BIOLOGICAL CONTROL OF BMSB (PREDATORS & PARASITOIDS)

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Predators	**Family**	**Stage Attacked**
Astata species	Crabronidae	late instars & adults
Bicyrtes quadrafaciata	Crabronidae	late instars & adults
katydids	Tettigoniidae	eggs
Green Lacewing larvae	Chrysopidae	Eggs, 1st instars
Geocoris sp.	Geocoridae	eggs
Harmonia axyridis	Coccinellidae	eggs
Arilus cristatus	Reduviidae	nymphs & adults
Spiders	various	nymphs & adults
Earwigs	Forficulidae	eggs

Anastatus spp.

Trissolcus spp. M. Buffington

Ooencyrtus spp. BT Cutting

Anastatus spp.	Eupelmidae
Anastatus pearsalli	Eupelmidae
Anastatus reduvii	Eupelmidae
Anastatus mirabilis	Eupelmidae
Gryon obesum	Scelionidae
Telenomus podisi	Scelionidae
Telenomus utahensis	Scelionidae
Trissolcus euschisti	Scelionidae
Trissolcus utahensis	Scelionidae
Trissolcus hullensis	Scelionidae
Trissolcus brochymenae	Scelionidae
Trissolcus edessae	Scelionidae
Trissolcus thyantae	Scelionidae
Ooencyrtus spp.	Encyrtidae

Egg parasitoids reported from BMSB in North American surveys

Anastatus reduvii

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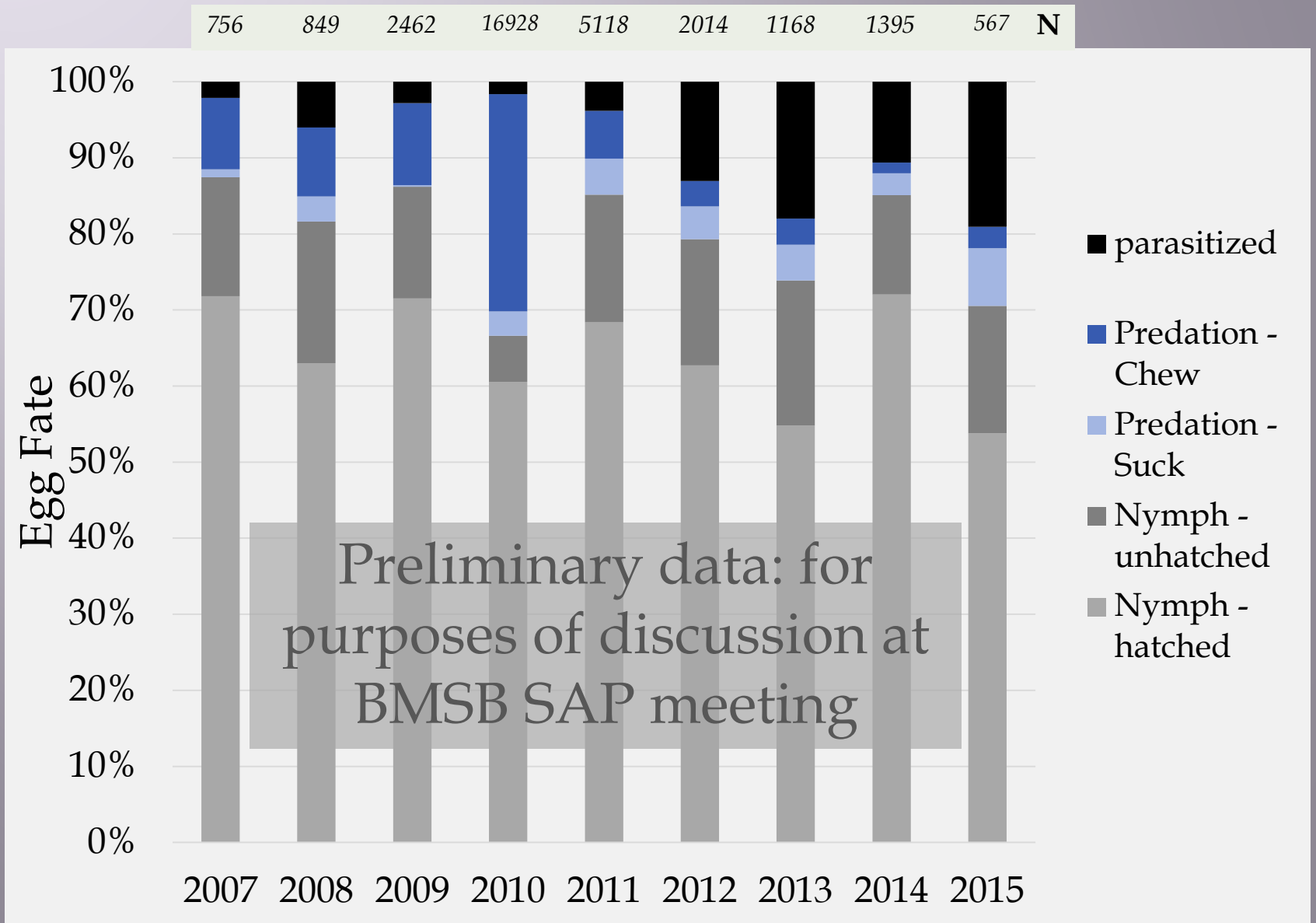
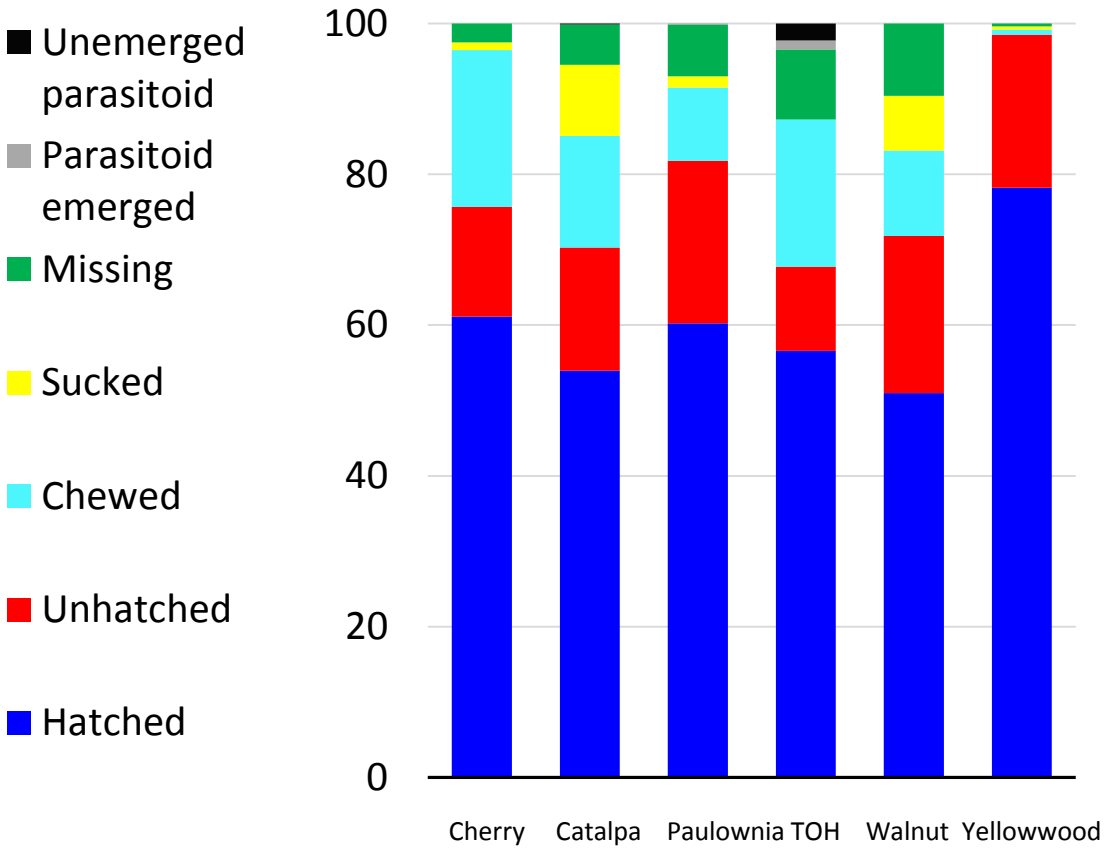
Tachinid flies reported from adult BMSB in North American surveys

Fate of naturally laid BMSB eggs

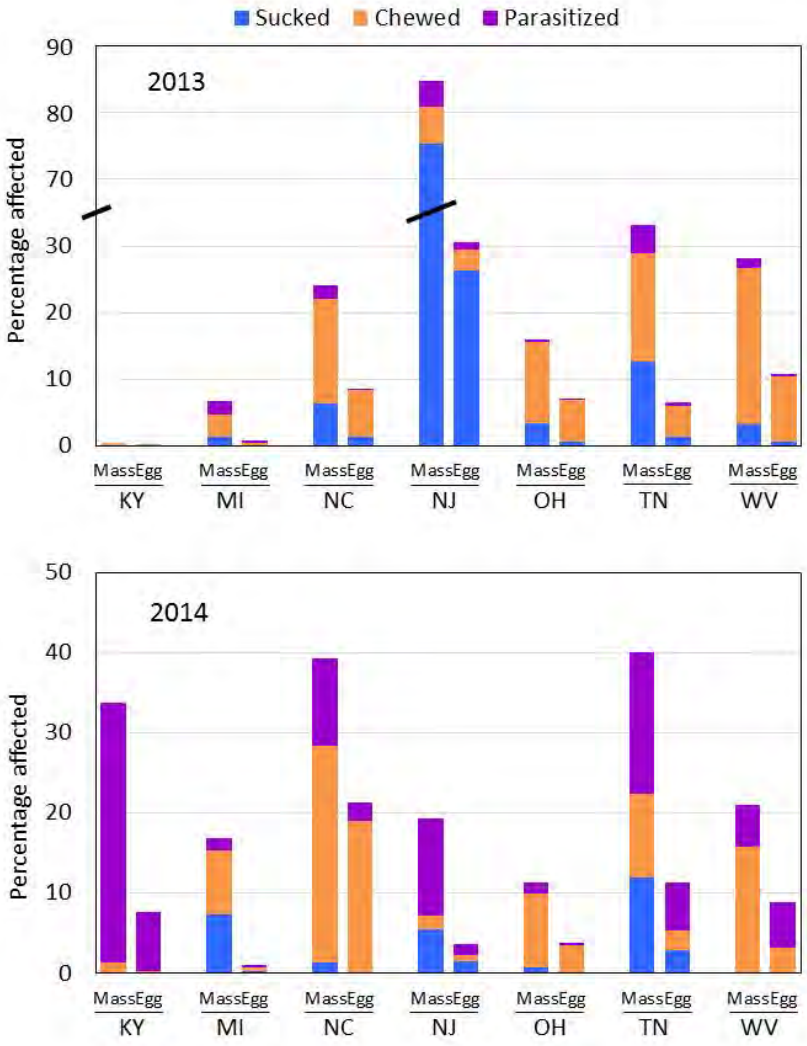


Fate of Sentinel & Naturally Laid BMSB Eggs on Trees in Non-Managed NC Habitats

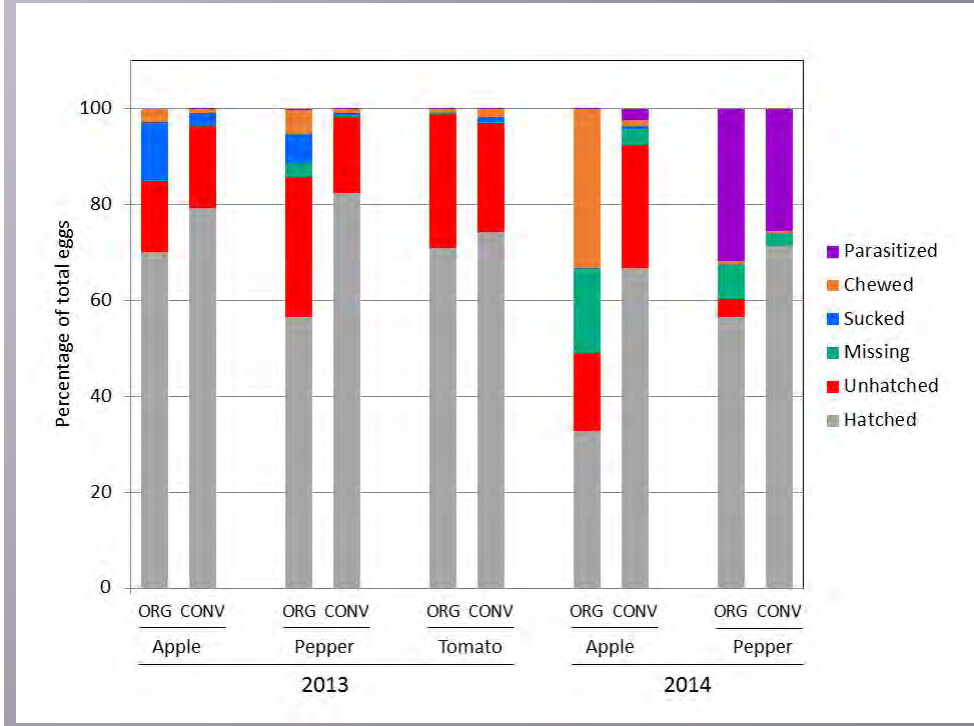


2014

Predator/Parasitoid Impact on BMSB Eggs / Egg Masses in Organic Crops by Region

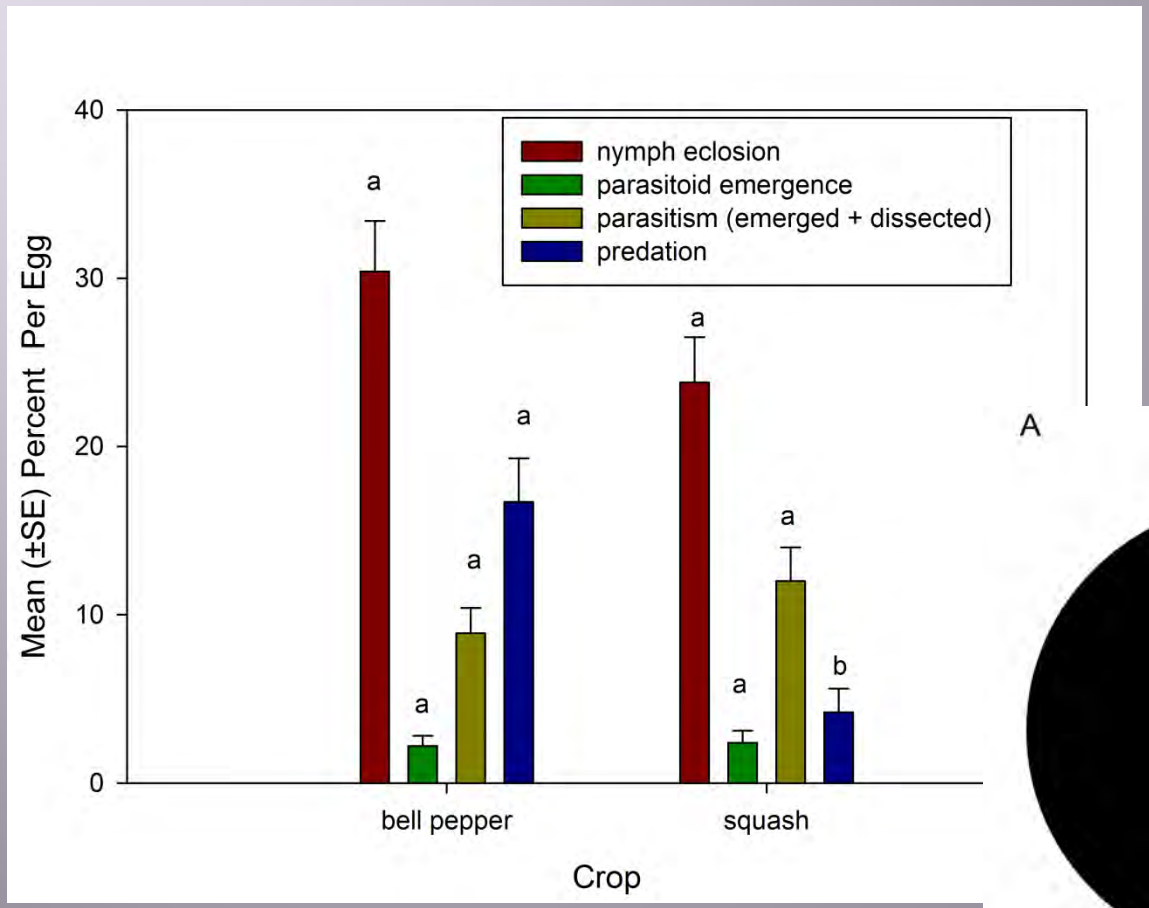


Masses (L) vs. Individual Egg (R) Fate

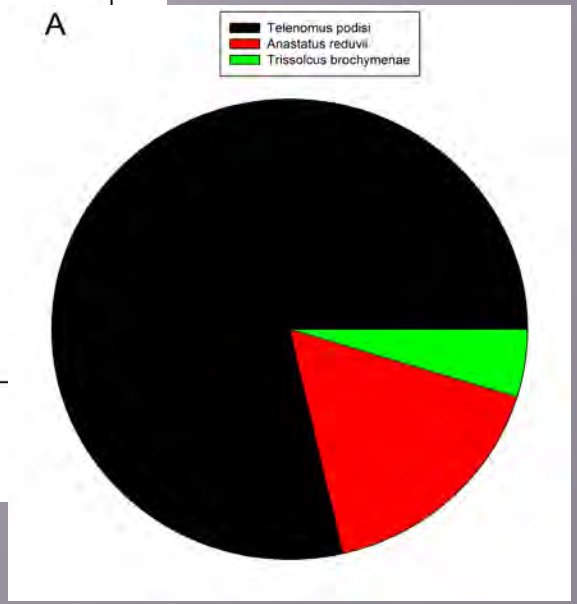


Ogburn et al. – 2016, Biol. Control

Fate of BMSB eggs on Vegetable crops (ARS/BARC)



Telenomus dominates in field crops



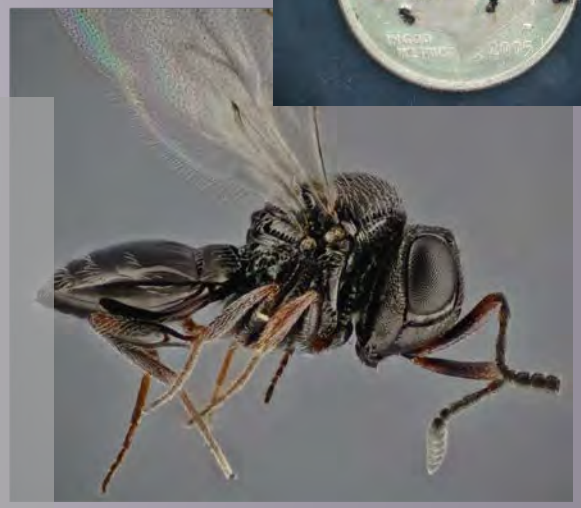
M. Cornelius et al., 2016 – Env. Entomol.

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?

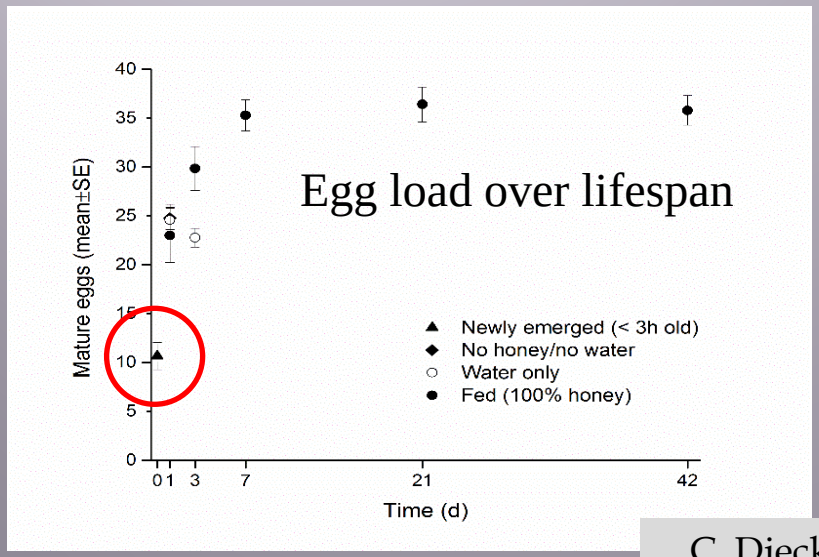
Exploration for Asian parasitoids of BMSB

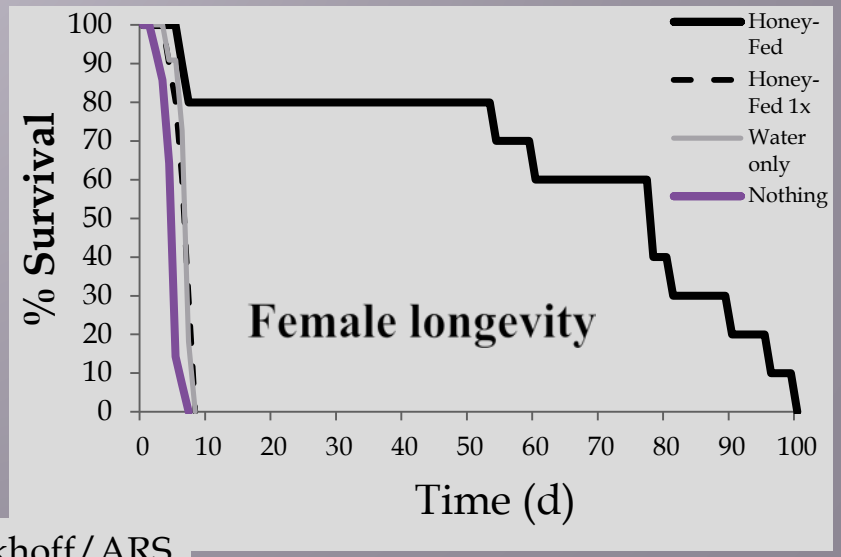
Trissolcus japonicus (Hym.: Scelionidae)



- **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**

Preliminary data: for discussion at BMSB SAP meeting





C. Dieckhoff/ARS

NAPPO Guidelines for Petitions for First Release of Arthropod Pest Biological Control Agents

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

Trissolcus japonicus attacks several pentatomid species in Asia

Halyomorpha halys

Glaucias subpunctatus

Plautia crossota

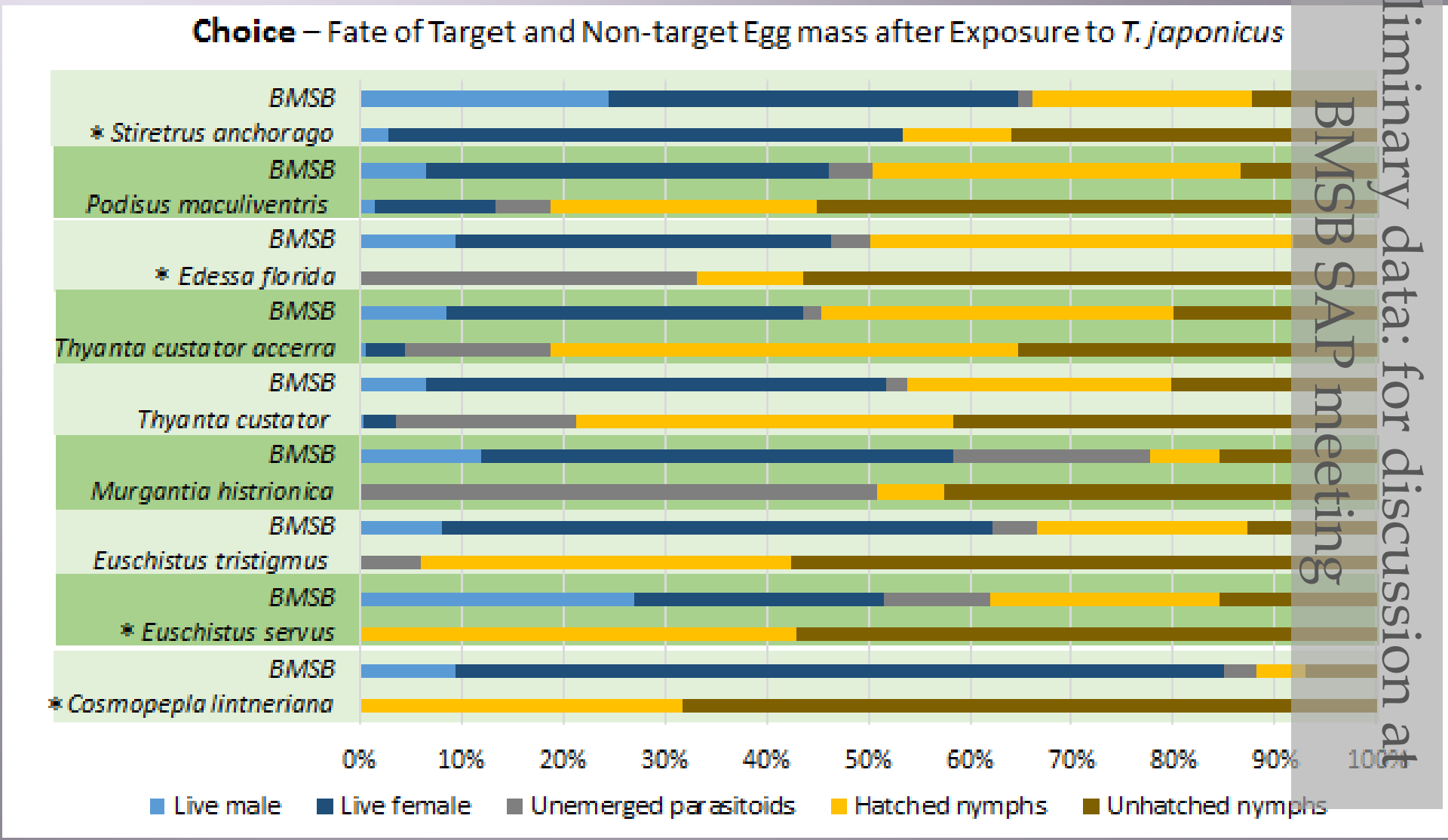
Dolycoris baccarum

Erthesino fullo

Summary – In Asia:

- *T. japonicus* is the dominant 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 likely of other stink bugs, risk-benefit analysis needed

Choice Test Outcome (as of 2015, Newark BIIR)



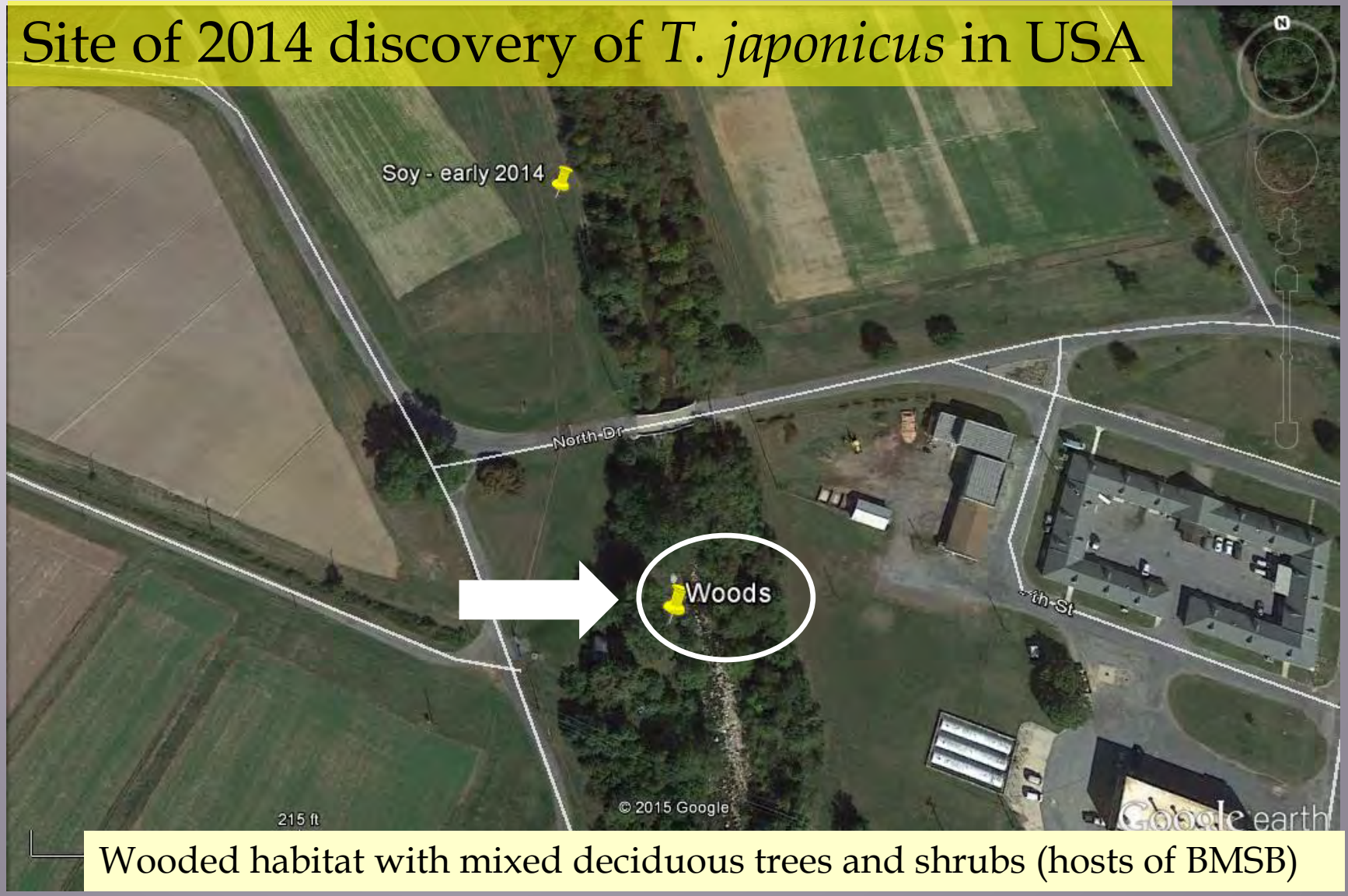
Preliminary data: for discussion at BMSB SAP meeting

Recovery of adventive *Trissolcus japonicus* in the U.S.

a game changer?

ARS BARC, Beltsville MD

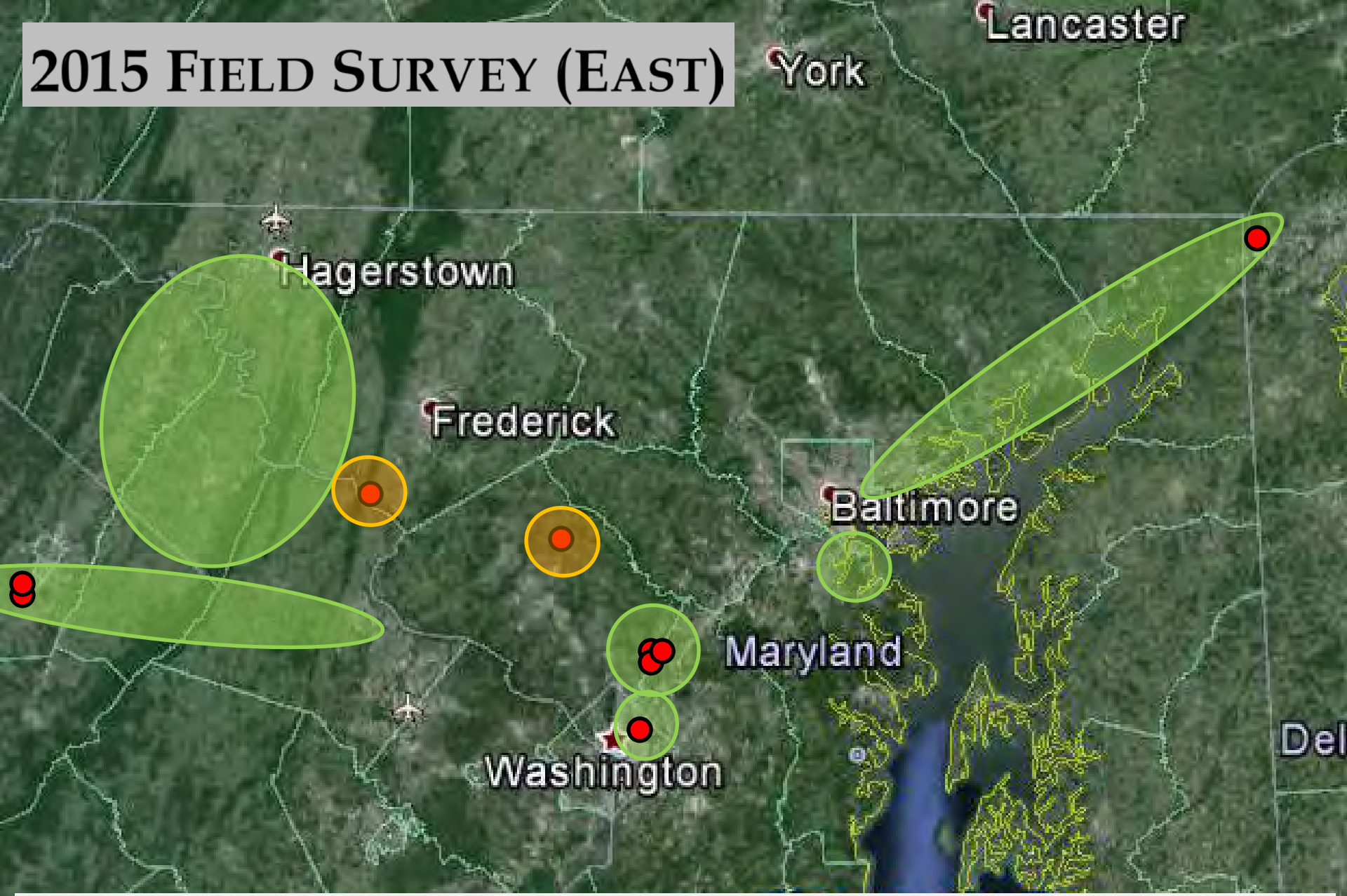
Site of 2014 discovery of *T. japonicus* in USA



Wooded habitat with mixed deciduous trees and shrubs (hosts of BMSB)

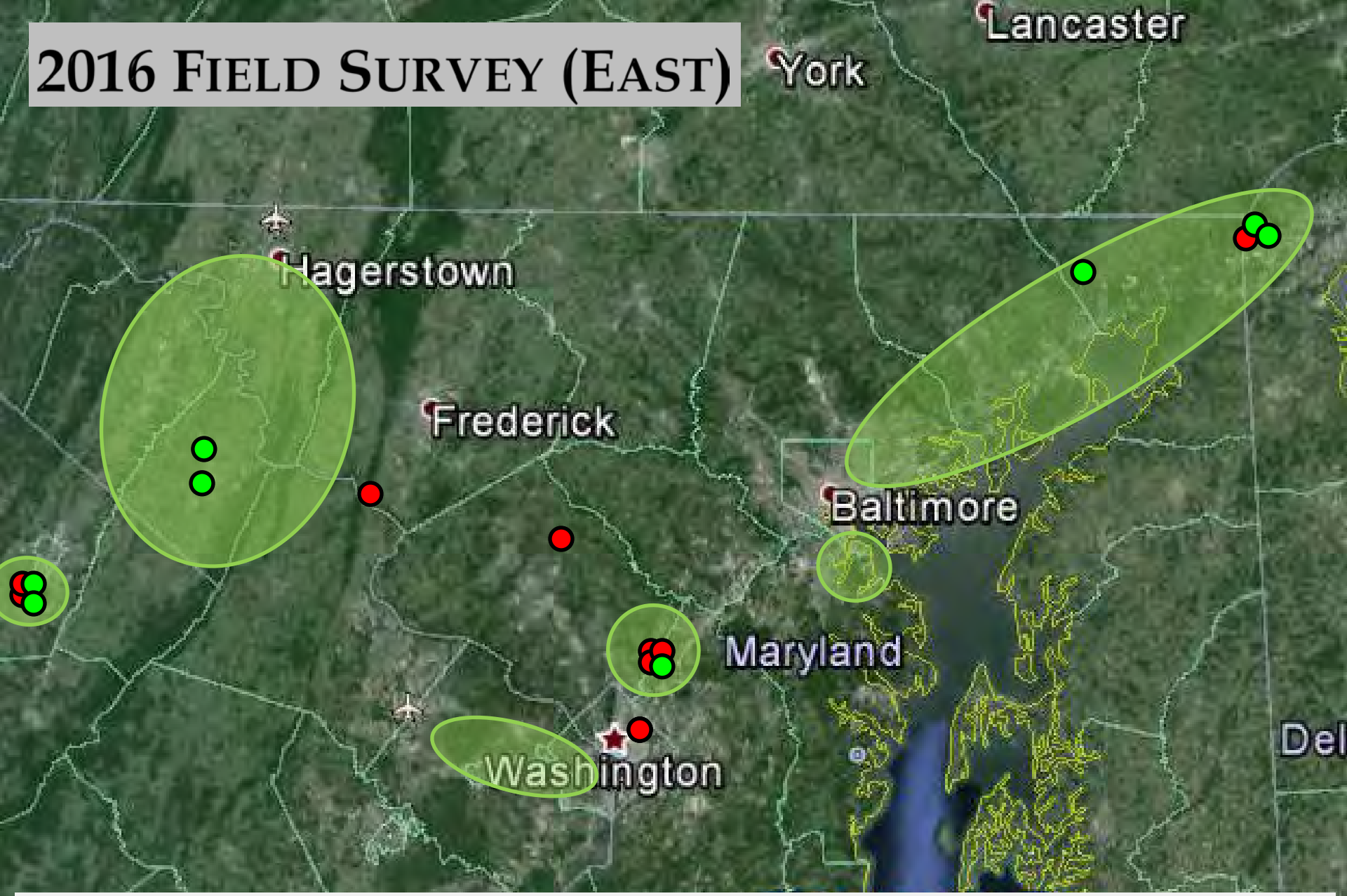
2014 Recovery site at BARC

Wooded habitat with mixed deciduous trees and shrubs host to BMSB



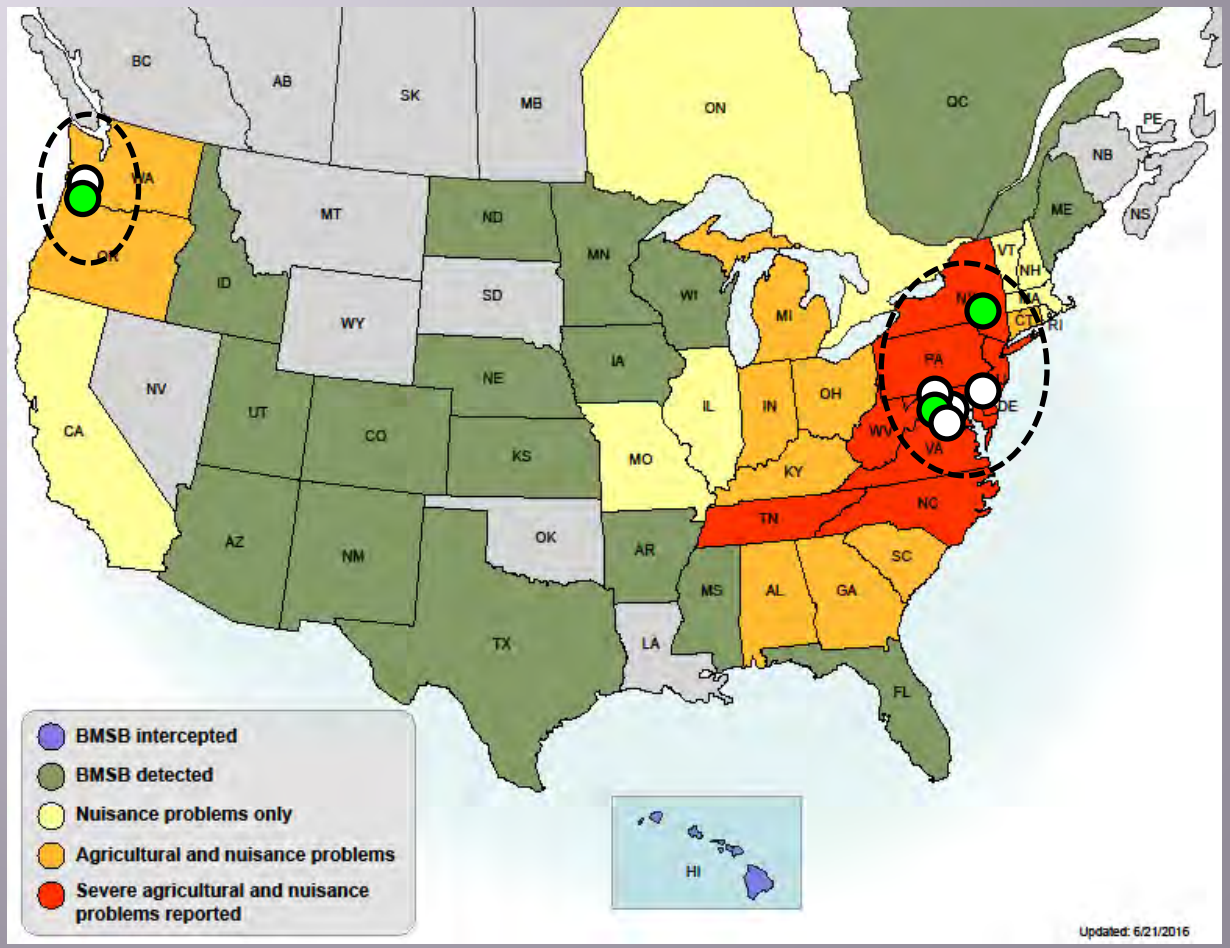
T. japonicus now found in: MD, D.C., VA, DE (east coast) and WA (west coast)

Recoveries were made from BMSB (sentinel & wild), *Podisus* and *Thyanta*



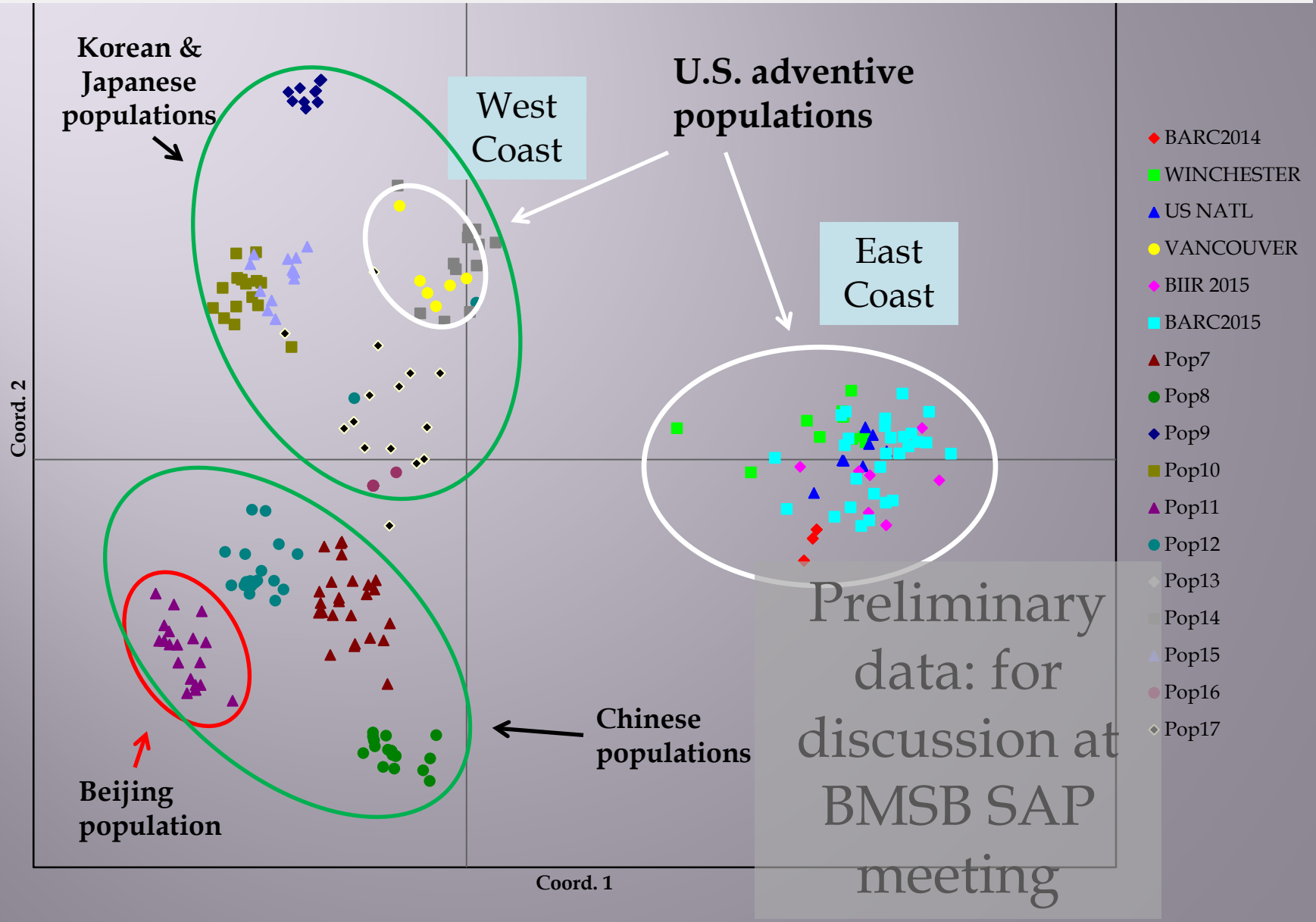
T. japonicus now in: MD, D.C., VA, WV, DE (east coast) & OR, WA (west coast)
2016 Recoveries were all from BMSB (sentinel & wild)

Field recoveries of *Trissolcus japonicus* (as of Sept. 2016)



New sites in 2016

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



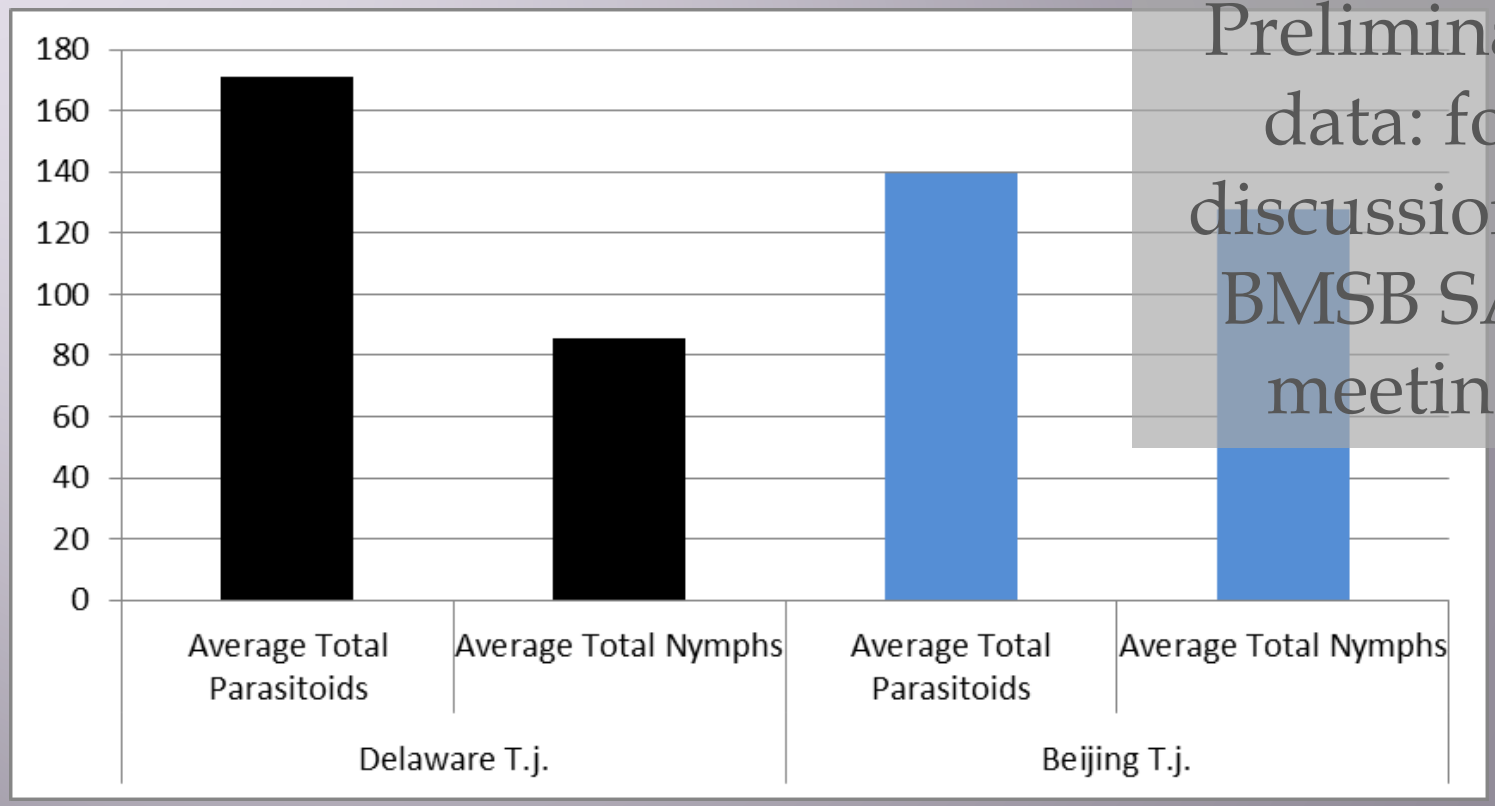
Preliminary data: for discussion at BMSB SAP meeting

Implications of adventive populations

- Wider surveys needed to monitor its spread
- Monitor its impact in the field on BMSB & non-targets
- APHIS regulates all interstate movement
- Continue preparation for a Petition to Release the Beijing quarantine population

Reproductive Output

Adventive vs. Beijing *T. japonicus*

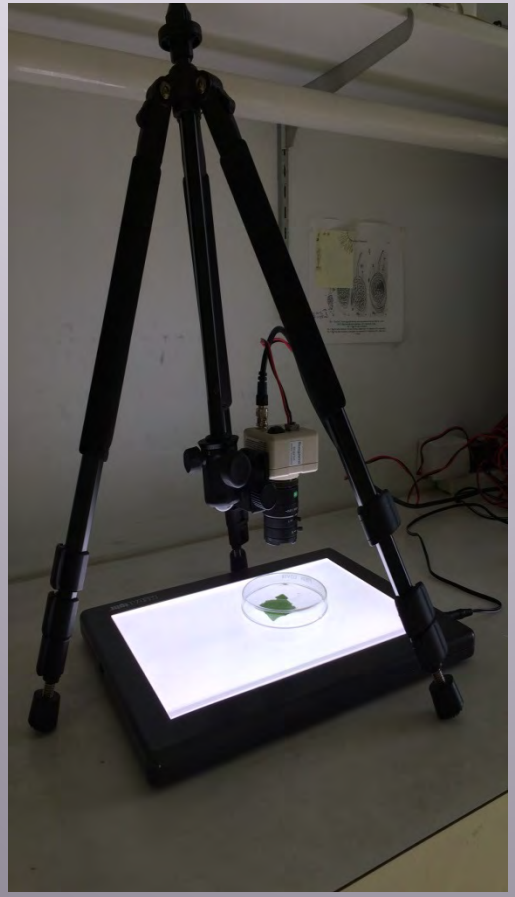


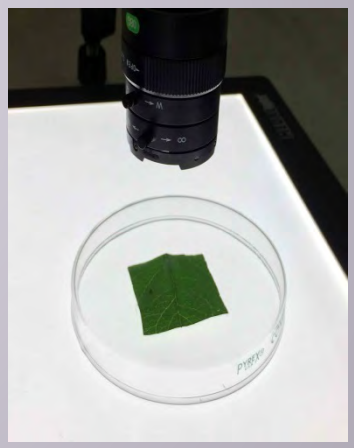
Preliminary data: for discussion at BMSB SAP meeting

Total parasitoid and BMSB nymph emergence from ≤ 24 hr. old Delaware and Beijing *Trissolcus japonicus* females exposed to 16 BMSB egg masses. Females were moved to a new egg mass every 48 hours. N=4 replicates.

Influence of BMSB kairomone on leaf surface

Sean Boyle, Univ. Delaware Thesis research





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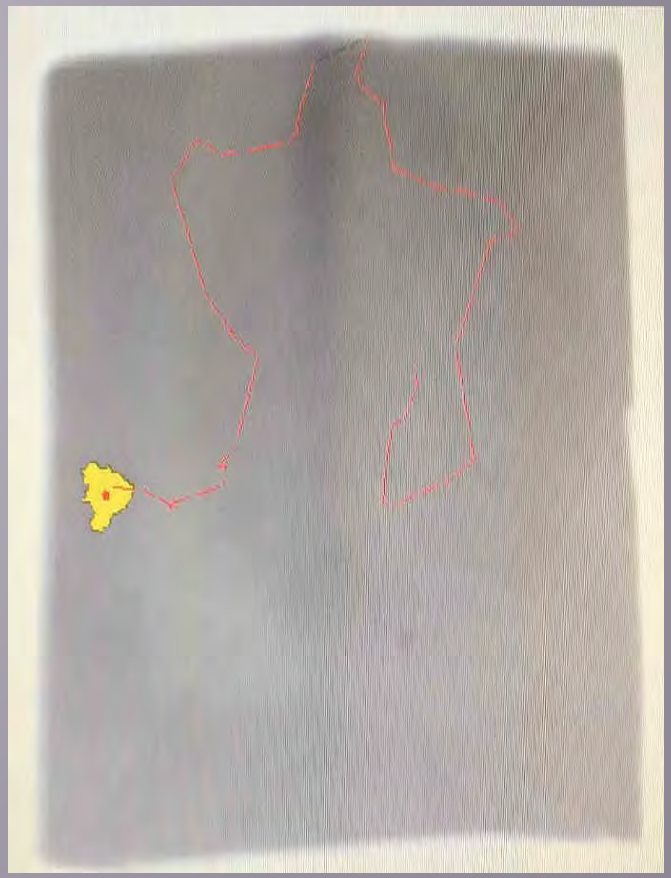
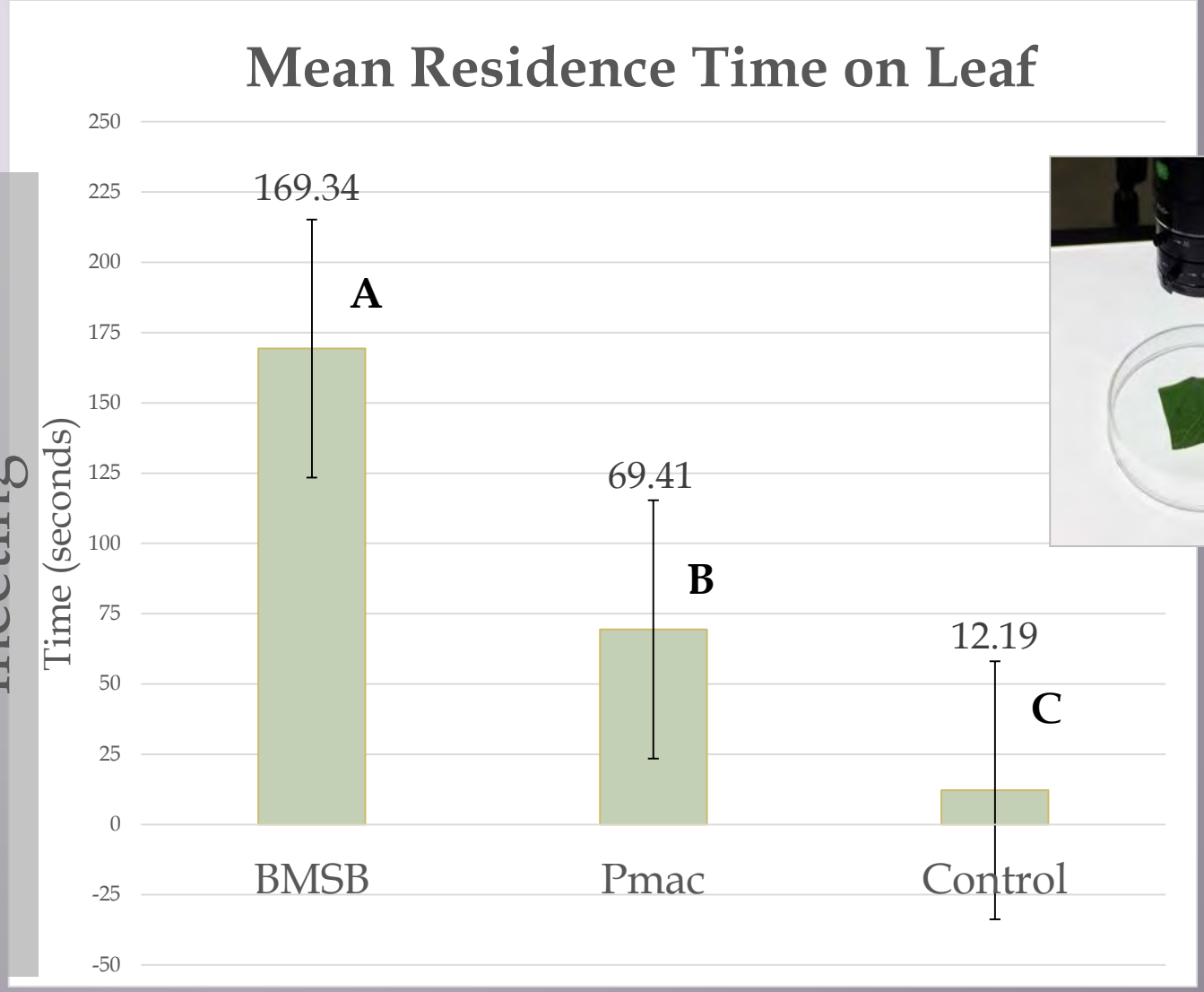
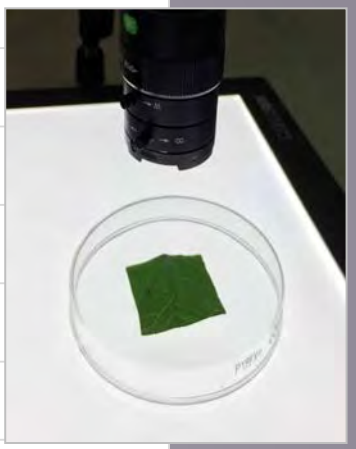


Tracking movements of female *T. japonicus* on leaf

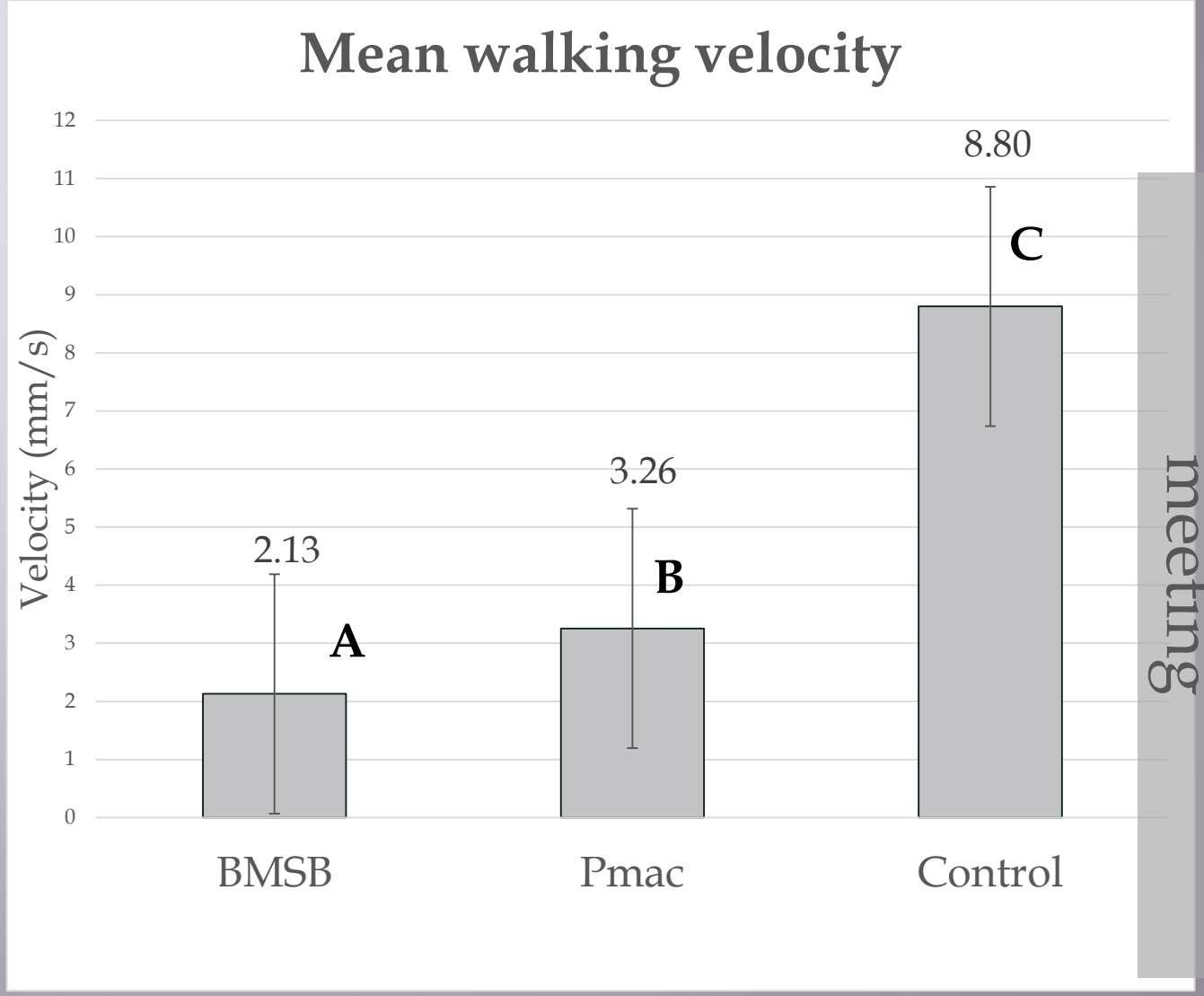
Preliminary data: for discussion at BMSB SAP meeting





T. japonicus stayed on leaves contaminated with BMSB kairomones longer than on leaves with *P. maculiventris* kairomones ($p<0.001$).

Data from Sean Boyle, Univ. Delaware



Preliminary data: for discussion at BMSB SAP meeting

T. japonicus walked more slowly on leaves contaminated with BMSB kairomones than on leaves with *P. maculiventris* kairomones ($p<0.004$).

Summary

- Native parasitoids have low impact in landscape reservoirs but may be important in certain habitats (e.g., *Anastatus, Telenomus*)
- *T. japonicus* is established and spreading in the U.S. in arboreal landscape habitats (important as population reservoirs)
- Physiological host range of *T. japonicus* includes other stink bug species in the U.S.
- Realized impact on non-target pentatomids in the field is likely to be less than in the laboratory.
- Impact of both native & introduced natural enemies should increase over time

SCRI Objective 2: Implement widespread biological control of BMSB, incorporating exotic Asian parasitoids and native natural enemies

- **2.a.i. Determine distribution/range expansion of adventive *T. japonicus* in the U.S.**
- **2.a.ii. Complete host range evaluations and proceed with petition for field release of quarantine laboratory populations of *T. japonicus*.**
- **2.a.iii. Determine habitat preferences and role of kairomones in host location.**
- **2.a.iv. Measure impact on BMSB populations and non-targets in key crops and landscape reservoirs.**

- **2.a.i. Determine distribution/range expansion of adventive *T. japonicus* in the U.S.**
- To support studies of impact of the adventive population
- Important background information for petition to release Beijing population
- Natural expansion vs. lab rearing & redistribution
  - Placement of sentinel egg masses & collect wild egg masses
  - Rear to emergence in laboratory & identify
  - Yellow sticky traps, yellow pan traps
  - Where to sample to measure impact? Landscape reservoirs vs crop

- **2.a.ii. Complete host range evaluations and proceed with petition for field release of quarantine laboratory populations of *T. japonicus*.**
  - Need to continue, in case adventive populations do not spread quickly / do not establish widely / have limited impact
  - Regional non-target species testing important for state permits (e.g., California)
  - Examine behavioral & ecological factors that may influence host use under field conditions & thus limit non-target impacts
    - Data will support Petition for Field Release

- **2.a.iii. Determine habitat preferences and role of kairomones in host location.**
  - **Assess habitat preference with sentinel egg experiments and surveys, wild egg surveys**
  - **Laboratory experiments to determine factors that influence parasitoid behavior (host kairomones on foliage, on eggs; chemical components inside eggs)**
  - **Isolation & identification of chemical components of kairomones & eggs (surface & interior)**

- **2.a.iv. Measure impact on BMSB populations and non-targets in key crops and landscape reservoirs:**
  - **Data from sentinel & wild-collected egg masses**
  - **Correlate parasitism levels with BMSB populations and/or damage**

Objective 2. Implement widespread biological control of BMSB, incorporating exotic Asian parasitoids and native natural enemies

- **2.b.i. Document regional differences in key parasitoid species composition and impacts on BMSB and non-target spp. in different crops and landscape habitats.**
- **2.b.ii. Adaptation/selection of native parasitoids to enhance BMSB as a host.**
- **2.c. Document regional differences in native predator species composition and measure predation impacts on pest populations in different crops/habitats.**
- **2.d. Identify entomopathogens of BMSB (Ann Hajek)**

- **2.b.i. Document regional differences in key parasitoid species composition and impacts on BMSB and non-target spp. in different crops and landscape habitats.**
  - **Parasitoid activity varies by habitat or crop and could be important in some regions as BMSB expands into new areas**
  - **Manipulations to conserve parasitoid populations and increase their activity in crops**

- **2.b.ii. Adaptation/selection of native parasitoids to enhance BMSB as a host.**
  - **Can native predators and parasitoids adapt to BMSB?**
    - **Predators can learning to identify a new prey item**
    - **Can parasitoids overcome the physiological defense mechanism of eggs?**
      - **Continue to monitor native parasitoid activity**
      - **Selection in the laboratory for strains that can successfully develop**

- **2.c. Document regional differences in native predator species composition and measure predation impacts on pest populations in different crops/habitats.**
  - **Predator activity varies by habitat or crop and could be important in some regions as BMSB expands into new areas**
  - **Manipulations to conserve predator populations and increase their activity in crops**

Thanks for your attention!