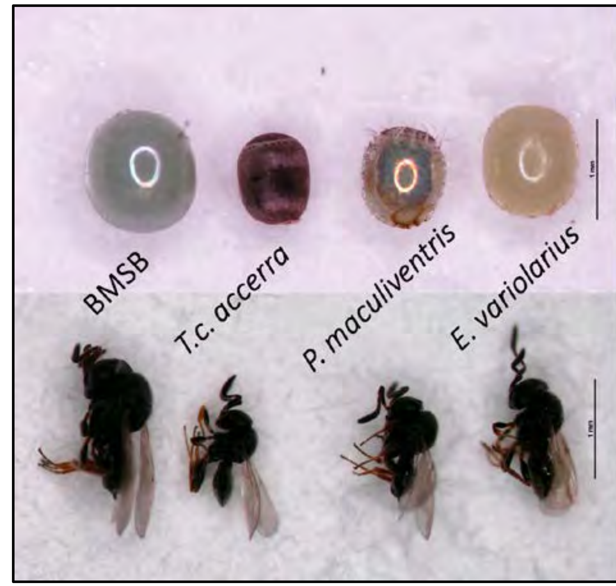
Brown Marmorated Stink Bug IPM Working Group Meeting

Alson H. Smith, Jr. Agriculture Research and Extension Center, Winchester, VA. 2 December 2015.

Identifying Potential Ecological Sieves That May Mediate Impacts from *Trissolcus japonicus*.



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Topics

- Origin of the use of “sieves” to describe events that mediate field behavior of a biological control agent.
- Risk as a matrix of probabilities.
- Risk *vs*. host range.
- Next steps.

Confusion re. Definitions

- Physiological host-specificity (innate, laboratory, artificial, predictive = hazard = "Can-Do").
- Ecological host range (field, realized; mediating hazard by ecological sieves = exposure = "Will-Do").
- Stability of host range.
- Host shifts.
- Risk.

3 x 3 Idealized Risk Matrix Model

Relating -phagy to Hazard, and Numbers to Exposure

Factors that mediate potential hazard, and reduce risk to non-target species.

Innate physiological characteristics of the agent

Hazard \ Exposure	**Low** Species in the same genus as the target species.	**Medium** Species in closely related genera in the same family as the target species.	**High** Species in other genera or families in the same Superfamily.
Low Monophagous agent Attacks one species.	Low Risk	N/A	N/A
Medium Oligophagous agent: Attacks genera in the same family.	Probably Medium Risk	Medium Risk	N/A
High Polyphagous agent: Attacks genera outside of the family.	Probably Medium Risk	Medium Risk	High Risk

Interpretation of Physiological Host-specificity Testing

Ecological Sieves

Exposure

Hazard

The Concept of Sieves Comes from Biological Control of Weeds

The most difficult challenge to biological control is predicting the risk from a natural enemy that attacks, in physiological host-specificity tests:

- **a rare,**
- **threatened,**
- **endangered,**
- **native species,**
- **in the same subgenus as the target species.**

Delfosse, E.S. 2005. Risk and ethics in biological control. *Biological Control* **35:**319-29.

Delfosse, E.S., R.C. Lewis and S. Hasan. 1995. Release of *Uromyces heliotropii* in Australia: A key agent in the integrated pest management system for common heliotrope. *Proceedings of the VIII International Symposium on Biological Control of Weeds*, 2-7 February 1992, Christchurch, New Zealand. Delfosse, E.S. and R.R. Scott (Eds.). DSIR/CSIRO, Melbourne, 329-36.

Hasan, S. and E.S. Delfosse. 1995. Susceptibility of the Australian native, *Heliotropium crispatum*, to the rust fungus, *Uromyces heliotropii*, introduced to control common heliotrope, *Heliotropium europaeum*. *Biocontrol Science and Technology* **5:**165-74.

Hasan, S., E.S. Delfosse, E. Aracil and R.C. Lewis. 1992. Host-specificity of *Uromyces heliotropii*, a fungal agent for the biological control of common heliotrope (*Heliotropium europaeum*) in Australia. *Annals of Applied Biology* **121:**697-705.

The Weed:

Heliotropium europaeum

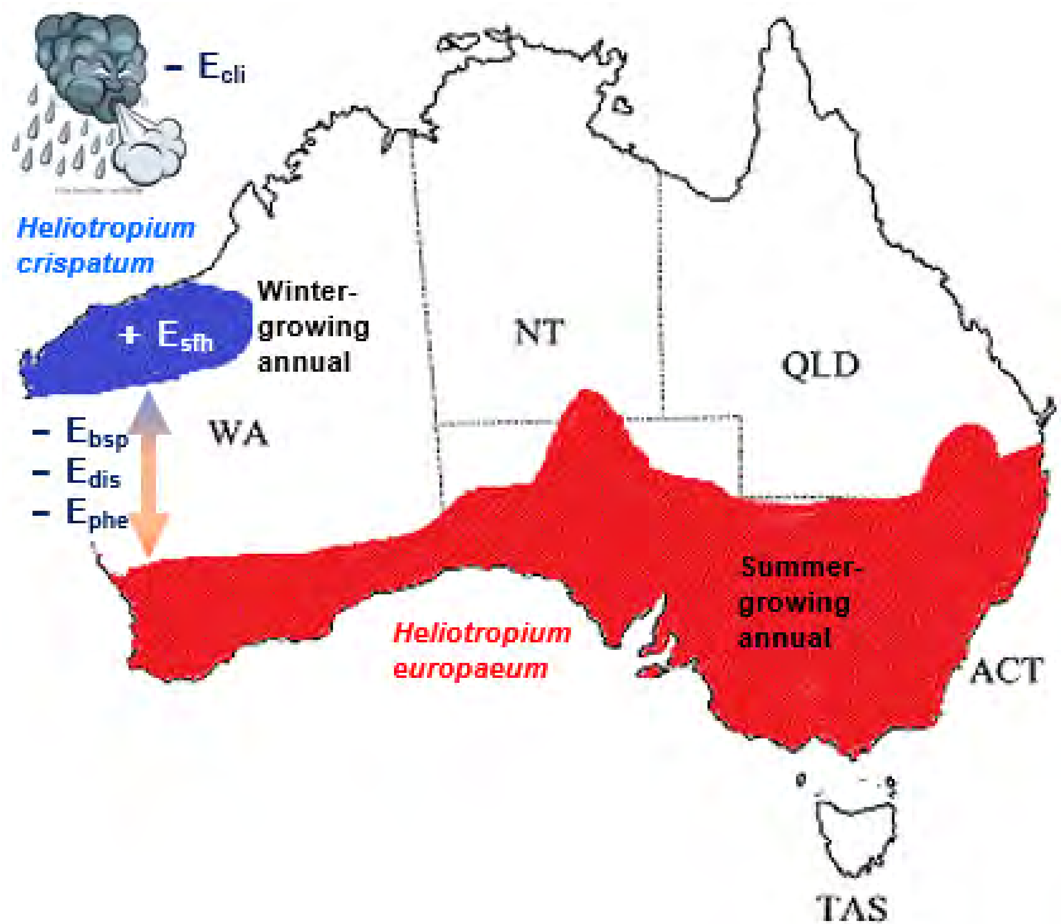
(Common Heliotrope)

The Natural Enemy:

Uromyces heliotropii

(CH Rust Fungus)

Exposure Analysis for *H. europaeum:* Identified Mediating Ecological Sieves



+ E_{sfh} = *H. crispatum* is the only susceptible non-target field host.

– E_{bsp} = No bridging species.

– E_{dis} = No overlap in distribution.

– E_{phe} = Minimal overlap in phenology of spores and young leaves; summer- *vs*. winter-growing annuals.

– E_{cli} = Prevailing wind in summer away from *H. crispatum* populations.

Looking for Ecological Sieves for *T. japonicus.*

- Exposure acts upon hazard.
- What sieves (exposure) can we identify that could mediate the physiological host range (hazard)?

Objective

- Determine if host acceptance behavior and attack by *T. japonicus* differs between BMSB and non-target egg masses in multiple-species choice tests.

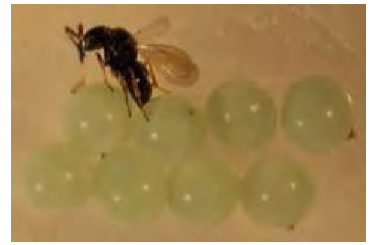
A Closer Look at Host Choice Behavior in *T. japonicus*

Influence of arena size and complexity


- **Size (Completed)**
  - 10 dram
  - 100 dram
  - 500 dram
  - 1000 dram
  - 2000 dram

- **Complexity (Started)**
  - Choice tests on plants

Role of parasitoid physiology & experience

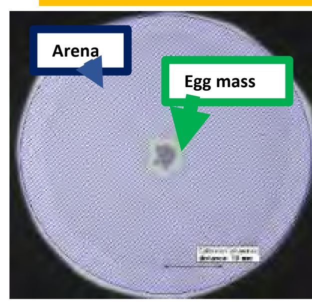


- Parental experience
- Parental physiology
- Effect of host choice on offspring physiology & behavior

Influence of time of exposure

- **Finished**
  - 1 h
  - 4 h
  - 6 h
  - 24 h

Behavioral observations



- **Ongoing**
  - Searching behavior
  - Oviposition behavior
  - Host choice
  - …

Olfactometer Studies

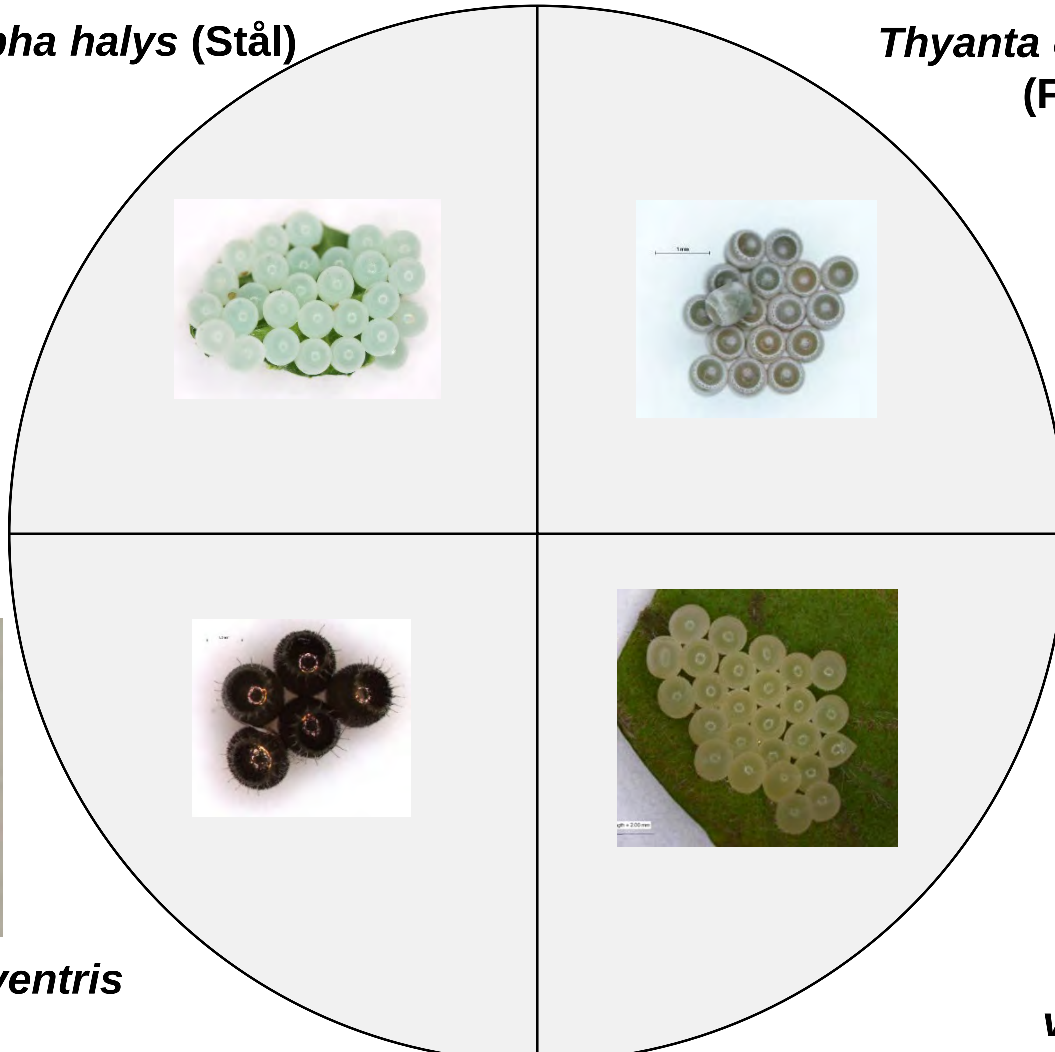
(FL, MI) - **ongoing**

Slide from Hoelmer lab

Methods
Multiple-Species Choice Experiments

Halyomorpha halys **(Stål)**

Thyanta custator accerra **(Fabricius)**



Podisus maculiventris **(Say)**

Euschistus variolarius **(Palisot de Beauvois)**

Methods

Selection Criteria for Native Stink Bugs

1. **All species attacked in PHST:**
   - *Thyanta custator accerra* -- 100% of egg masses attacked.
   - *Podisus maculiventris* -- 52% of egg masses attacked.
   - *Euschistus variolarius* -- 20% of egg masses attacked.

2. **Biological relevance:**
   - *T.c. accerra* – Most-often attacked native stink bug in PHST.
   - *P. maculiventris* – Beneficial predatory species.
   - *E. variolarius* – Most common native stink bug in Michigan.

3. **Must be able to rear and have eggs available daily for testing.**

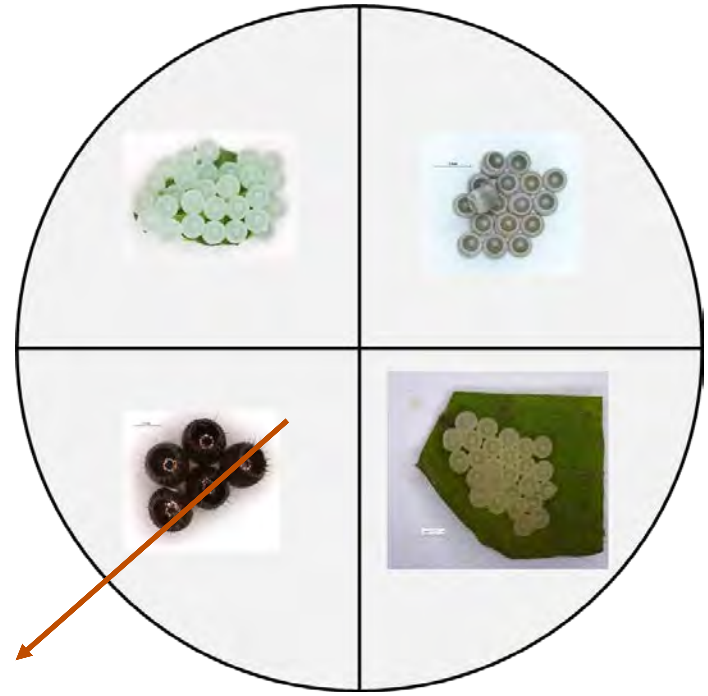
Influence of Arena Size on Host Choice

- Arena sizes – 4 treatments total:
  - 10 Dram
  - 100 Dram
  - 1000 Dram (2 treatments)
- Arena Setup:
  - Egg masses 1” apart & placed in center of card stock (10 – 1000 Dram)
  - PLUS egg masses 6.5” apart in 1000 Dram

Slide from Hoelmer lab

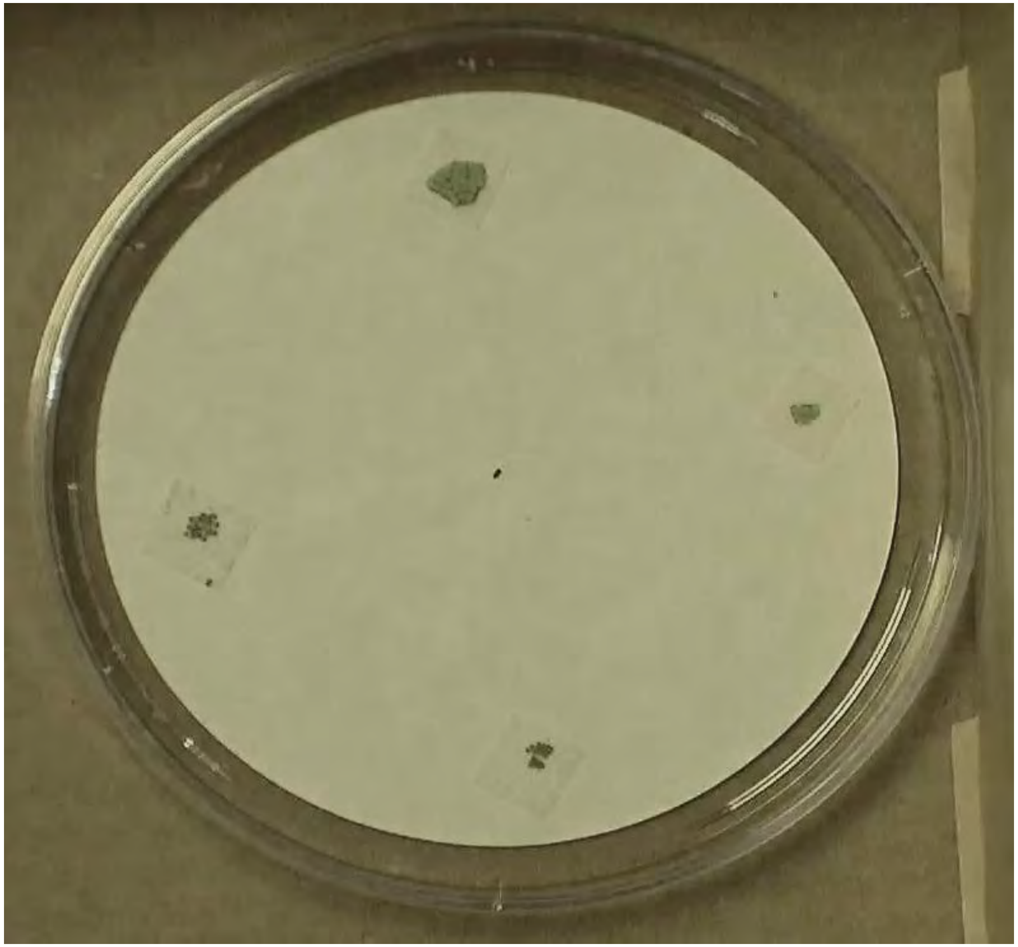
Methods
Arena Configuration

- 150 x 15 mm Petri dish arenas.
- 24-h-old egg clusters on filter paper.
- Randomized quadrants.
- Randomized directional bearing of BMSB cluster.



Methods
Behavioral Scoring

- **24-h-old mated, naïve female *T. japonicus* reared from BMSB eggs placed in middle of arena.**
- **Scored behaviors (video):**
  - Encounter with eggs;
  - Inspection of eggs by circling and antennal drumming;
  - Egg rejection (abandoning); and
  - Egg acceptance (oviposition).



Influence of Exposure Time on Host Choice

BMSB ***P. maculiventris***

Naïve, 24h-old female *T. japonicus* exposed to egg masses

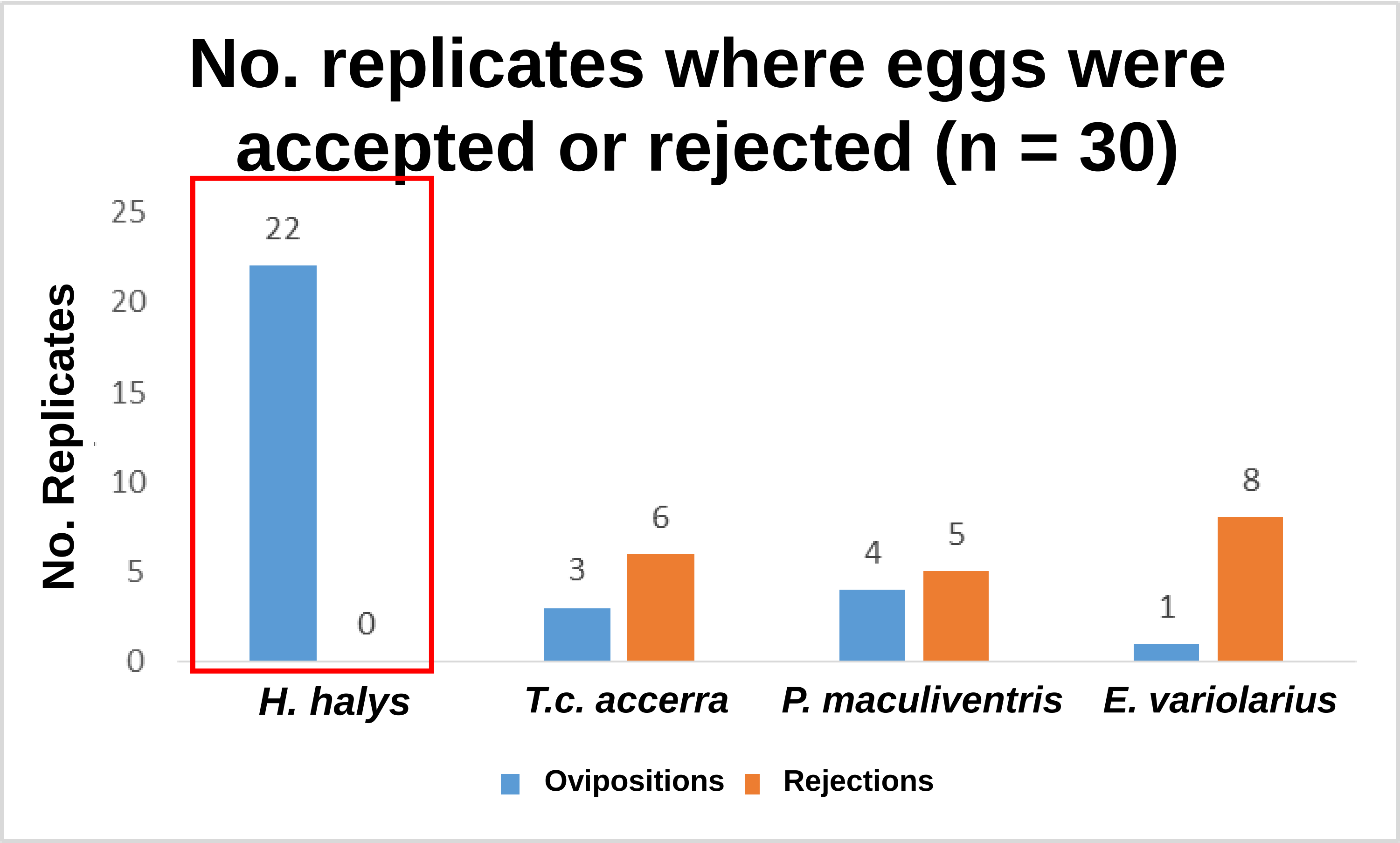
- 1 hour
- 4 hours
- 6 hours
- 24 hours

Observation of parasitoid behavior for 1 hour

Slide from Hoelmer lab

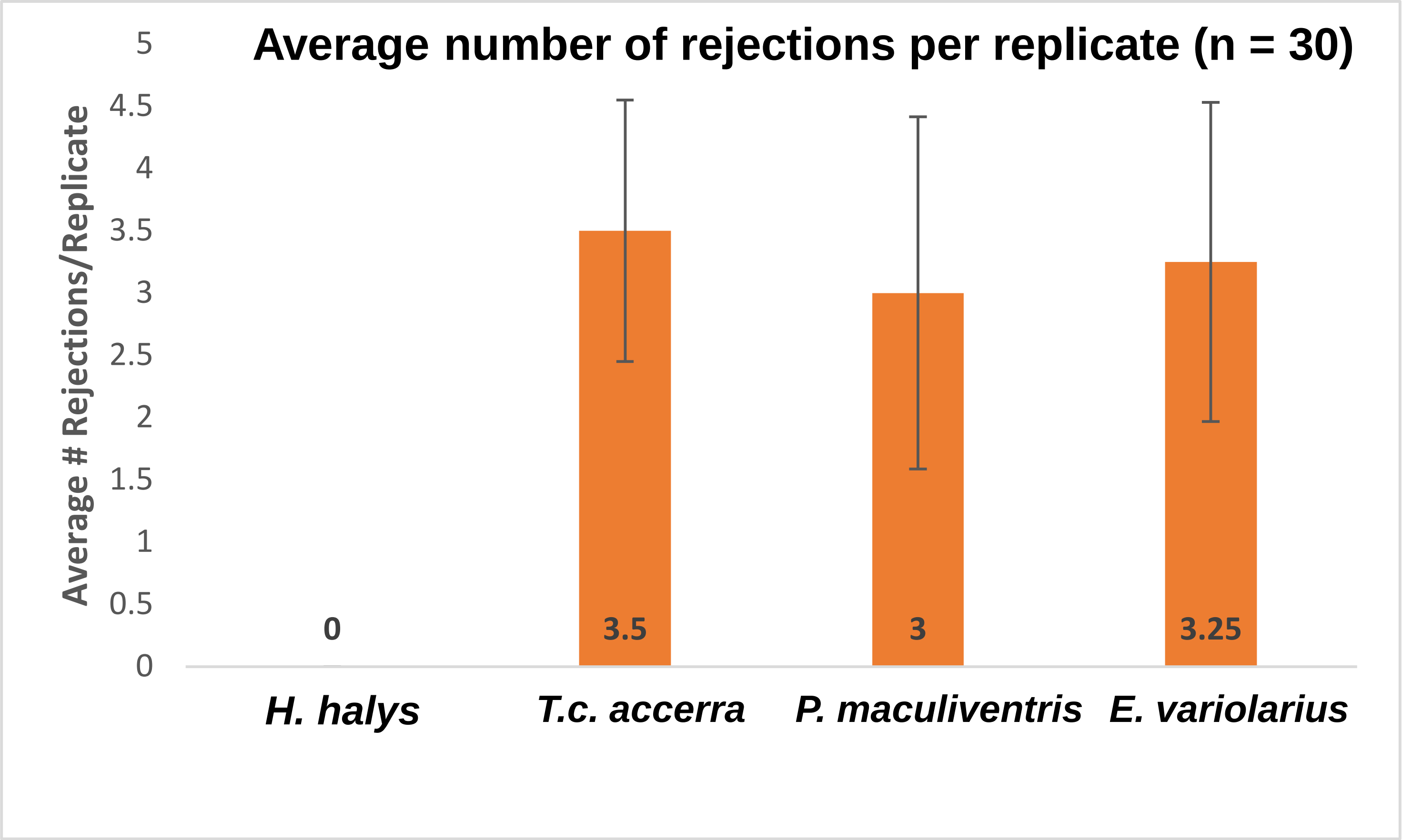
Results

Oviposition and Rejection of Eggs



BMSB accepted significantly more than native species ($p < 0.00001$; X^2)

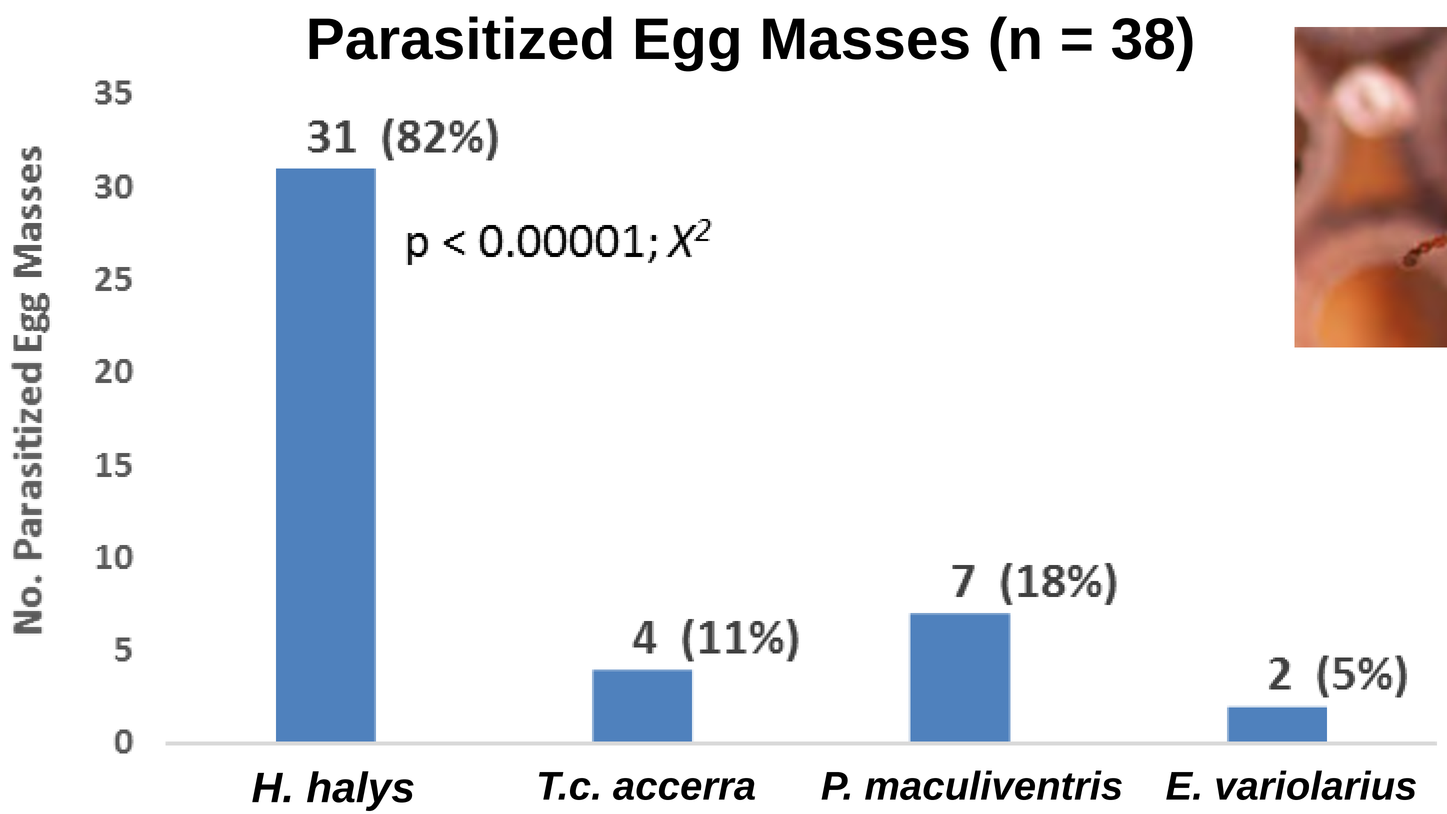
Results
Oviposition and Rejection of Eggs



Native stink bugs rejected multiple times per replicate

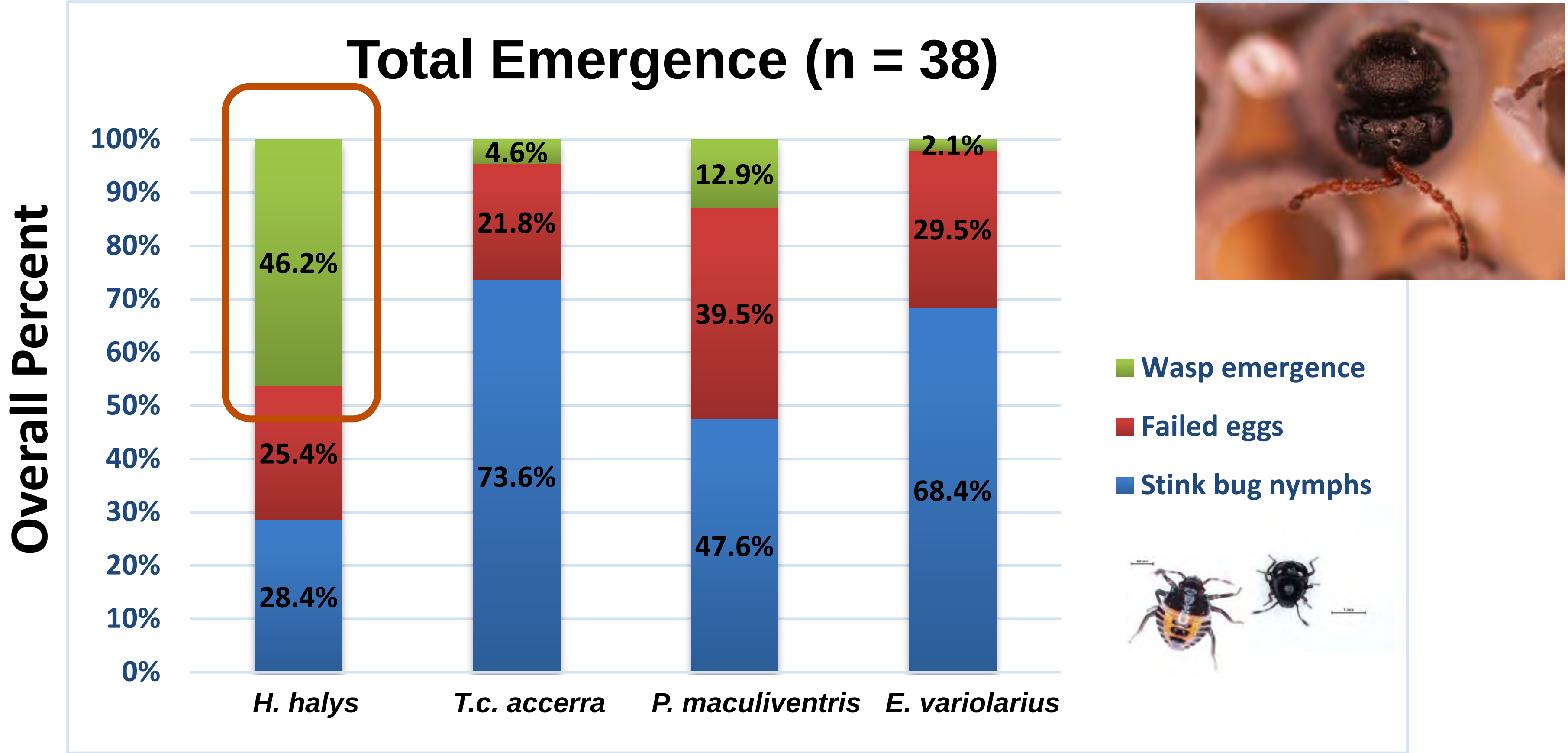
Results

T. japonicus Emergence

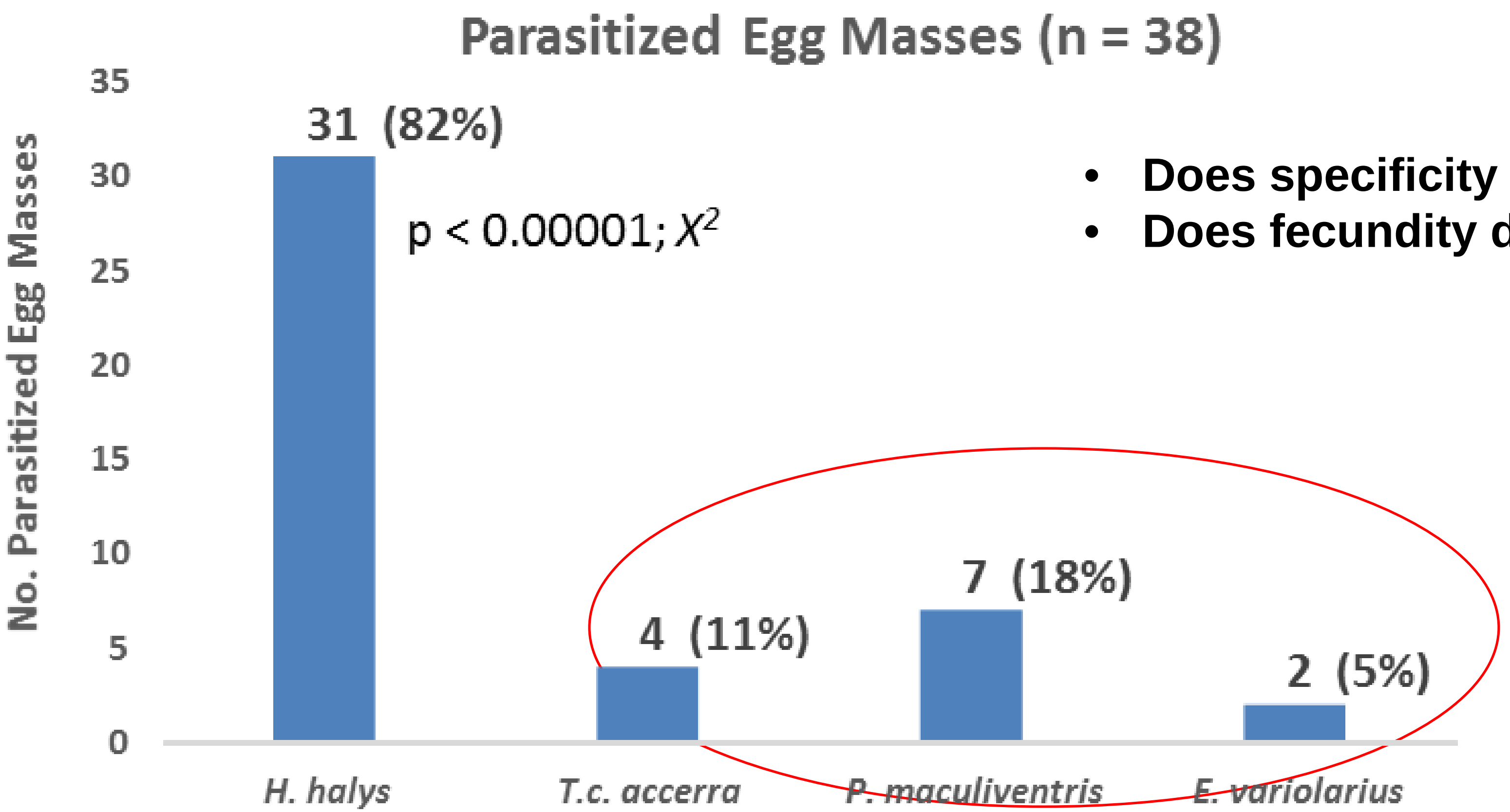


Wasps attacked only one egg mass 87% of the time (33 of 38 reps).

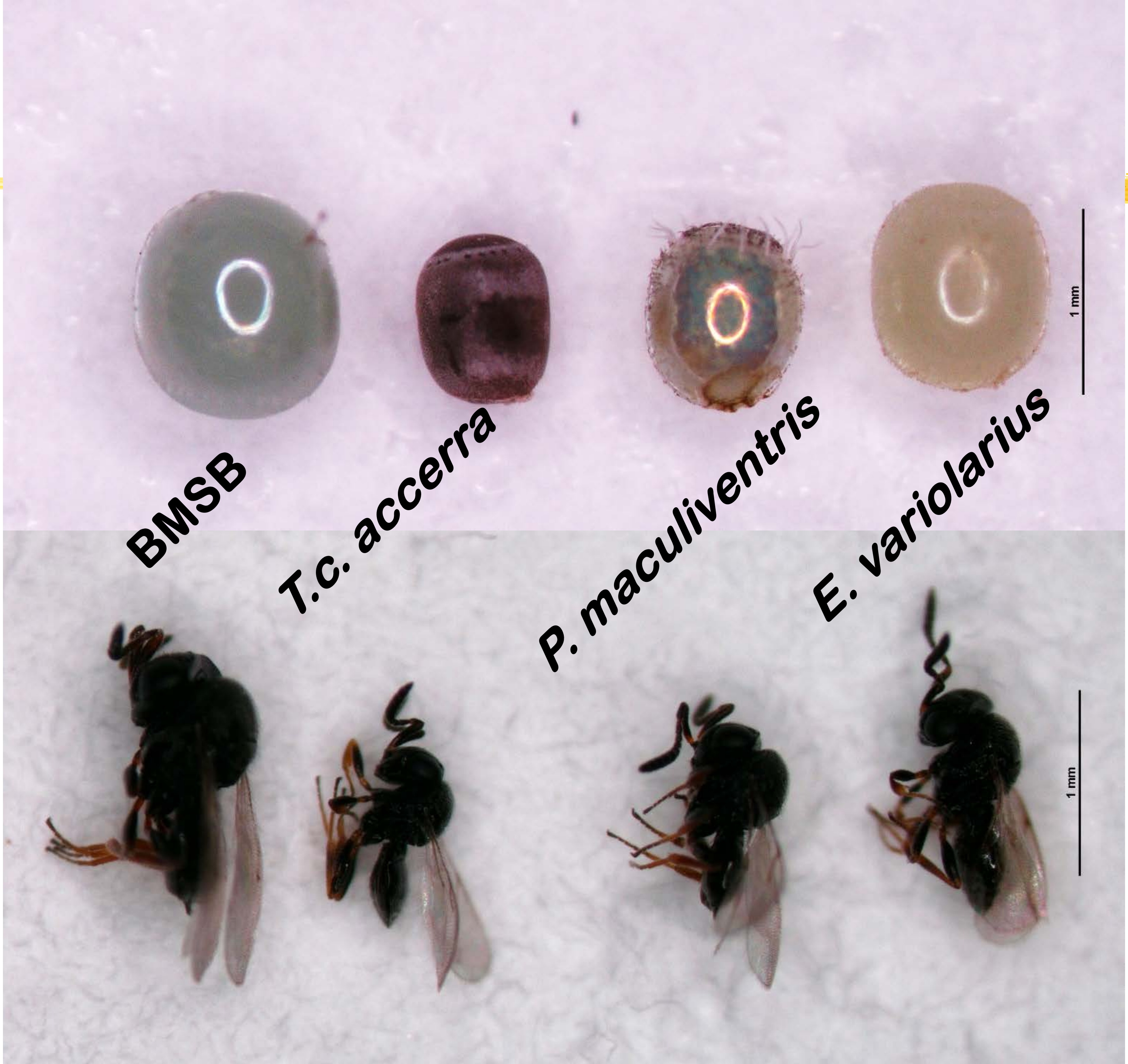
Results
T. japonicus Emergence



What About Wasps Emerged from Non-target Hosts?



- **Does specificity differ?**
- **Does fecundity differ?**

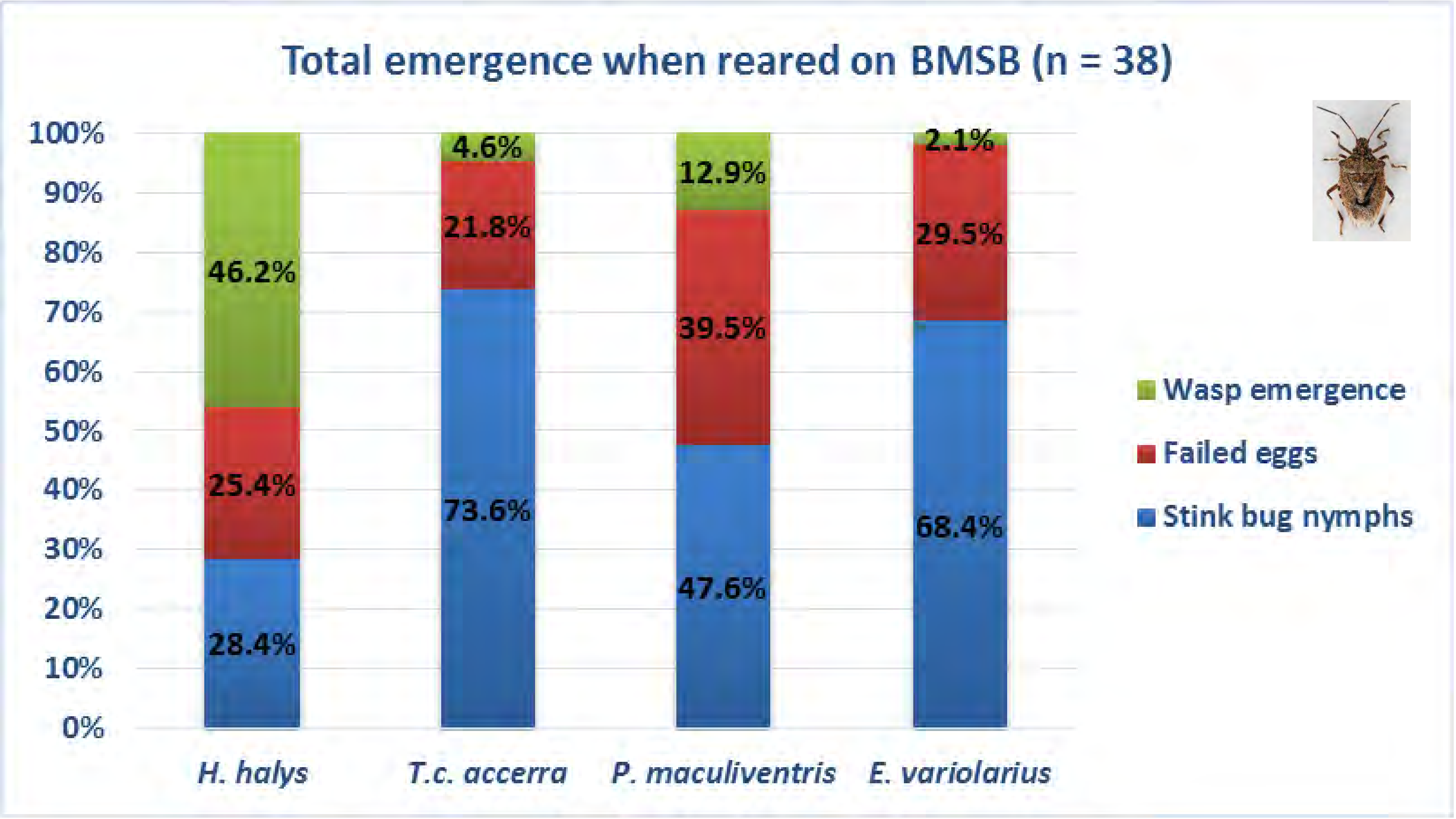


BMSB
T.c. accerra
P. maculiventris
E. variolarius
1 mm
1 mm

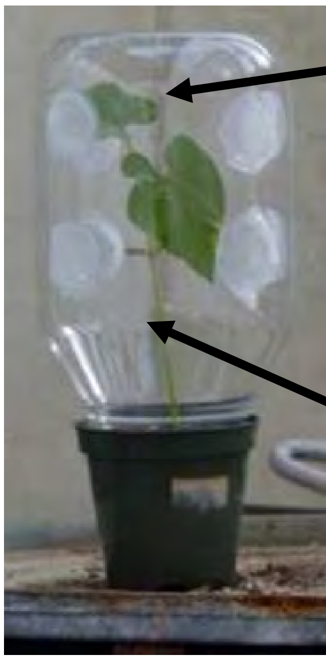
Results

Emergence Proportions by *T. japonicus* Reared on Native Stink Bugs

Overall Percent



Influence of Environmental Cues on Host Choice



BMSB

O R

P. maculiventris

placed on the underside of top leaf

BMSB

O R

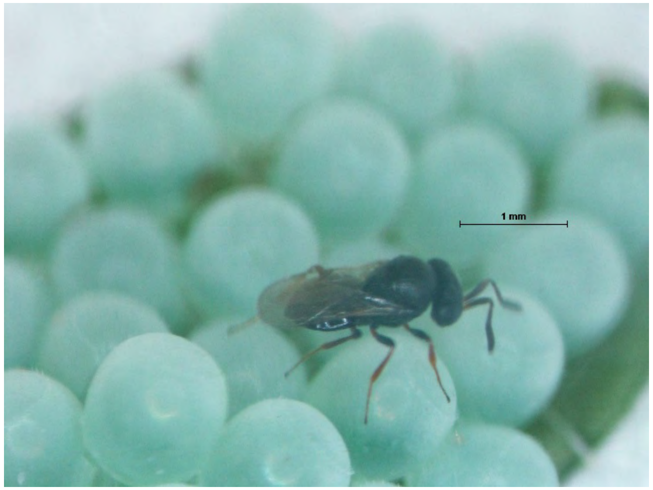
P. maculiventris

placed on the underside of bottom leaf

Slide from Hoelmer lab

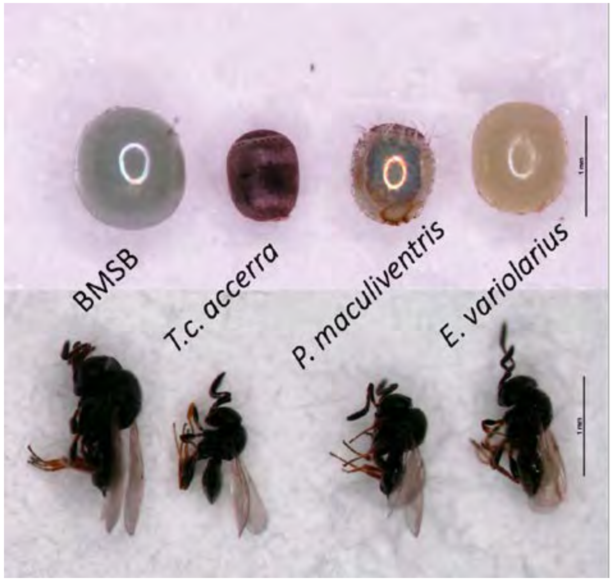
Conclusions

- BMSB was strongly preferred in multiple-species choice tests using eggs of non-target species attacked in PHST.
- Native non-target pentatomid eggs that were attacked in no-choice tests were frequently rejected.
- BMSB was never rejected by wasps reared on BMSB.



Conclusions

- Wasps reared on non-target native hosts preferred BMSB, but also continued to attack the native hosts to a lesser degree.
- Possibly due to a combination of genetic inclination, training, and chemical cues.
- Wasps reared on *T.c. accerra* and *P. maculiventris* produce fewer offspring than those reared on BMSB.



Future Research on Ecological Sieves

- Effects of egg age on successful parasitization by *T. japonicus* and emergence in non-target hosts.
- Effects of habitat partitioning on host location and attack on non-target hosts.
- On-going olfactometry to determine chemical cues associated with host location.

Acknowledgements

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Delfosse Classical Biological Control Lab

Questions and Group Discussion