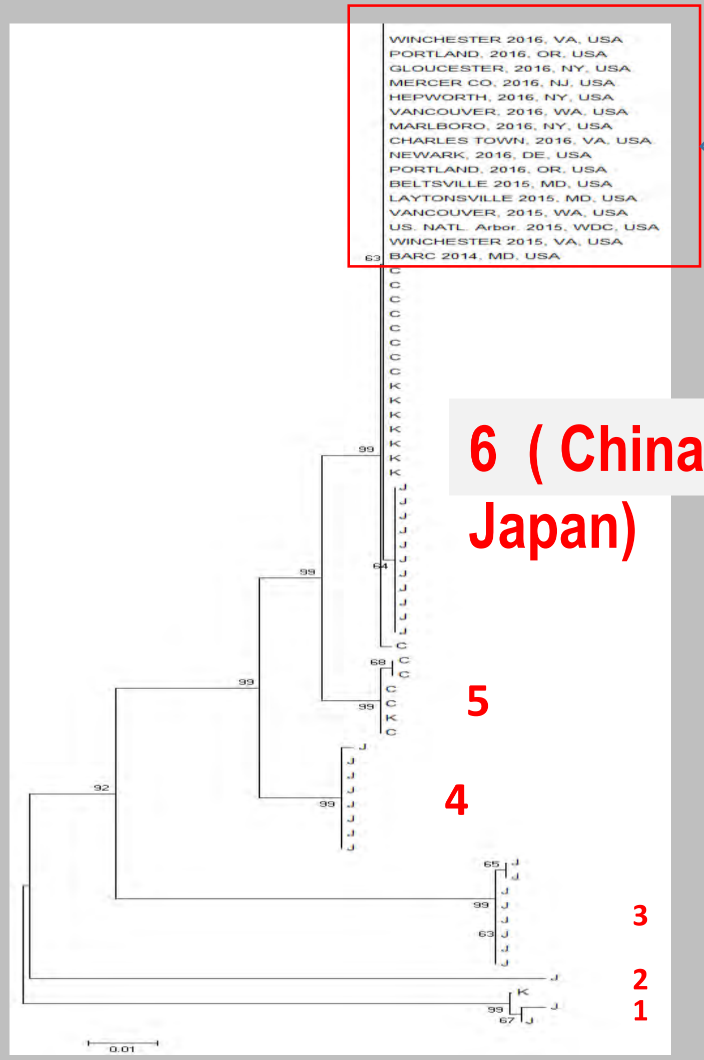
N with 2 or more parasitoid spp. emerged = 8



Emerged Parasitoid Species Composition

COI **(barcode gene) insights:**

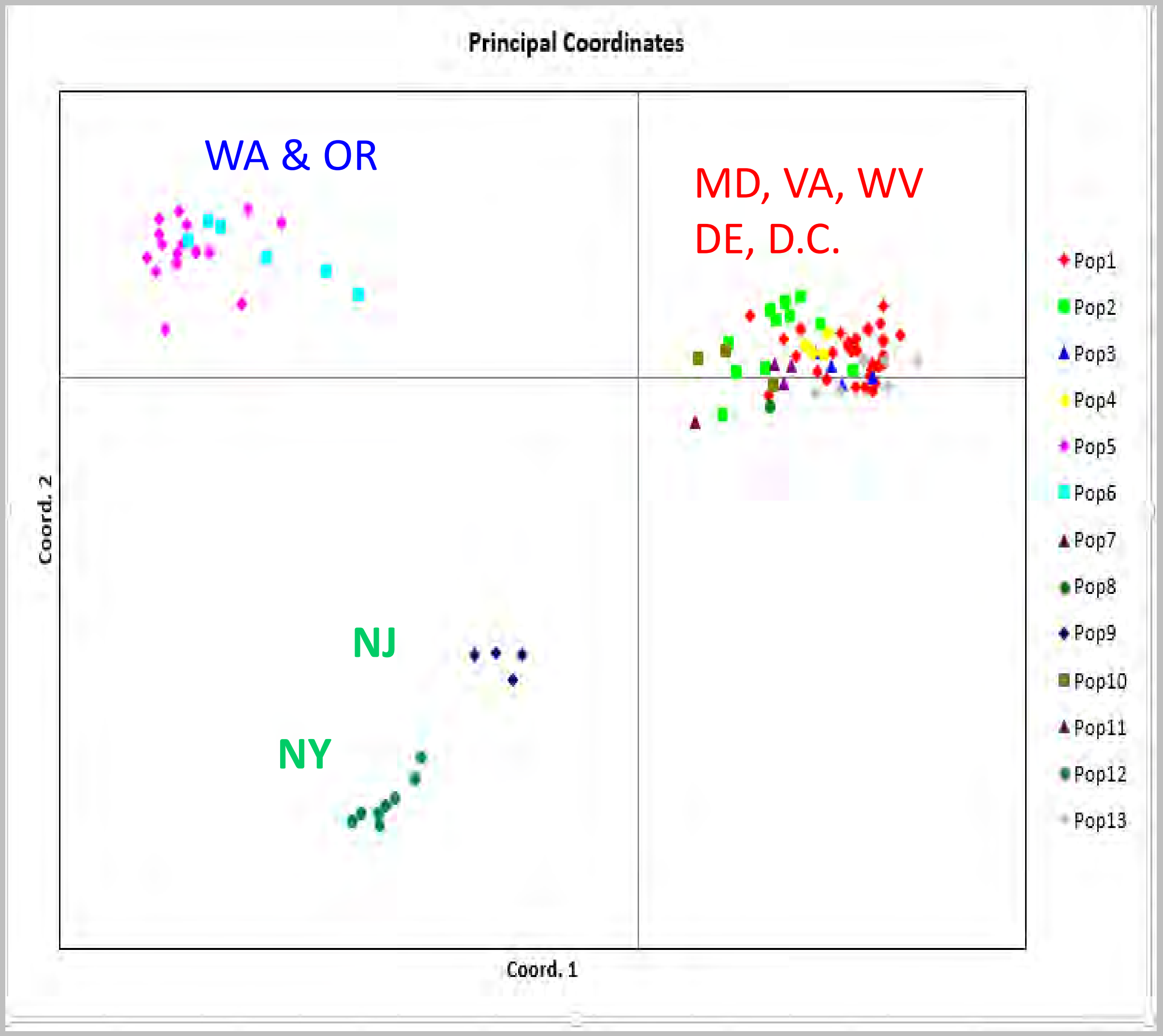
- ✓ Genetic diversity of *T. japonicus* in Asia is structured in six major lineages
- ✓ Lineage 6 is the most widely distributed in Asia
- ✓ All U.S. adventive populations belong to lineage 6
- ✓ No significant variability among U.S. adventive populations



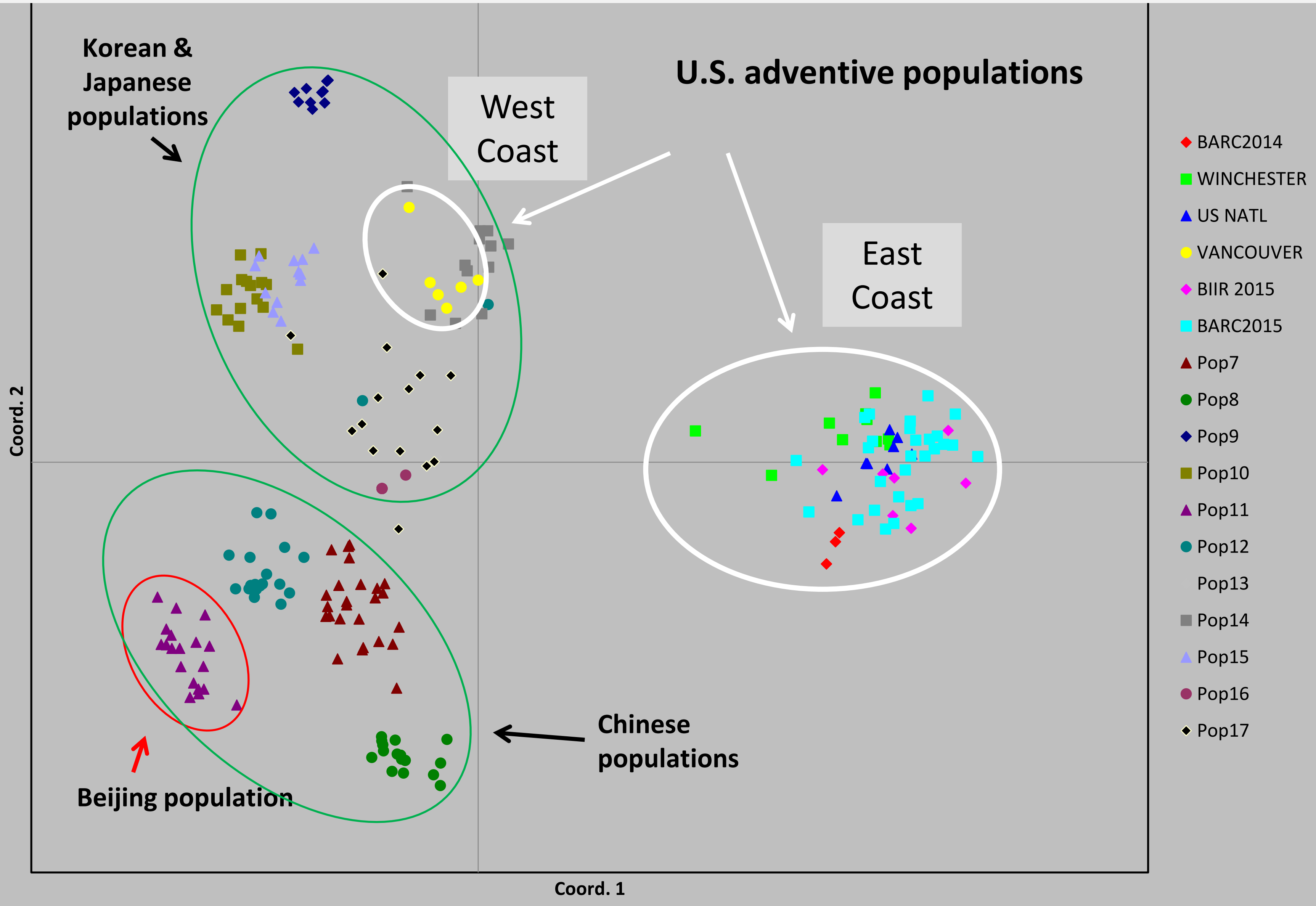
All U.S. recovered populations (2014-2017)

6 (China, Korea, Japan)

PCoA of 115 specimens recovered in U.S. & haplotyped



Principal coordinate analysis (PCoA) of haplotype diversity of 23 microsatellite markers in *T. japonicus* (through 2015)



Cornell University

Hudson Valley Research Laboratory

Redistributions of *Trissolcus japonicus* within states

Over 60 egg clusters placed on 16 farms in 27 sites in 6 NY State counties in 2017 (Peter Jentsch)

APHIS policy on redistribution of *T. japonicus*

- APHIS regulates movement (including redistribution) *between* state lines but not *within* States.

- What is their policy about moving established adventive *T. japonicus* between states?
  - APHIS Permits Group has discussed permitting the movement of "feral" *T. japonicus* and made preliminary notes for a proposal to articulate what policy would be.
  - However, it was not finished or taken "up the line" for official approval.

- Further response from APHIS is pending…

Status of Petition for field release of *T. japonicus* (Beijing population)

- Non-target attack laboratory data required addition research to evaluate the effect of environment and parasitoid behavior on attack of non-targets
- Researchers in the U.S. and in Canada are proceeding with (hopefully) concurrent Petitions for Field Release
  - Time line: submission by this spring?
  - Concurrent approach may strengthen the case for approval

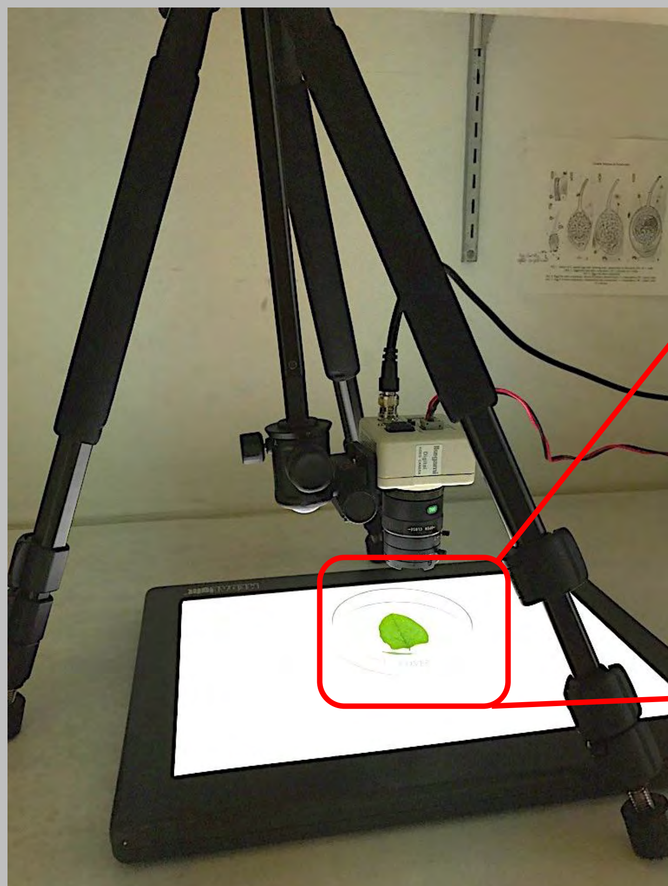
What is the impact of attack on non-target species?

lower

- Host egg killed from stinging, but without oviposition, or partial (but unsuccessful) development of parasitoid
- Host egg killed with *occasional* full development and emergence of adult parasitoid
- Viable offspring, but mostly male
- Reproductive females produced
- **Exotic enemy displaces a native enemy**

higher

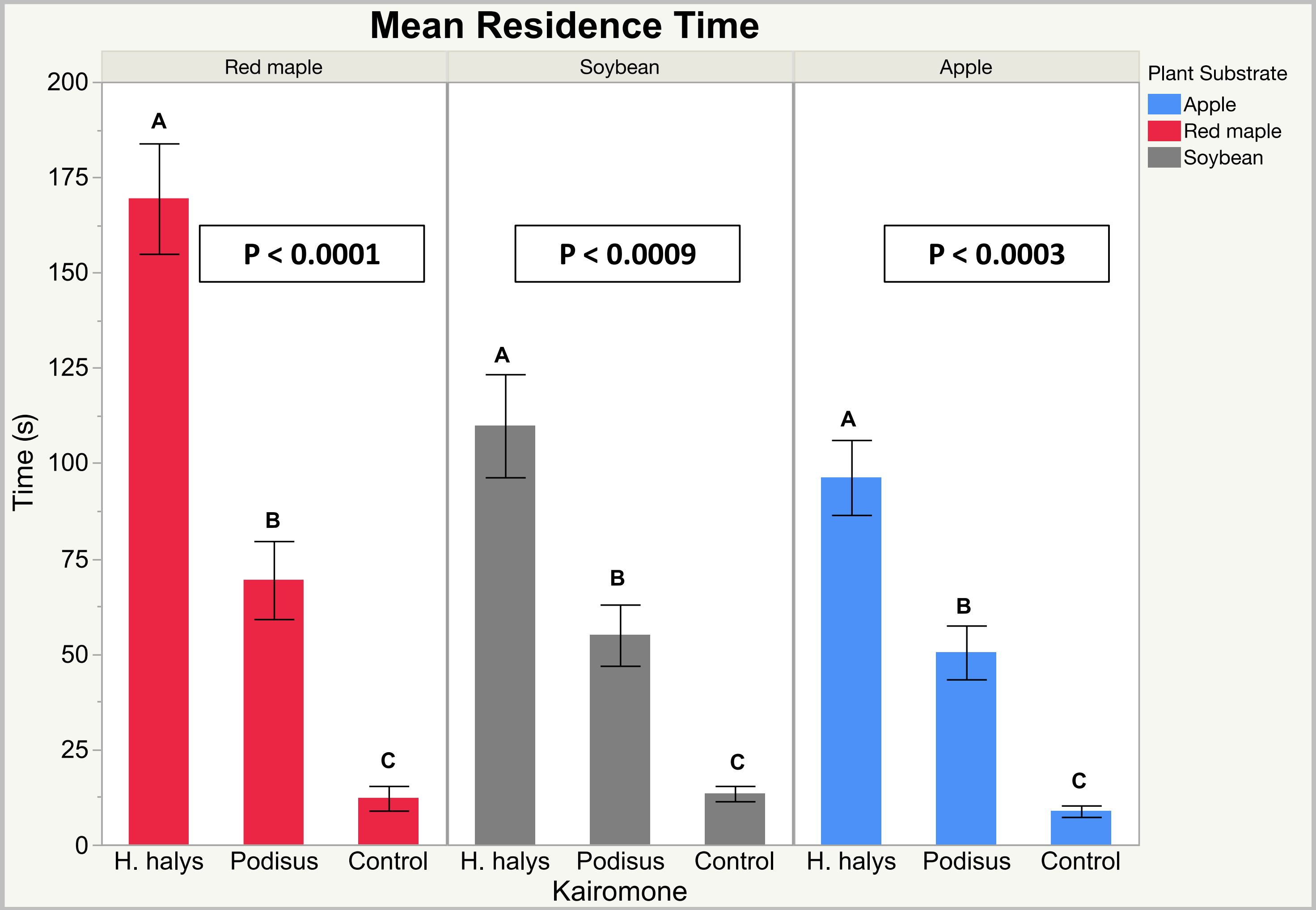
T. japonicus Behavioral Assays
MSc thesis research of Sean Boyle, Univ. Delaware

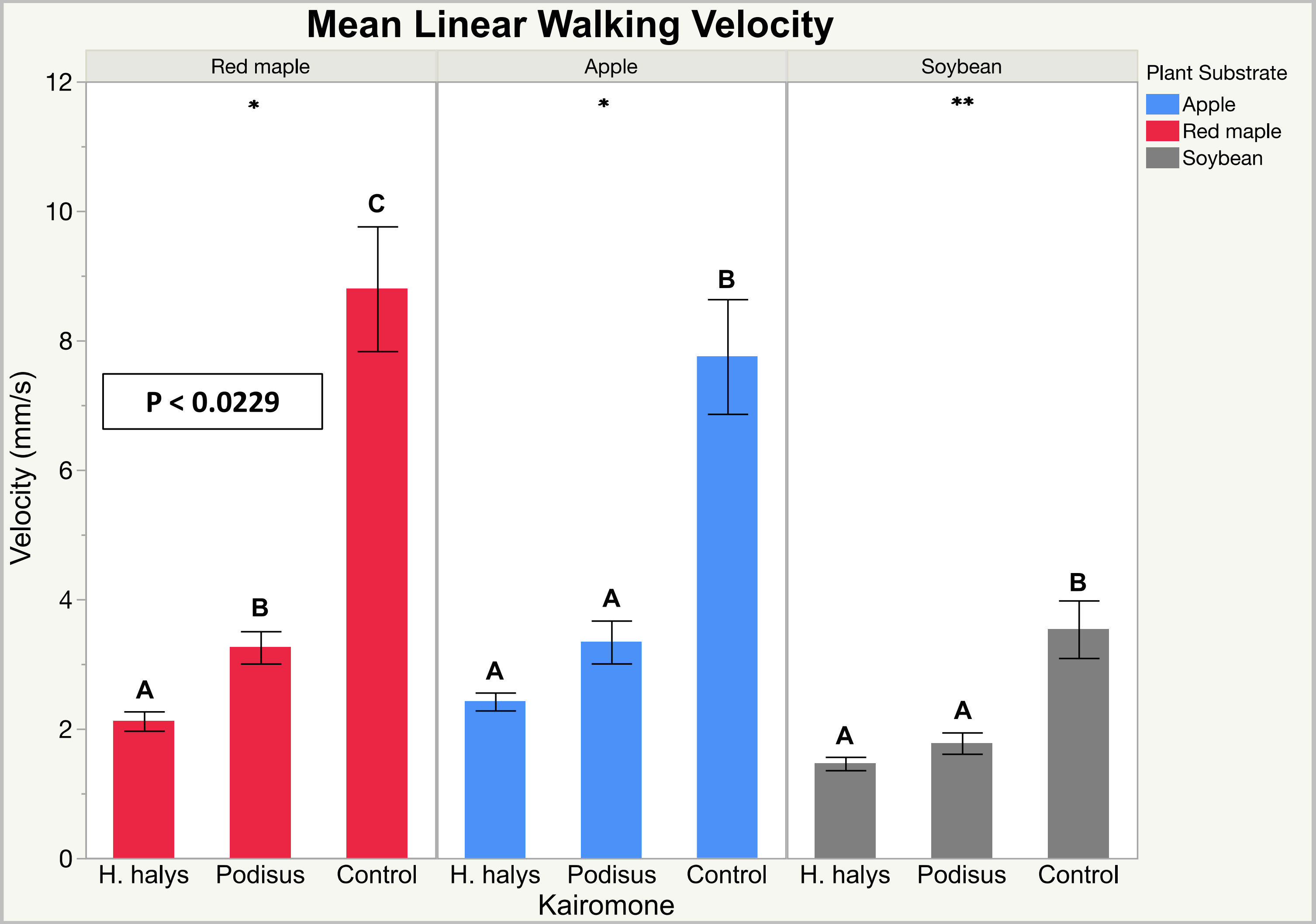


Experimental Design

60 mm petri dish arena

Ethovision XT 8.0 (Noldus Technologies)


Mean Residence Time
Red maple
Soybean
Apple
Plant Substrate
Apple
Red maple
Soybean
200
175
150
125
100
75
50
25
0
Time (s)
A
B
C
P < 0.0001
P < 0.0009
P < 0.0003
H. halys
Podisus
Control
Kairomone



Mean Linear Walking Velocity
Red maple
Apple
Soybean
Plant Substrate
Apple
Red maple
Soybean
*
*
**
P < 0.0229
Velocity (mm/s)
0
2
4
6
8
10
12
A
B
C
A
A
B
A
A
B
H. halys
Podisus
Control
H. halys
Podisus
Control
H. halys
Podisus
Control
Kairomone

Experimental Set-Up: No-choice tests

Kairomone contamination of *P. vulgaris* leaf surfaces with 2 gravid female stink bugs

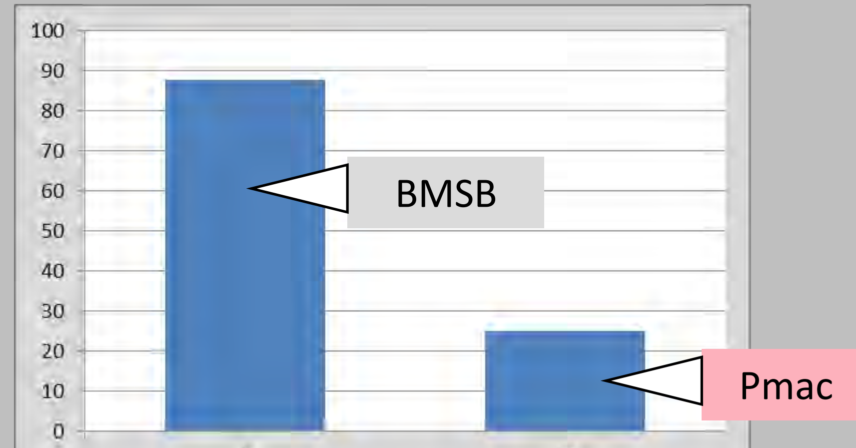
Attach *H. halys* or *P. maculiventris* egg mass to contaminated plant

24 h exposure of H- or P-strain *T. japonicus* females (mated, naïve, 3-5 days old)

Searching in cage arena for egg mass

Single BMSB or Pmac Egg Mass exposed inside cage arena

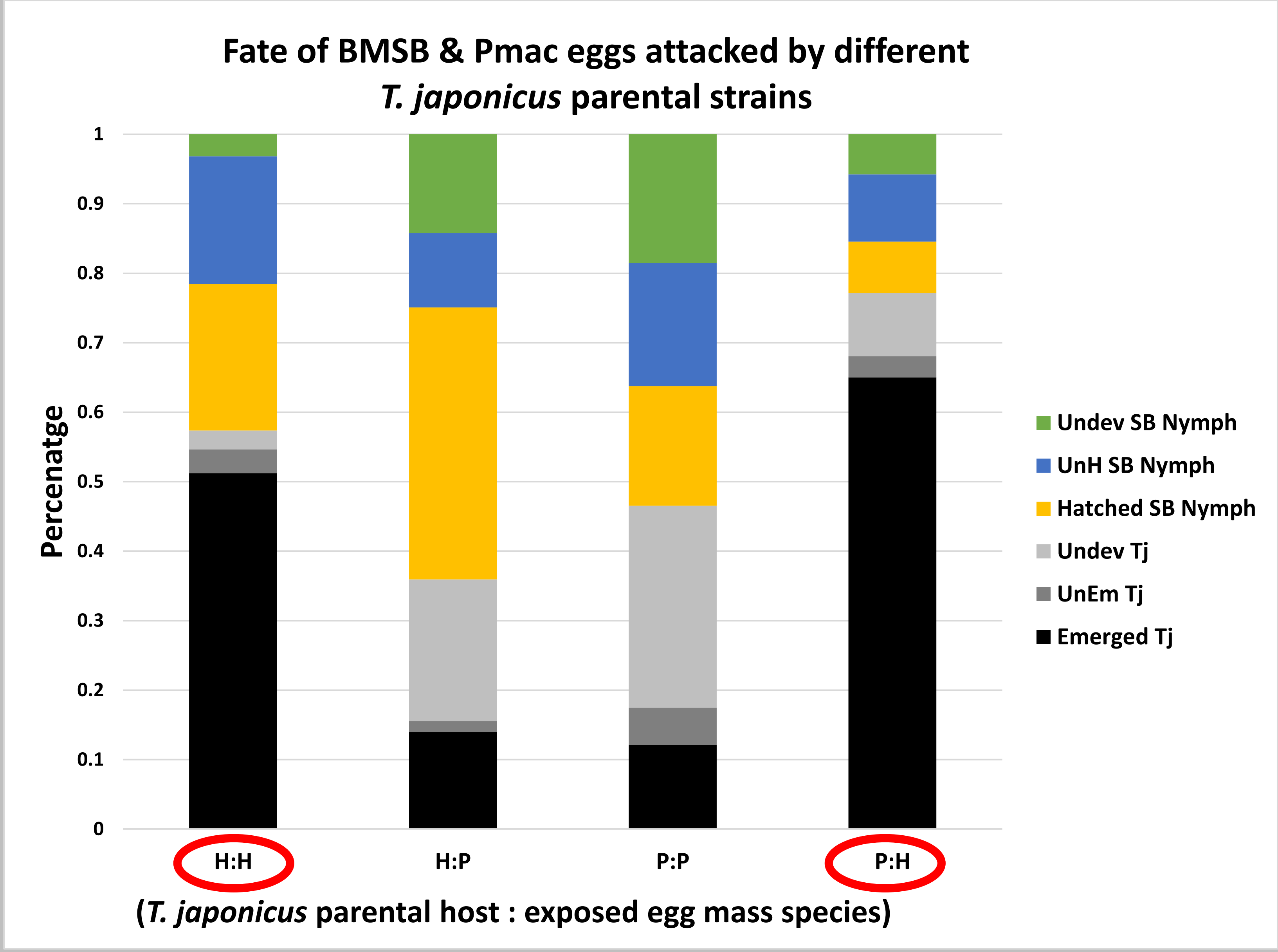
Parent female *T. japonicus* reared from either BMSB or Pmac



T. japonicus reared from BMSB host

T. japonicus reared from Pmac host

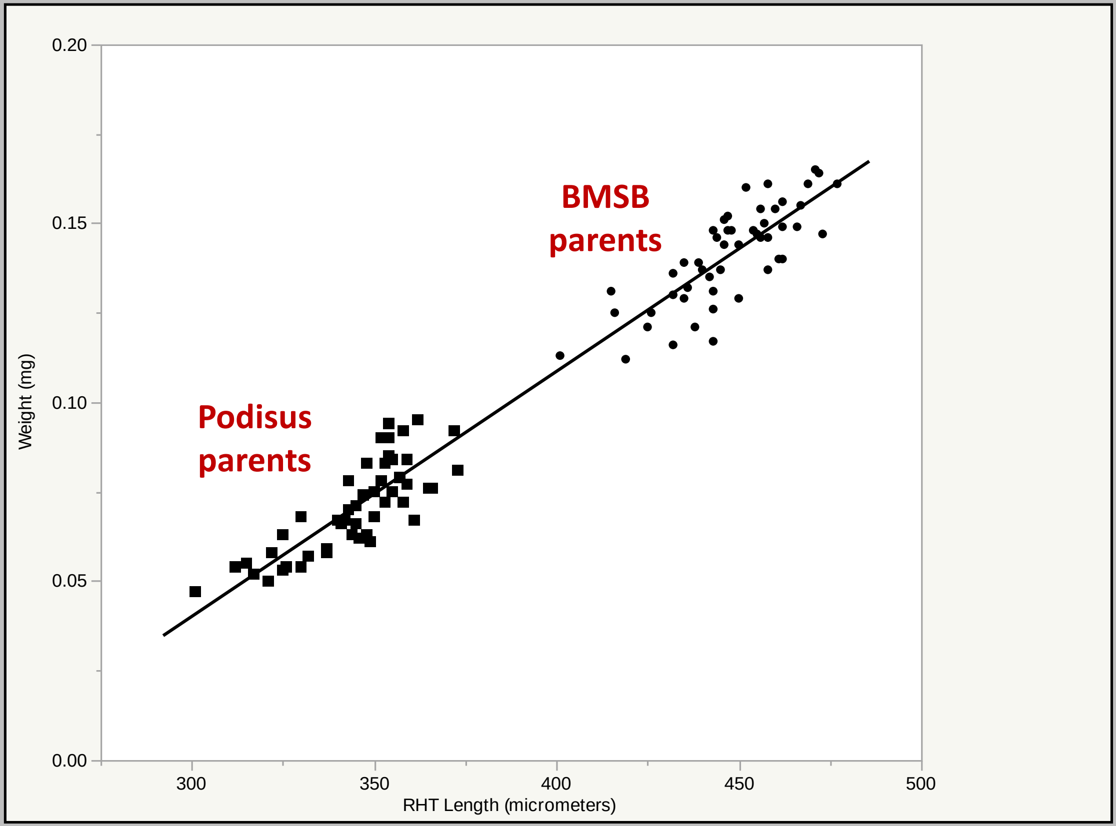
Percent of Egg Masses Attacked



Fate of BMSB & Pmac eggs attacked by different
T. japonicus parental strains
Percenatge
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
H:H
H:P
P:P
P:H
(T. japonicus parental host : exposed egg mass species)
Undev SB Nymph
UnH SB Nymph
Hatched SB Nymph
Undev Tj
UnEm Tj
Emerged Tj

Parasitoid Size

(using right hind tibia length as indicator)



- BMSB-host wasps possessed 30% longer HLT (***P* < 0.0001**)
- BMSB-host wasps weighed over twice as much as Podisus-parent wasps (***P* < 0.0001**)
- Strong positive correlation between *T. japonicus* HTL length and weight (**R^2=0.957; *P* < 0.0001**)

Continuing research with *T. japonicus*

- What is the distribution of *T. japonicus*?
  - Continue deploying sticky traps farther afield
- Do Tj prefer to forage on some host plants compared with others?
  - Lab and semi-field assays
    - Host plant effects on % parasitism and attack rates
    - Response of Tj to host plant volatiles
    - Mark-release-recapture
- Where does Tj overwinter?
- Is Tj attacking non-targets?

Implications of adventive populations

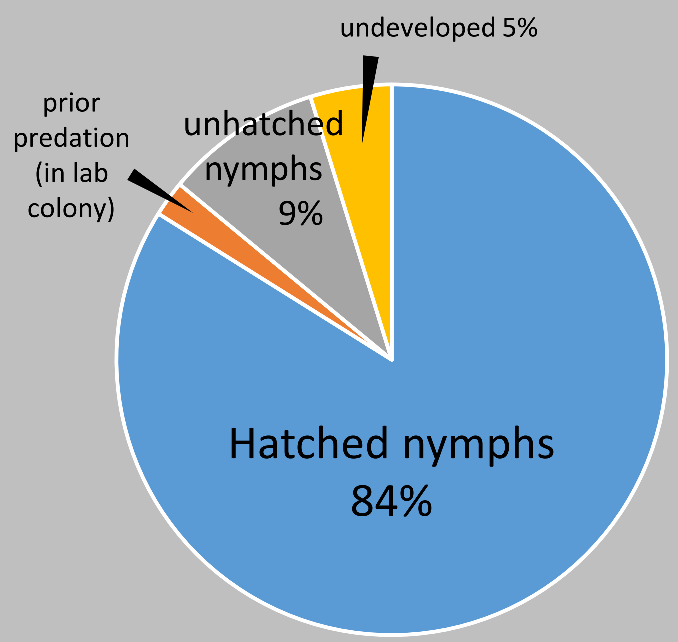
- What will be impact of competition with indigenous parasitoids and predators? Will native natural enemies be affected negatively?
- How will they impact non-target stink bugs and other spp.?
- Several states already proceeding to redistribute populations within their boundaries.
- Given the adventive populations, should preparations be continued for a Petition to Release the Beijing quarantine population?

Comparison of parent female wasps reared from BMSB vs. SSB (*P. maculiventris*)

Parasitized Egg Masses

Parental host species	Exposed egg mass species	*n parasitized* (> 50% parasitism)	% suitable egg masses	% Emerged parasitoids
H. halys	*H. halys*	18 (17)	94.4	84.8 ± 16.4
H. halys	*P. maculiventris*	6 (4)	66.7	69.2 ± 20.2
P. maculiventris	*H. halys*	22 (20)	90.9	73.7 ± 18.6
P. maculiventris	*P. maculiventris*	8 (3)	37.5	44.1 ± 26.5

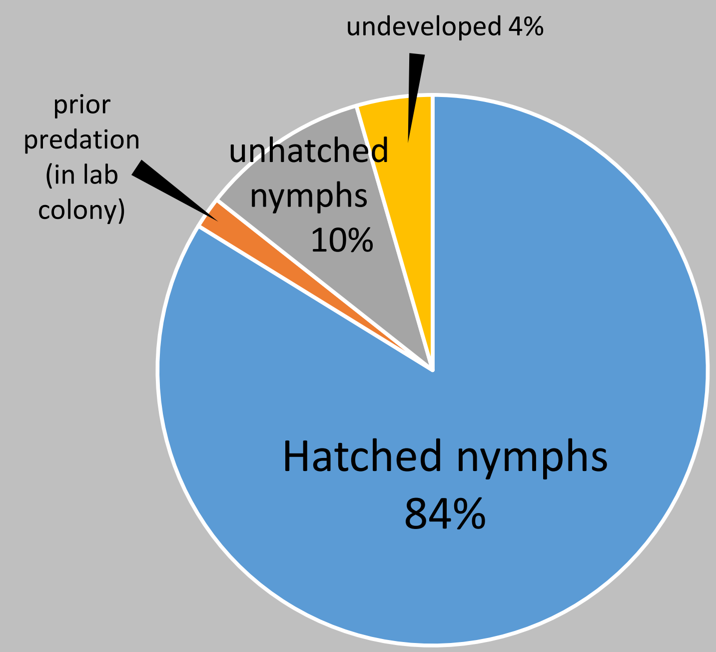
Fate of Control BMSB Eggs in Field (within mesh cages)



N = 115 egg masses with 3,125 eggs total

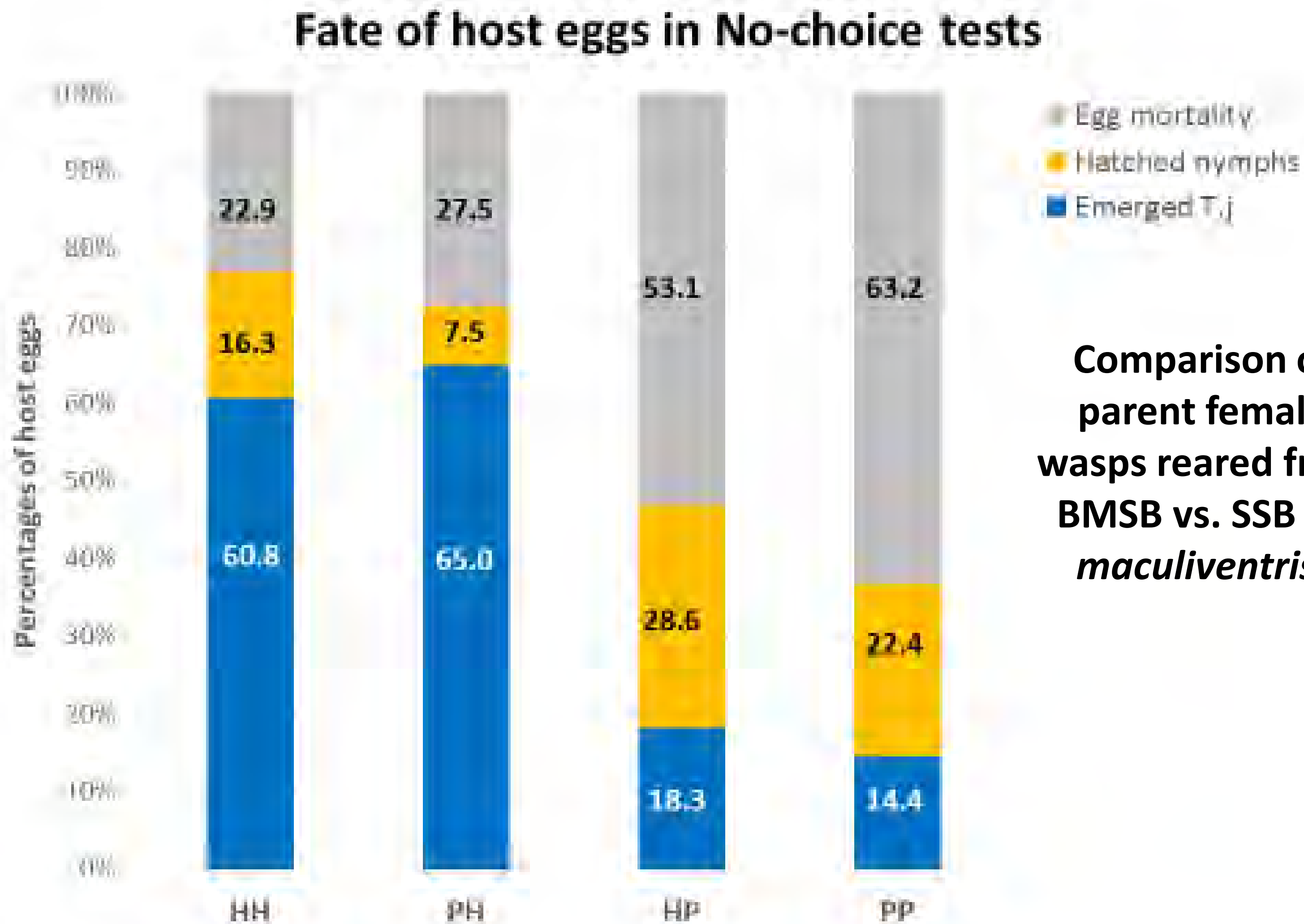
22 egg masses (19%) had 100% hatch of nymphs

Fate of BMSB Egg Controls Kept in Laboratory



N = 62 egg masses with 1,677 eggs total

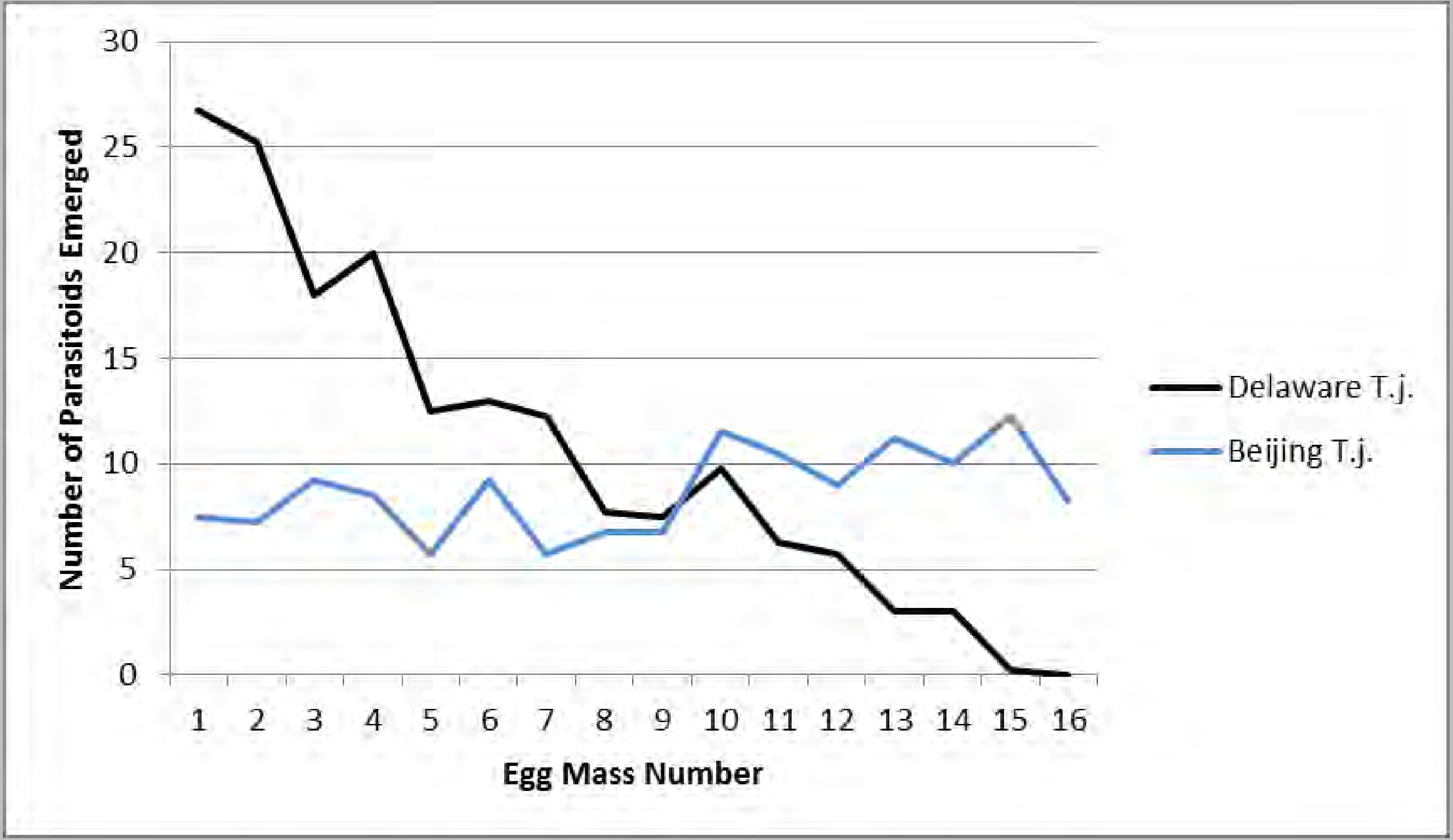
13 egg masses (21%) had 100% hatch of nymphs



Comparison of parent female wasps reared from BMSB vs. SSB (*P. maculiventris*)

Status of Biological Control In North America:

- **Regional surveys (ongoing) to document the occurrence & impact of natural enemies:**
  - Overall low levels of parasitism
  - Impact varies according to habitat
  - Predation is often more important than parasitism
- **Studies in conservation biological control to increase impact of native predators and parasitoids**
  - Border plantings, trap crops, insectary plants
- **Will native natural enemies adapt to BMSB over time?**
  - Why are native parasitoids poorly adapted to BMSB?
  - Can adaptation be enhanced via laboratory selection?



F1 progeny from ≤ 24 hr. old Delaware & Beijing *T. japonicus* females, each given 16 BMSB egg masses successively (a new egg mass every 48 hours).
Delaware *T. japonicus* had ~89% parasitism rate (~28 eggs per egg mass) for the first 8 days (4 egg masses) which then tapered off, while the Beijing *T. japonicus* did not exceed 38% parasitism rate over any 8 day period.

(preliminary data from Zach Schumm, UD)