Traps and Lures for the Invasive Brown Marmorated Stink Bug

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Monitoring and Surveillance Tools for BMSB

- Tools that provide accurate measurements of presence, abundance, and seasonal activity of BMSB.

Growers can make informed management decisions. Tactics that reduce the use of broad-spectrum insecticides.

BMSB SCRI 2 Objectives

- **1.a. Monitor BMSB in specialty crop and alternative hosts across the USA (*ALL*).**

- **3.a. Develop decision support tools to assess BMSB abundance and to mitigate damage.**

  3.a.i. Optimize trap design for monitoring and surveillance. (*W, G, M, S*)

  3.a.ii. Determine the relationship between captures in traps and crop injury. (*ALL*)

Key Components of Trap-Based Monitoring

- Visual Stimulus
- Olfactory Stimulus
- Capture Mechanism
- Deployment Strategy

One Attractant Available Prior to 2012

- Methyl (2E, 4E, 6Z)-decatrieonate is an attractant produced by the Asian stink bug, *Plautia stali.*

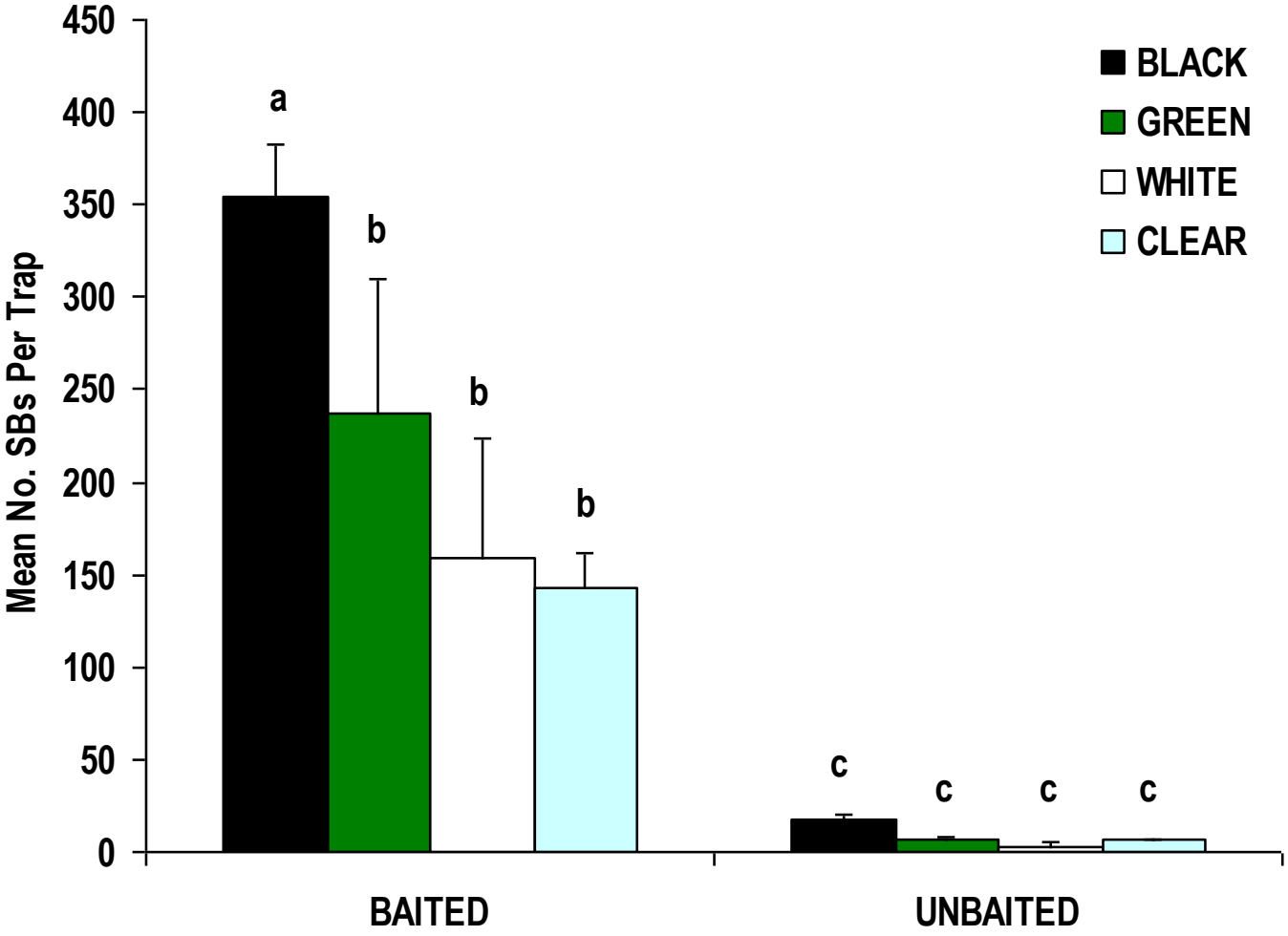
- Cross attractive to BMSB and other pentatomids.

2009-2010 BMSB Response to Visual Stimuli

Black	Green	Yellow	White	Clear
				
Trunk Mimic	Foliar Stimulus	Foliar Stimulus	Unapparent Stimulus	Unapparent Stimulus

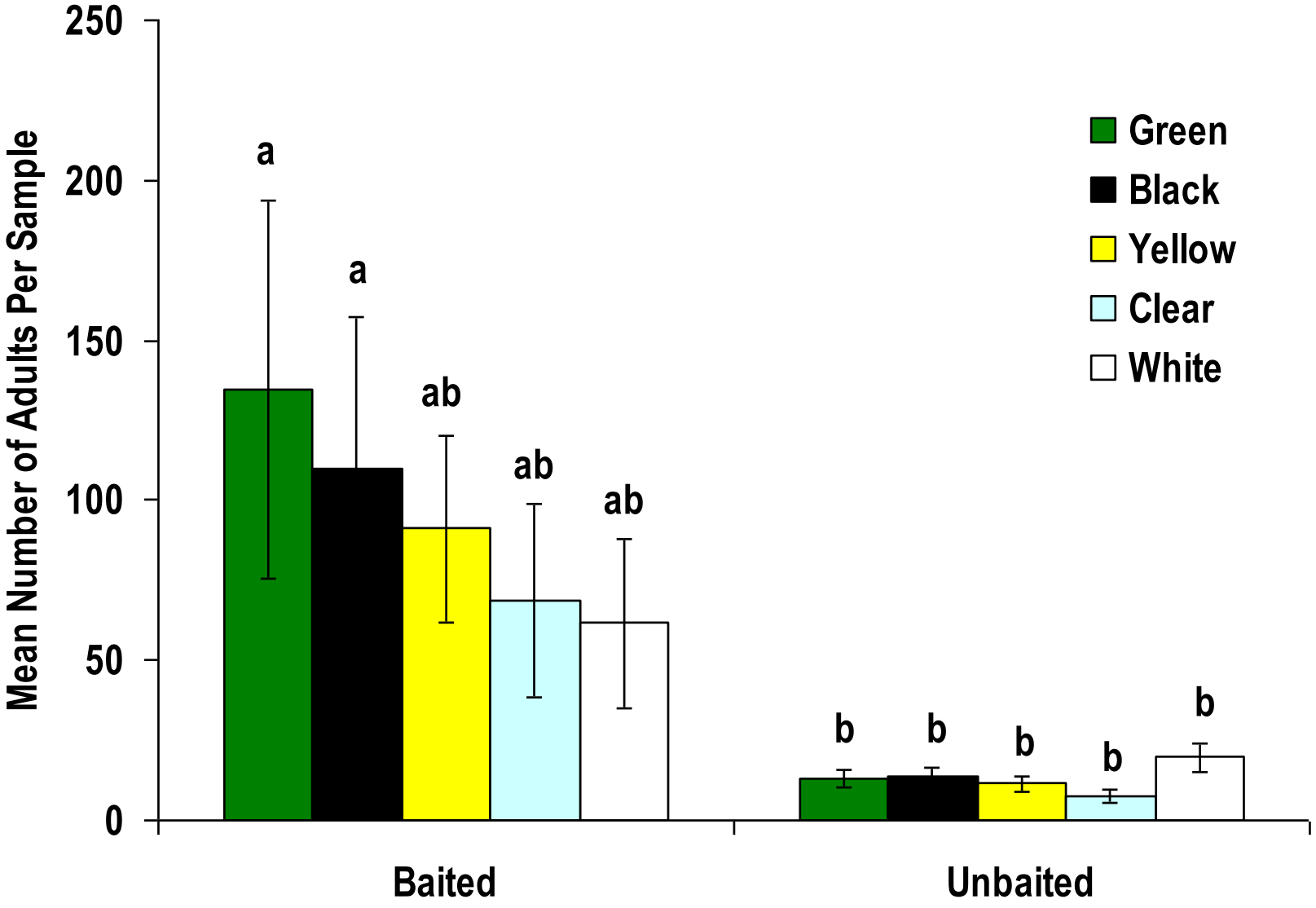
- Responses to visual stimuli associated with trap bases.
- Baited and unbaited traps at the periphery of orchards. Four replicates. Sampled twice weekly.
- Captures from October 7-November 17, 2009 and July 23-October 14, 2010.

2009 Adult Captures

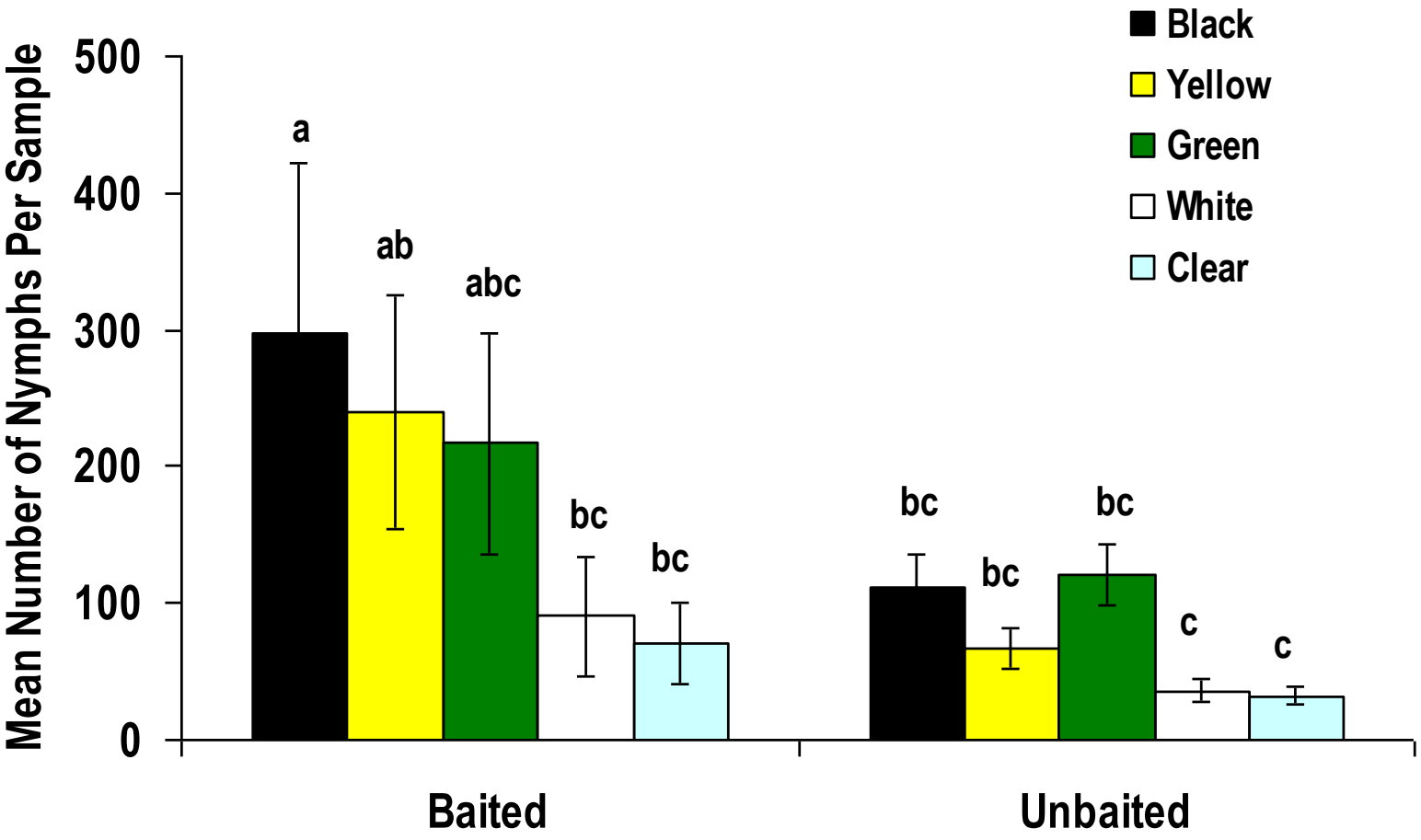


- **Significantly greater response to baited traps. Greatest captures in baited black pyramid traps. (October 7-November 17).**

2010 Adult Captures



2010 Nymphal Captures



Trap Type Comparisons

= ground deployment

= canopy deployment

= visual cue

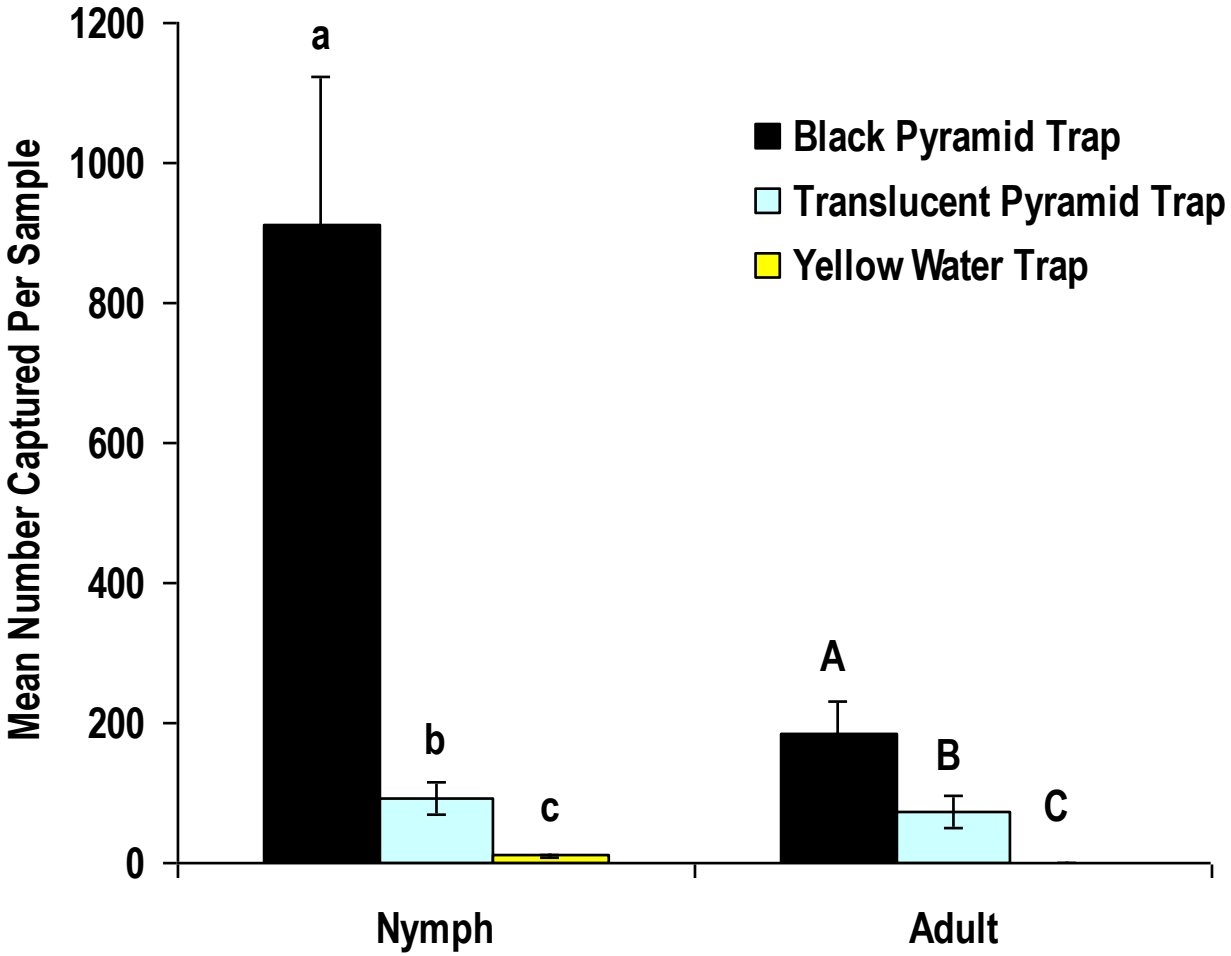
CBC America, Japan

Sankei Chemicals Co., Ltd., Kagoshima, Japan

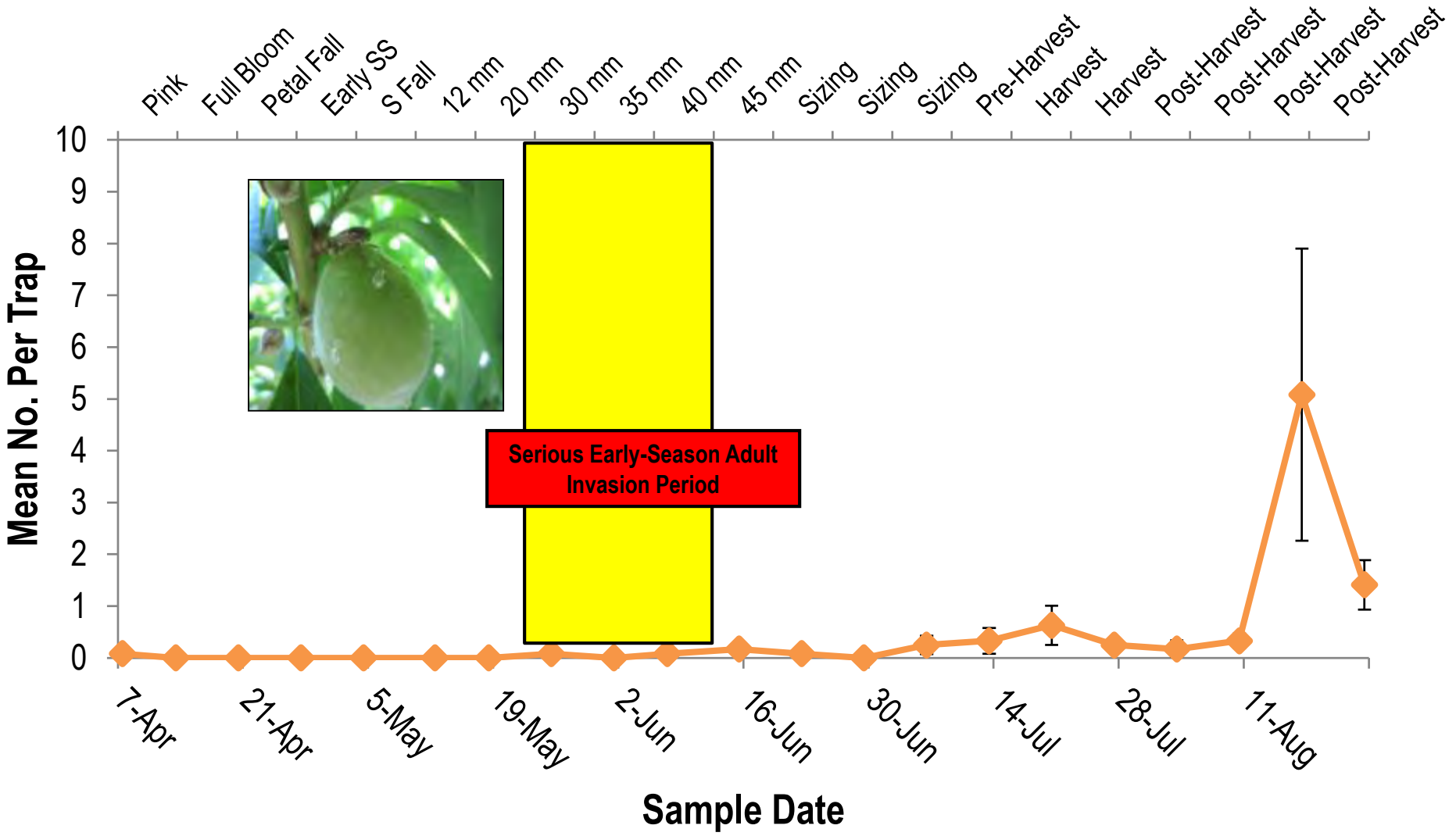
AFRS

- **Comparison with commercially available traps.**
- **Deployed in perimeter row of a pear orchard. Three replicates. Sampled twice weekly from August 2-September 30, 2010.**

Trap Type Results



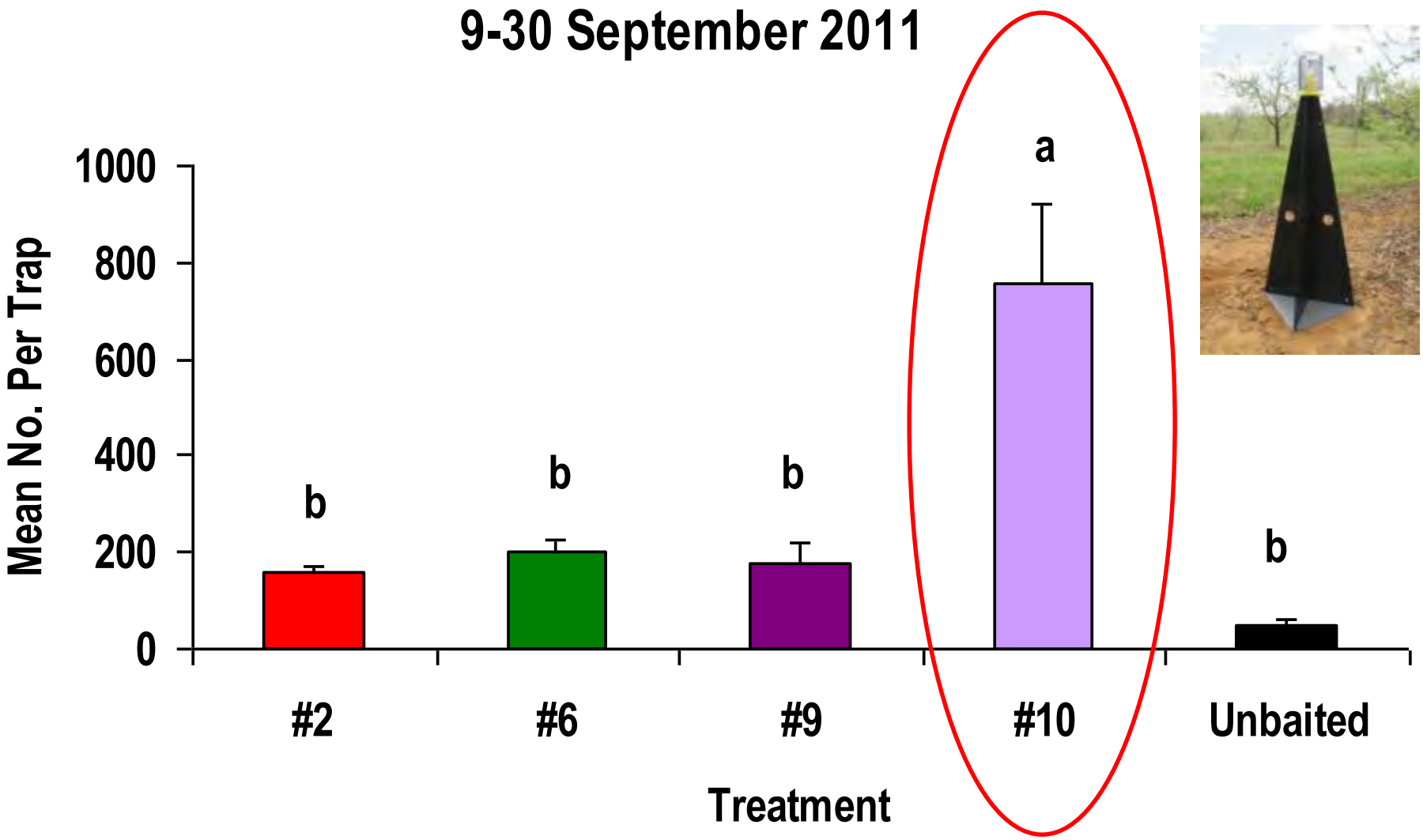
Serious Limitations For Season-Long Monitoring



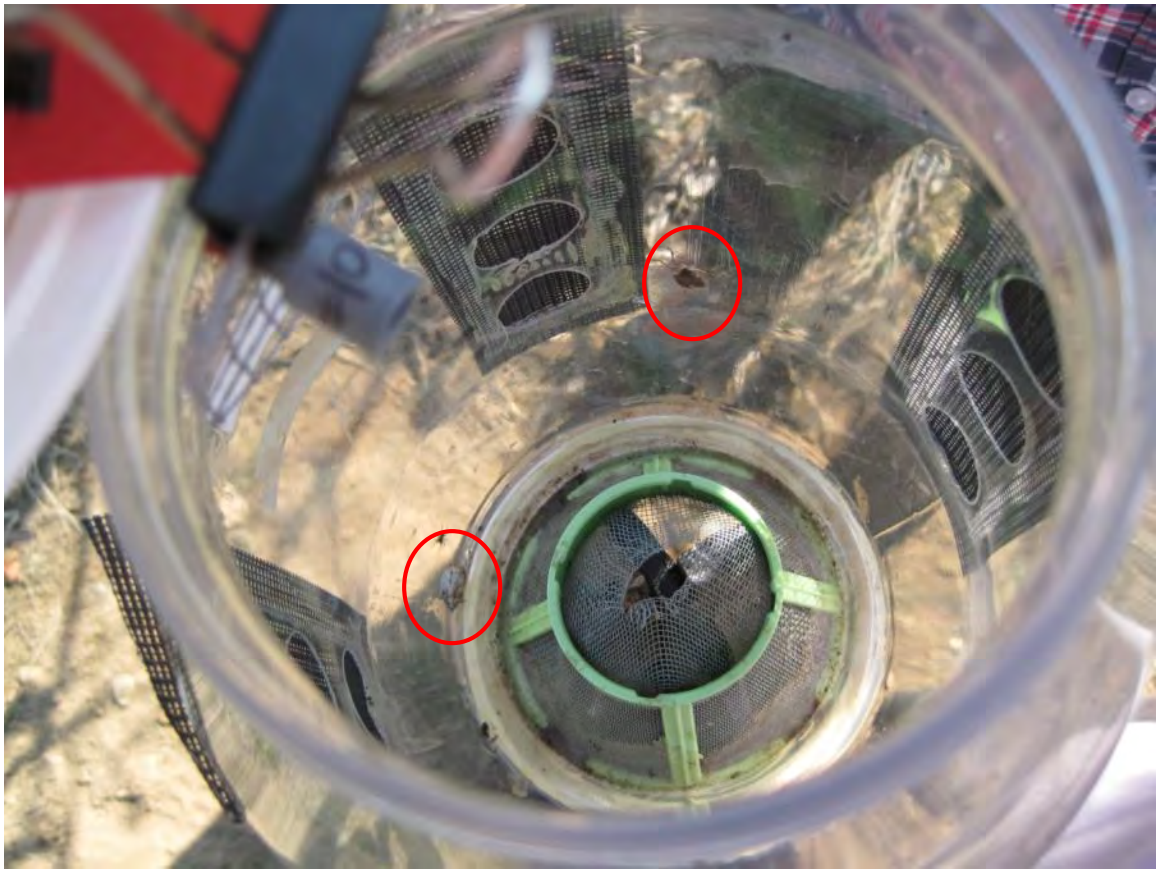
Leskey et al. 2012d

Identification and Commercialization of BMSB Aggregation Pheromone

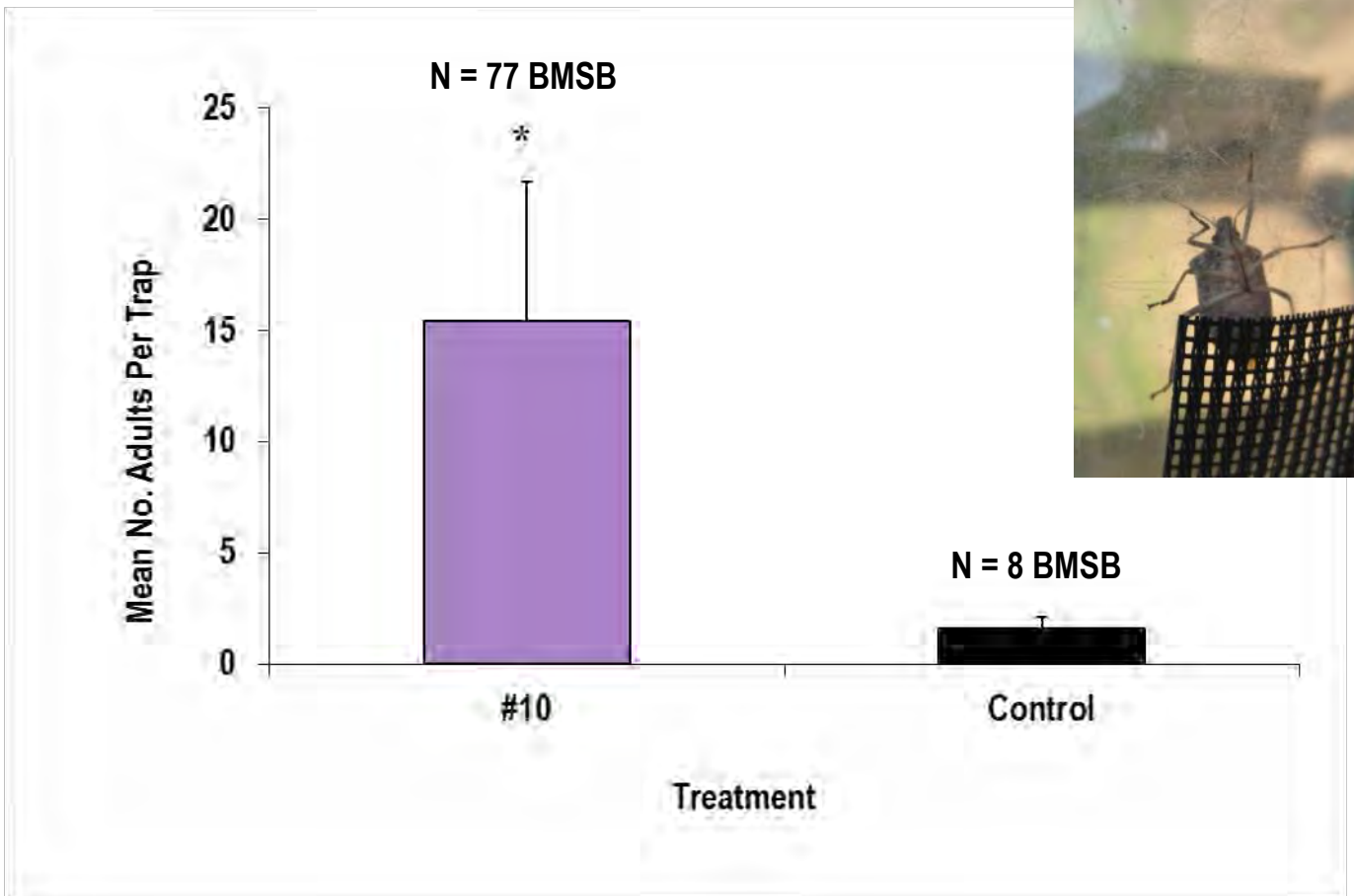
BMSB Aggregation Pheromone Breakthrough



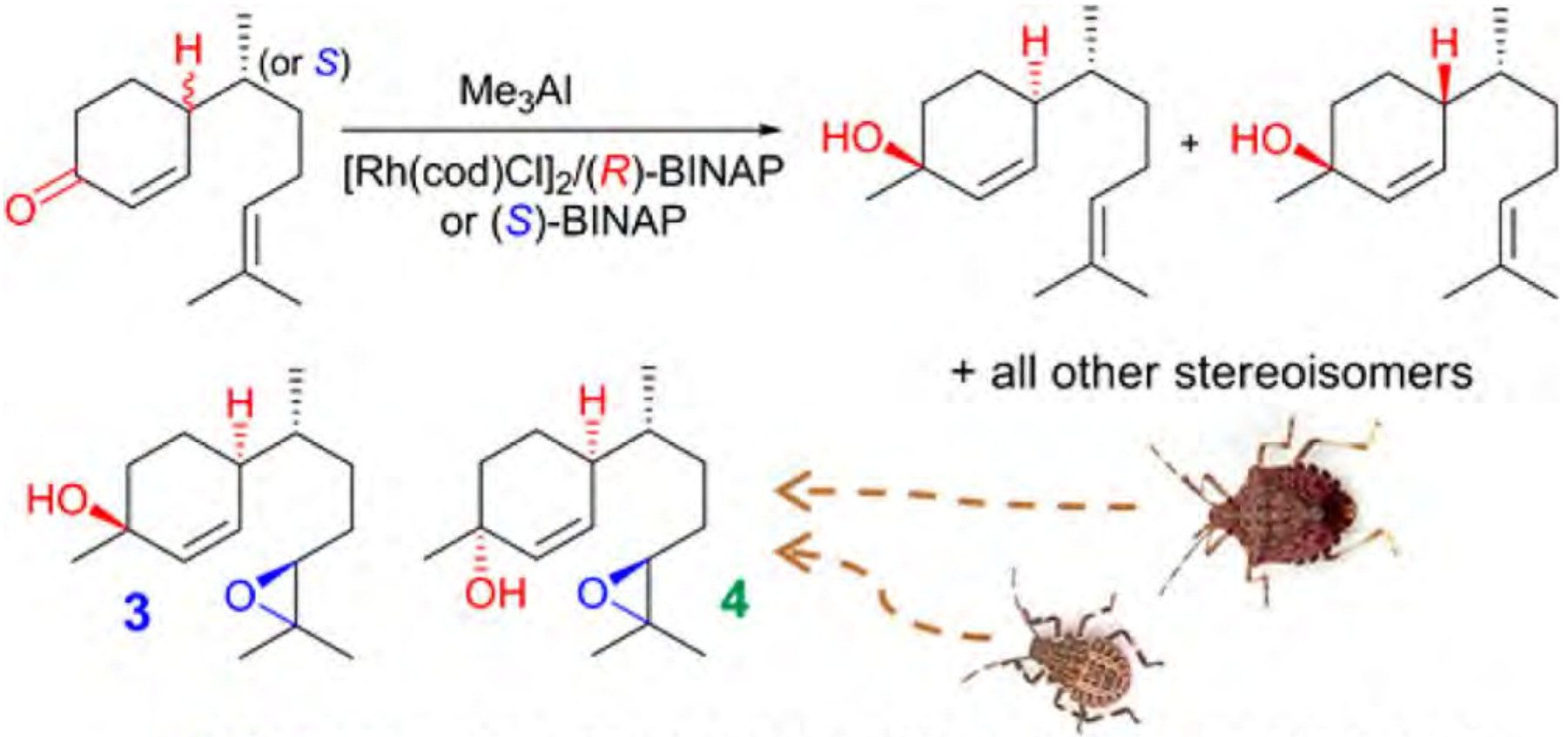
Is #10 Attractive in the Early Season?
Pre-Trial (March 20-April 17, 2012)



Early Season Attraction Documented for BMSB March 20-April 17, 2012



Two-Component BMSB Aggregation Pheromone Identified



3+4: aggregation pheromone of brown marmorated stink bug, *Halyomorpha halys*

Khrimian et al. 2014

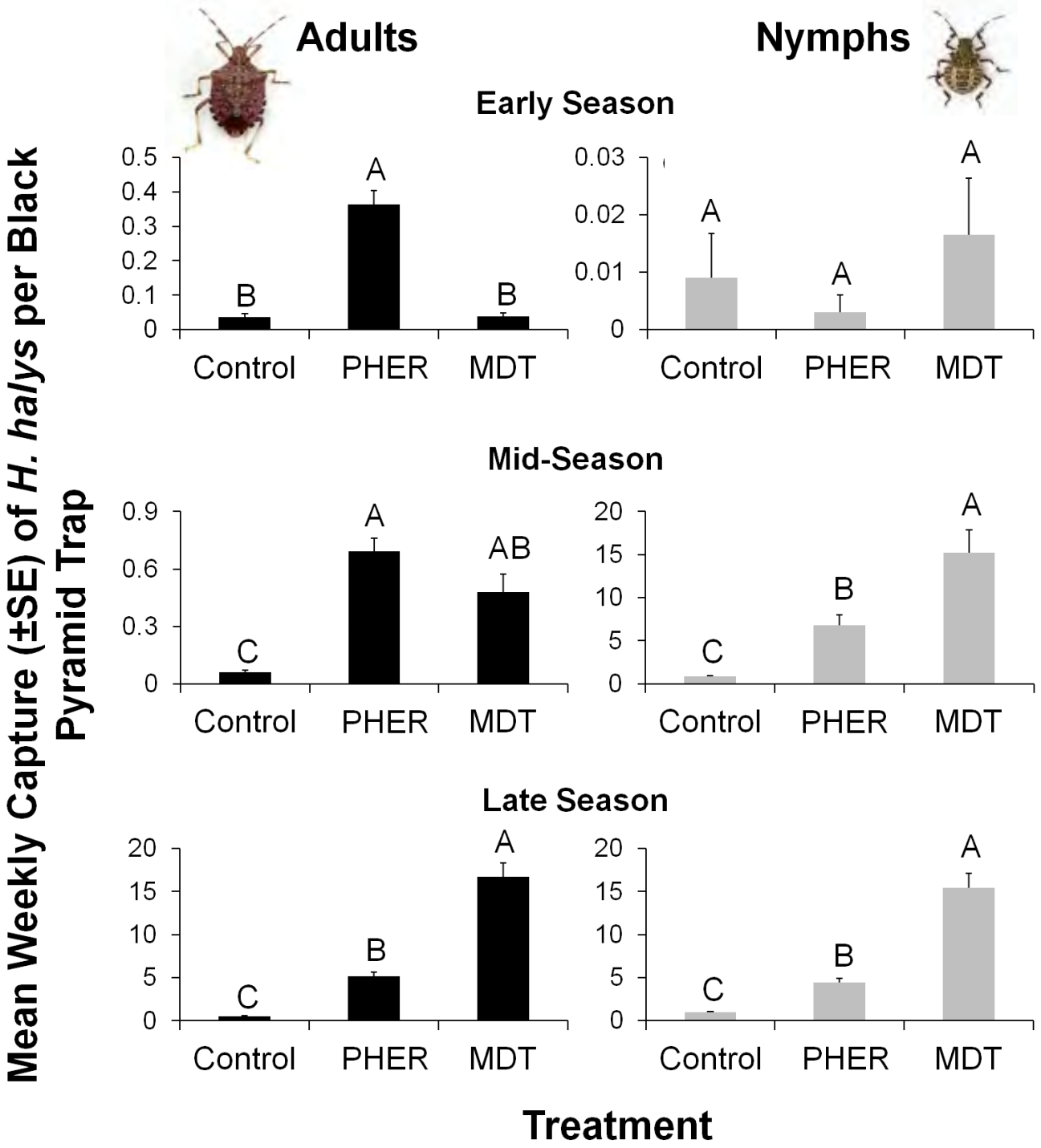
Broad Validation Across The Country

- Is BMSB attracted to the pheromone in the early season?
- Is BMSB attracted to the pheromone season-long?
- How attractive is this stimulus relative to MDT and unbaited traps?
- Traps evaluated in over 12 states across the country.

General Protocol

- Black pyramid traps
- Three odor treatments
  - 1) BMSB Pheromone (10 mg)
  - 2) MDT (119 mg) 10X greater
  - 3) unbaited control
- Traps are deployed between wild host habitat and agricultural production areas.
- Traps were deployed in mid-April and left in place season-long.

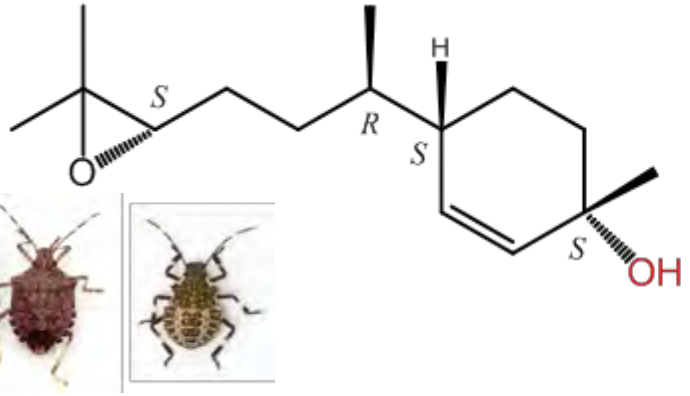
2012 Summary Results



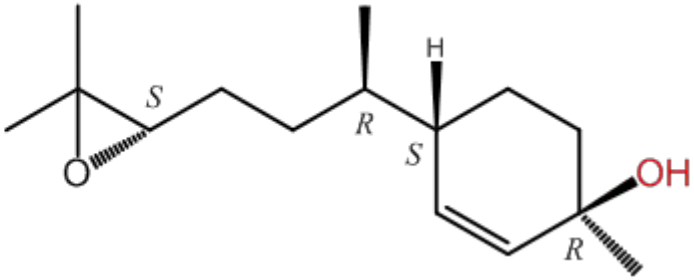
Leskey et al. 2015a

Two-Component BMSB Aggregation Pheromone and Synergist

Main component of BMSB aggregation pheromone
(3*S*,6*S*,7*R*,10*S*)-10,11-epoxy-1-bisabolen-3-ol

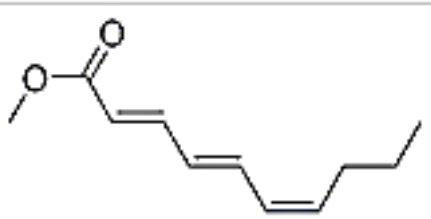


Minor component of BMSB aggregation pheromone
(3*R*,6*S*,7*R*,10*S*)-10,11-epoxy-1-bisabolen-3-ol



+

Methyl (*E,E,Z*)-2,4,6-decatrienoate (MDT) acts as a synergist for BMSB pheromone



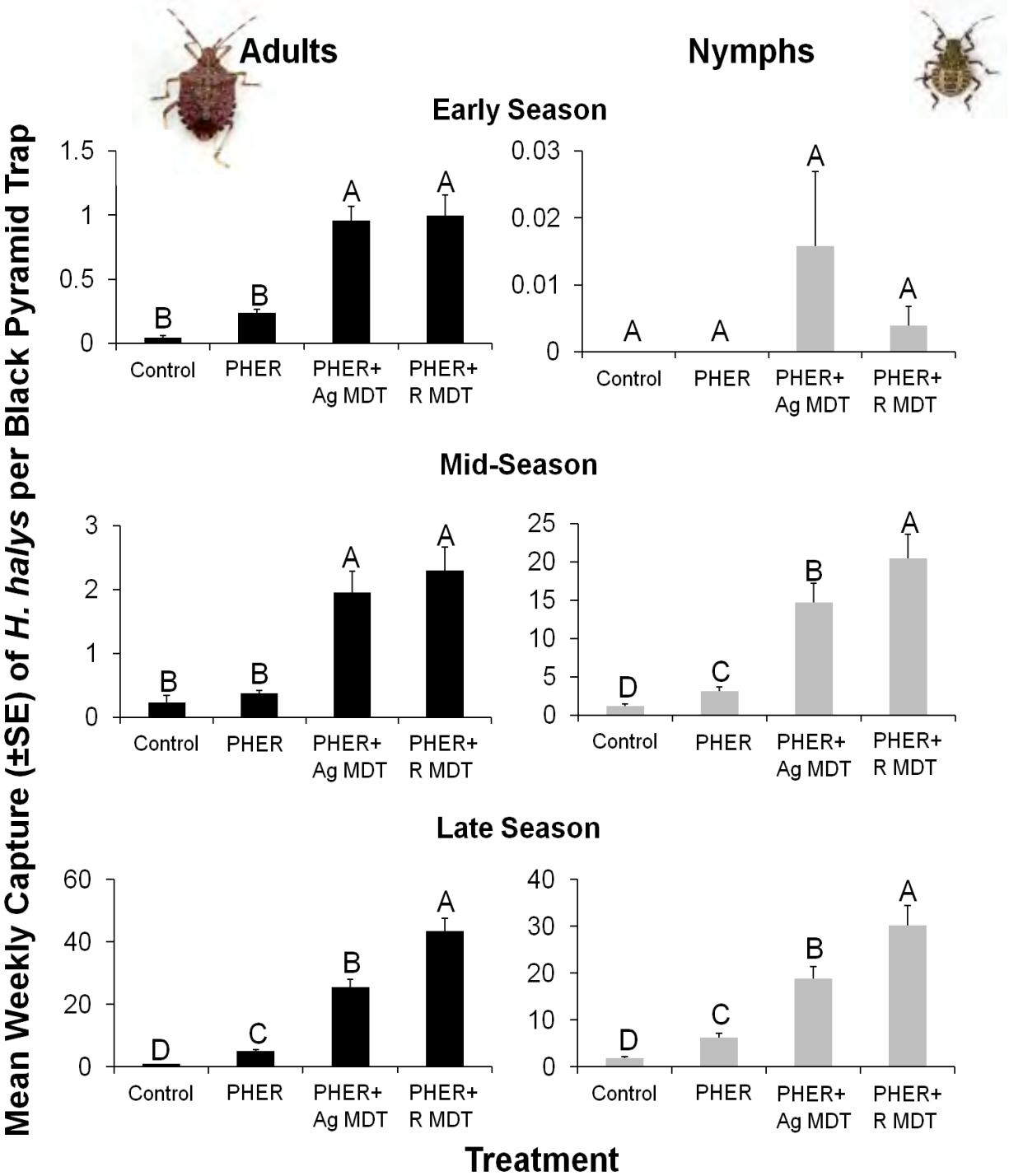
= **Synergism**

Weber et al. 2014

General Protocol

- Black pyramid traps
- Three odor treatments
  - 1) #10 (10 mg)
  - 2) #10 (10 mg) + Rescue MDT (119 mg)
  - 3) #10 (10 mg) + AgBio MDT (66 mg)
  - 4) Unbaited control
- Traps are deployed between wild host habitat and agricultural production areas.
- Traps were deployed in mid-April and left in place season-long.

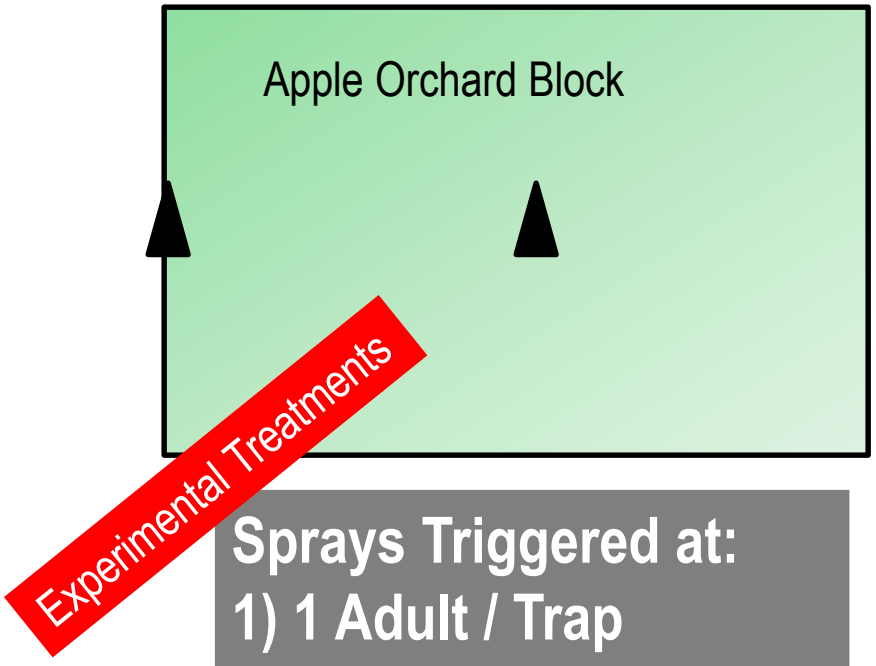
2013 Summary Results



Leskey et al. 2015a

Can we use biological information provided by trap captures to guide management decisions?

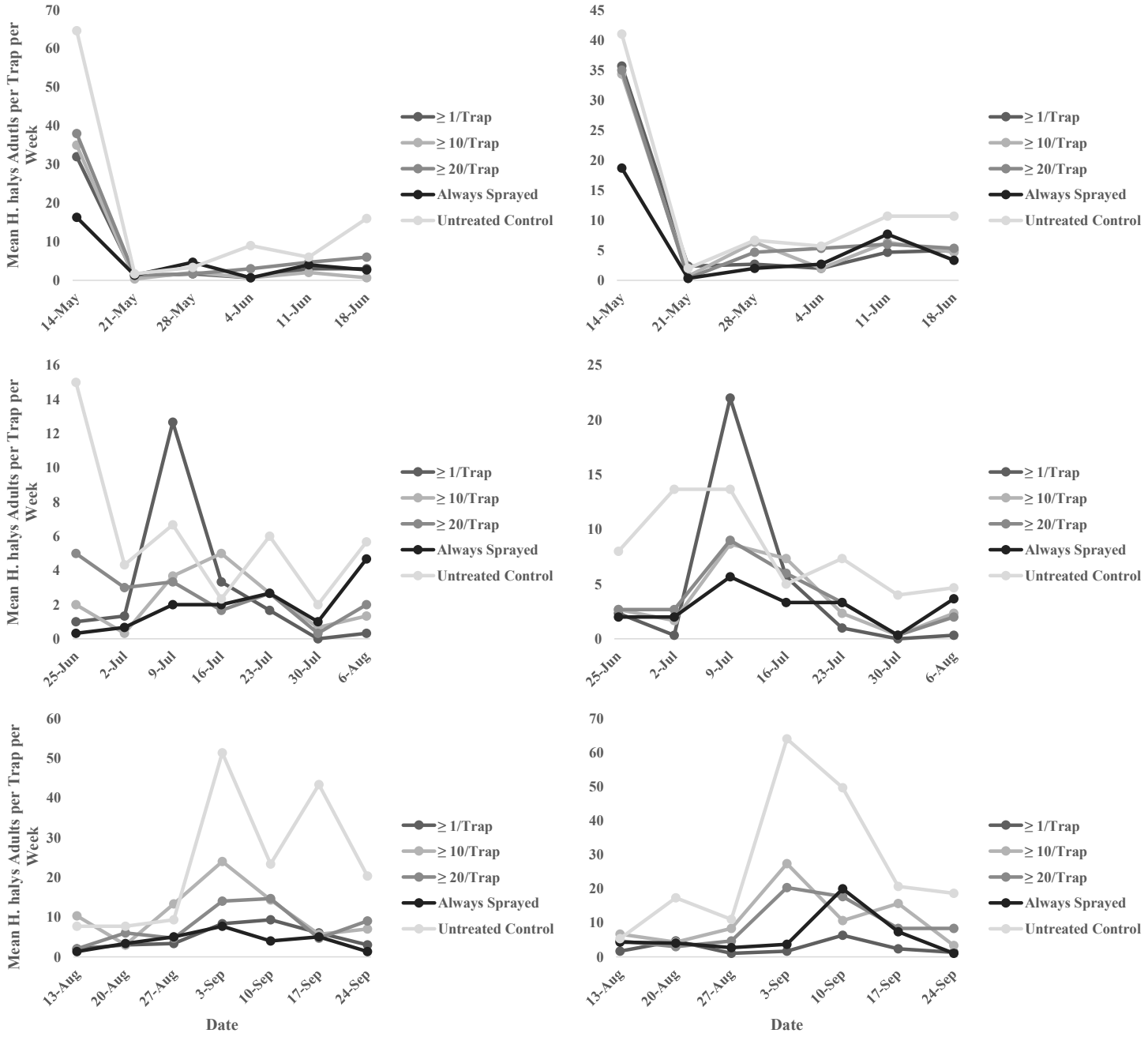
- Apple blocks. monitored with two baited traps. Traps checked weekly.
- When adult captures in either trap reached a set threshold, the block was treated with BMSB material (ARM).
- Block treated again 7-d later. Threshold was then reset.



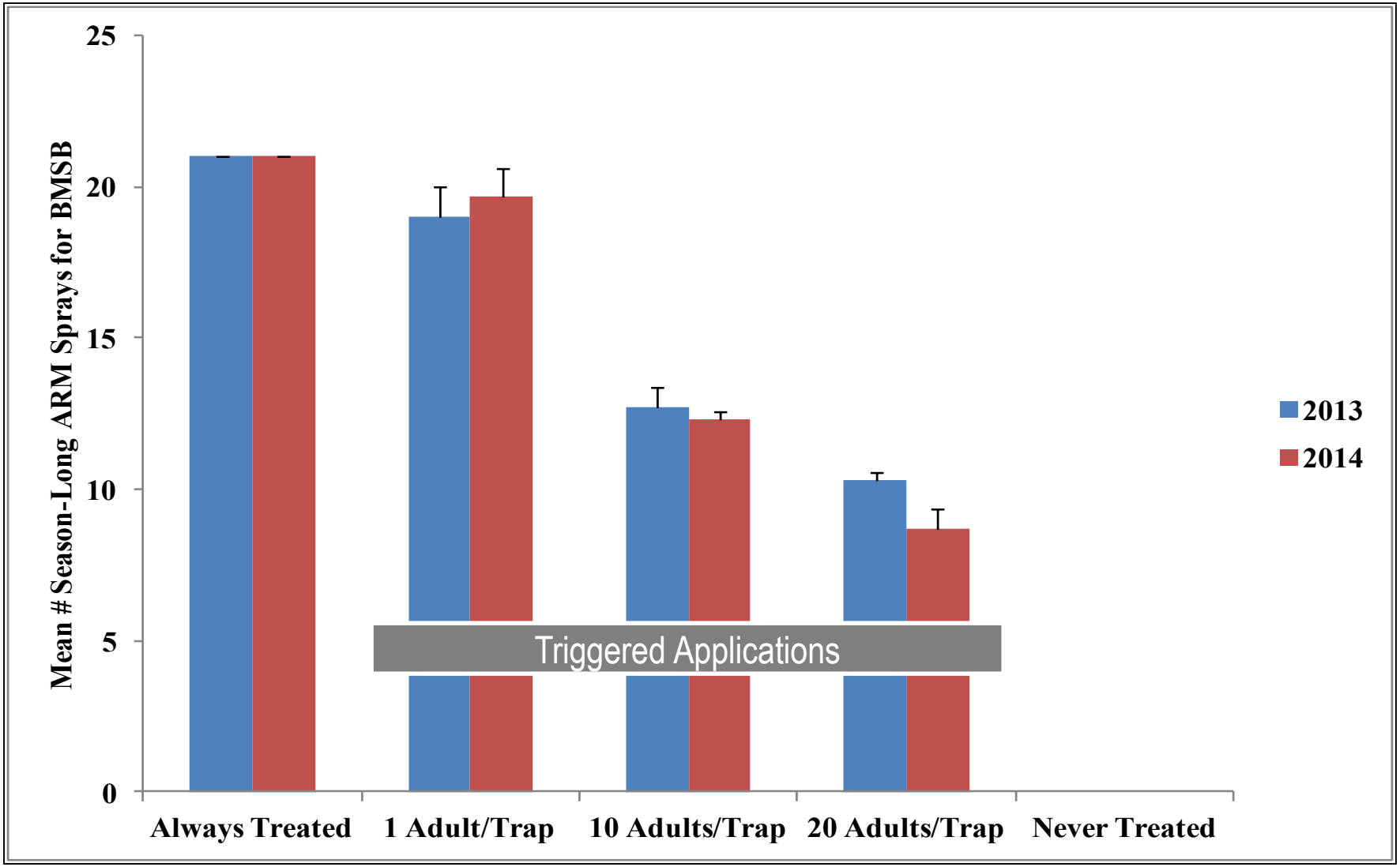
Sprays Triggered at:
1) 1 Adult / Trap
2) 10 Adults / Trap
3) 20 Adults / Trap

4) Treated Every 7 d

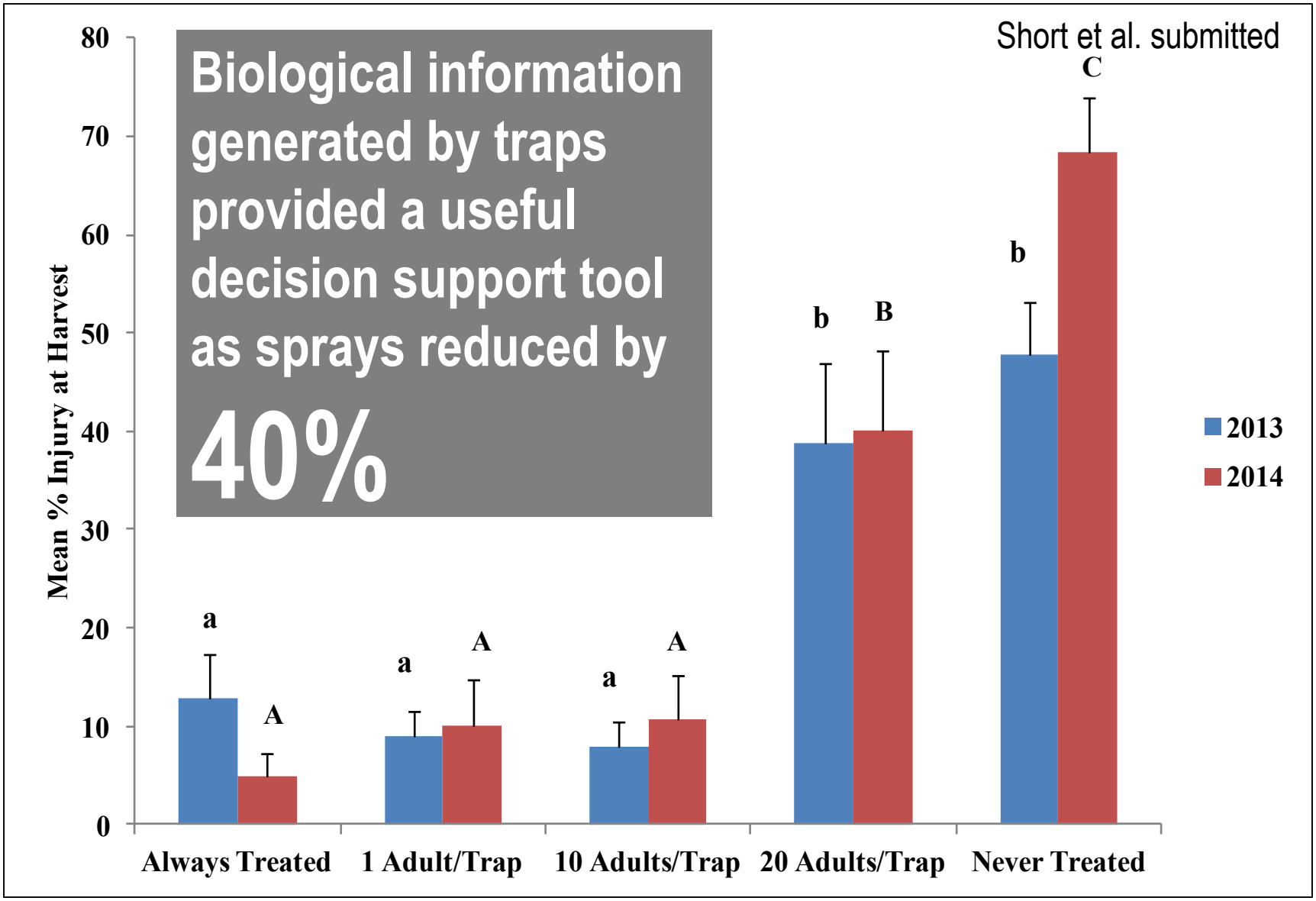
5) No Spray (Control)


Mean H. halys Adutls per Trap per Week
Mean H. halys Adults per Trap per Week
Mean H. halys Adults per Trap per Week
≥ 1/Trap
≥ 10/Trap
≥ 20/Trap
Always Sprayed
Untreated Control
14-May
21-May
28-May
4-Jun
11-Jun
18-Jun
25-Jun
2-Jul
9-Jul
16-Jul
23-Jul
30-Jul
6-Aug
13-Aug
20-Aug
27-Aug
3-Sep
10-Sep
17-Sep
24-Sep
Date

Season-Long Insecticide Applications Made Against BMSB



BMSB Injury at Harvest



Can we make trapping simpler for growers?

- **Visual Stimulus**
  - Large black pyramid (trunk-mimicking stimulus)
- **Olfactory Stimulus**
  - PHER + MDT
- **Capture Mechanism**
  - Tapered pyramid attached to inverted funnel jar with DDVP strip
- **Deployment Strategy**
  - Traps placed in peripheral row or border area

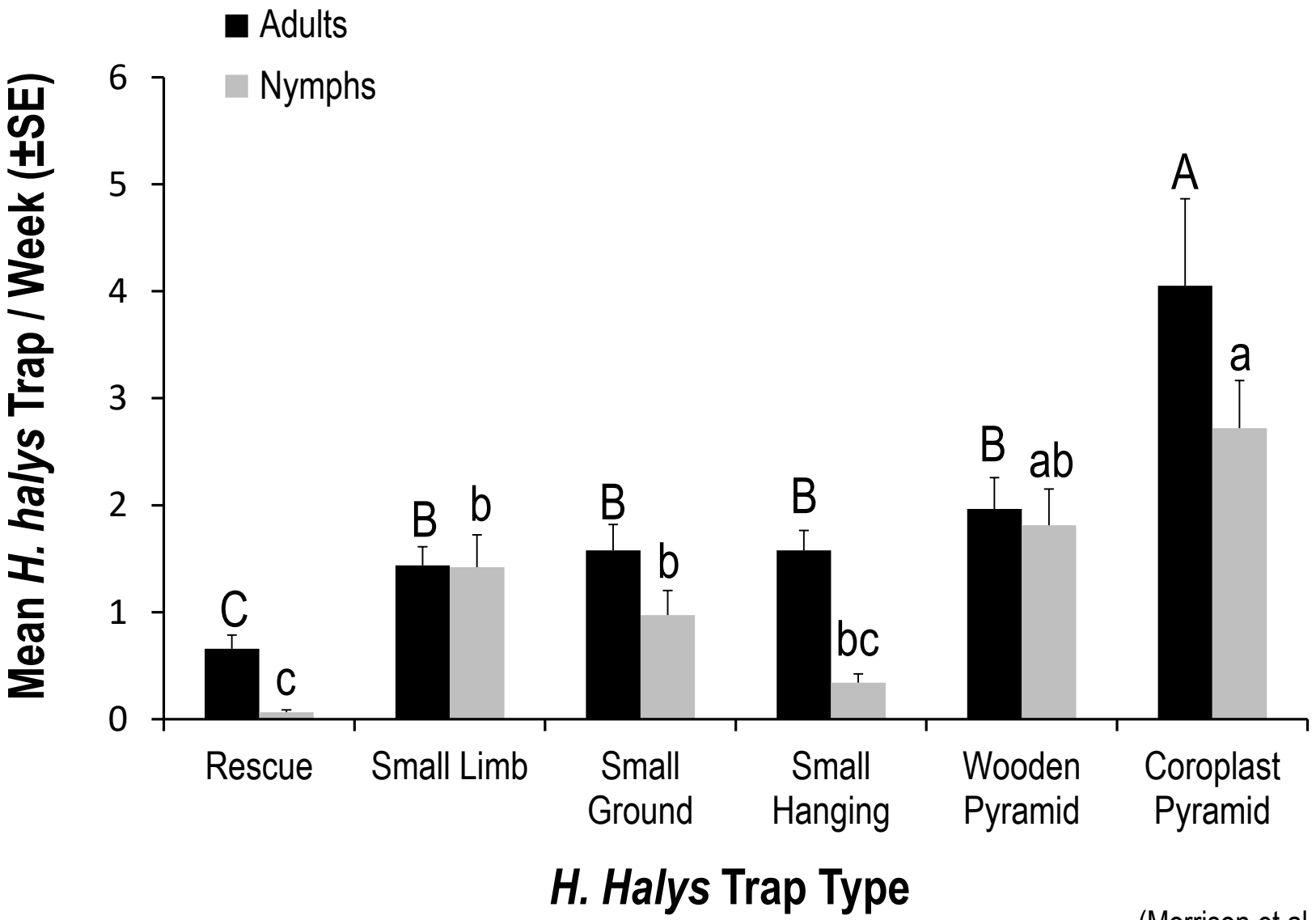
Can we utilize other trap styles?

Experimental Standard Wooden Pyramid	Coroplast Pyramid	Small Pyramid (Ground)	Small Pyramid (Limb)	Small Pyramid (Hanging)	Rescue (Hanging/ Foilage)
					

- Are captures similar among other trap types and deployment strategies compared with our experimental standard?

- Baited with BMSB Pheromone + MDT synergist. Two years of data from commercial orchards.

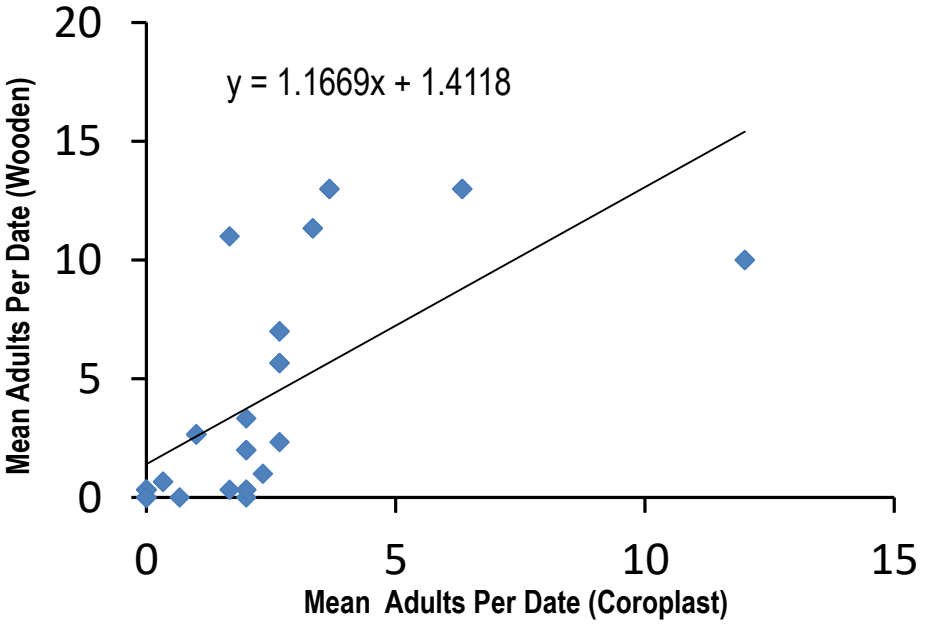
Season-Long Trap Captures / Sensitivity



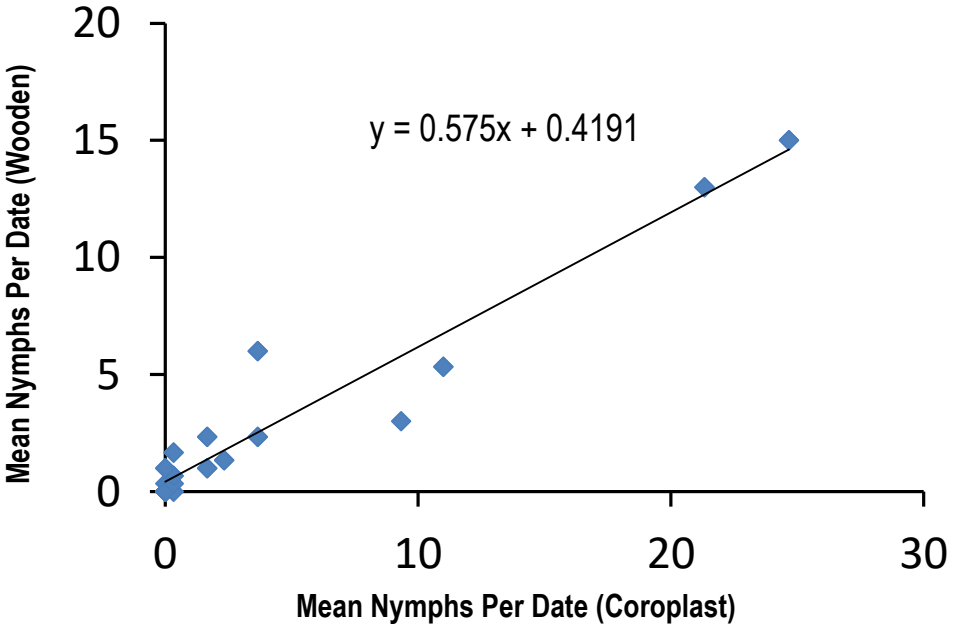
(Morrison et al. 2015)

Coroplast vs. Standard Wooden Pyramids

Spearman Rank Correlation
ρ=0.735
P < 0.0001

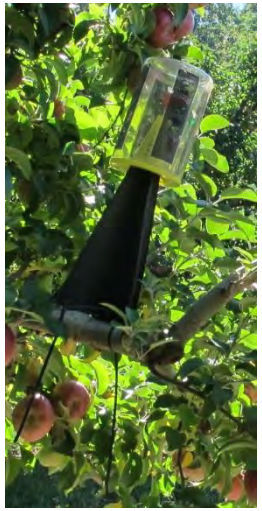


Spearman Rank Correlation
ρ=0.900
P < 0.0001



(Morrison et al. 2015)

Coroplast vs. All Others

Coroplast Pyramid	Small Pyramid (Ground)	Small Pyramid (Hanging)	Small Pyramid (Limb)	Rescue (Hanging/ Foilage)
				
	 SIG.	 SIG.	 SIG.	 NS
	 SIG.	 SIG.	 SIG.	 SIG.

(Morrison et al. 2015)

New Trap Comparisons

Delta Trap

Yellow Sticky Card

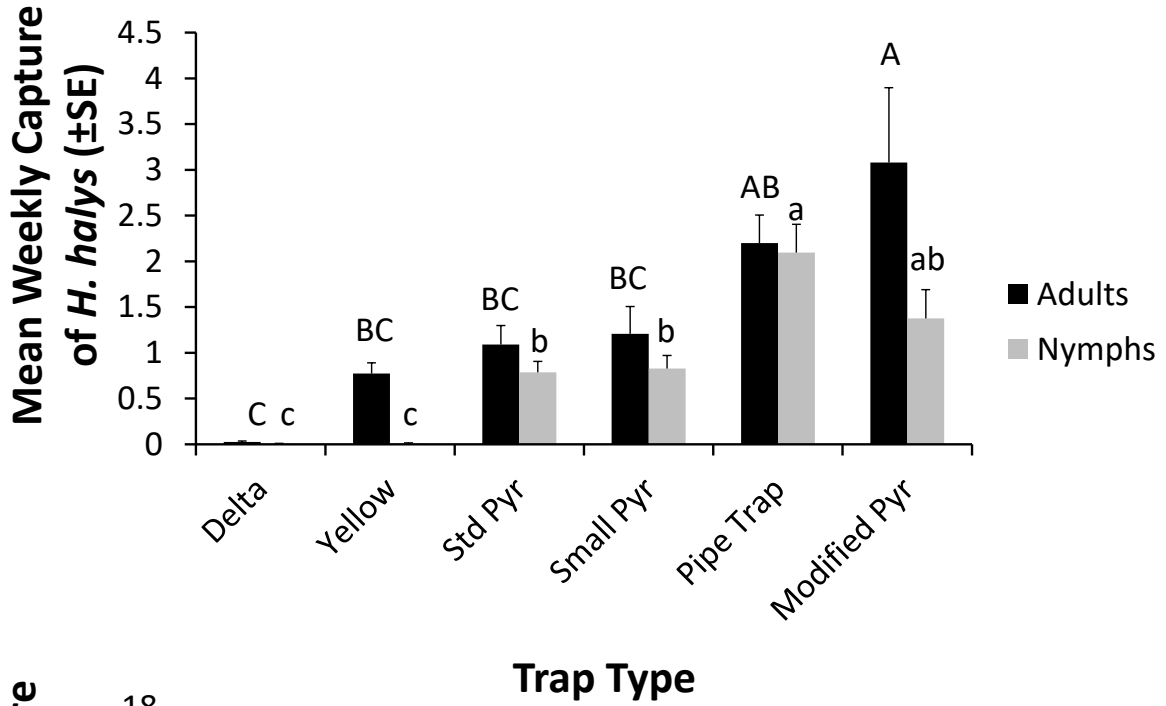
Standard Coroplast Pyramid

Small Black Pyramid

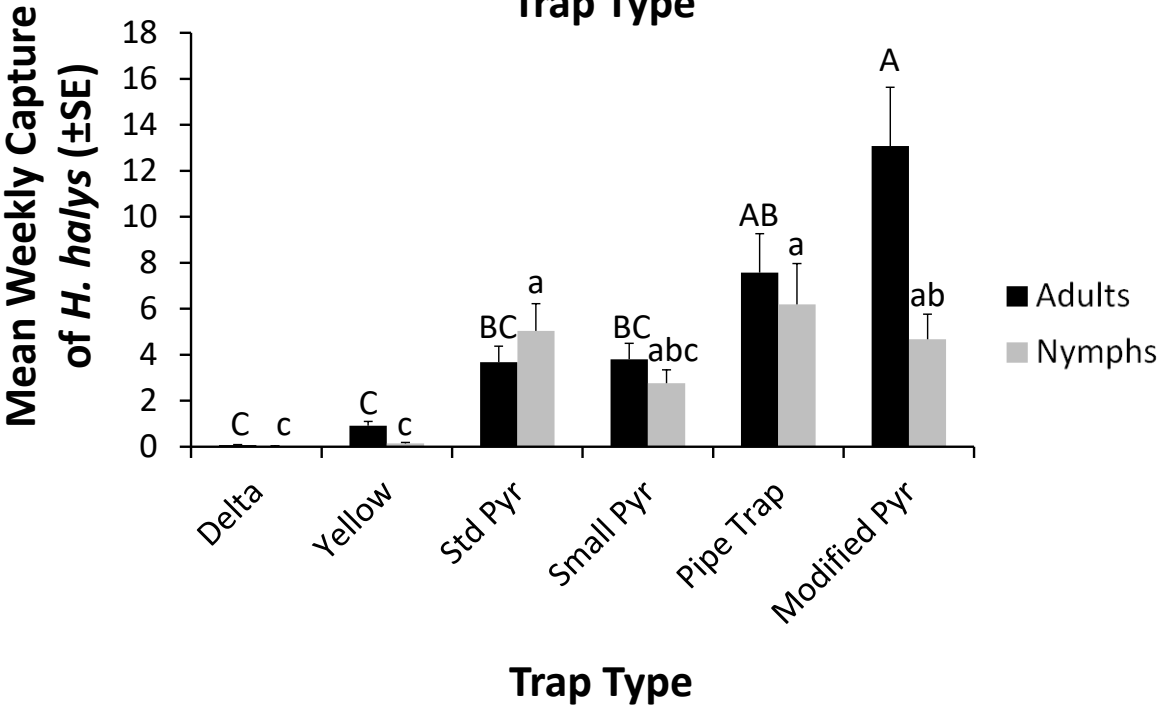
Pipe Trap

Modified Jar Top Pyramid

2015 Results



2016 Results



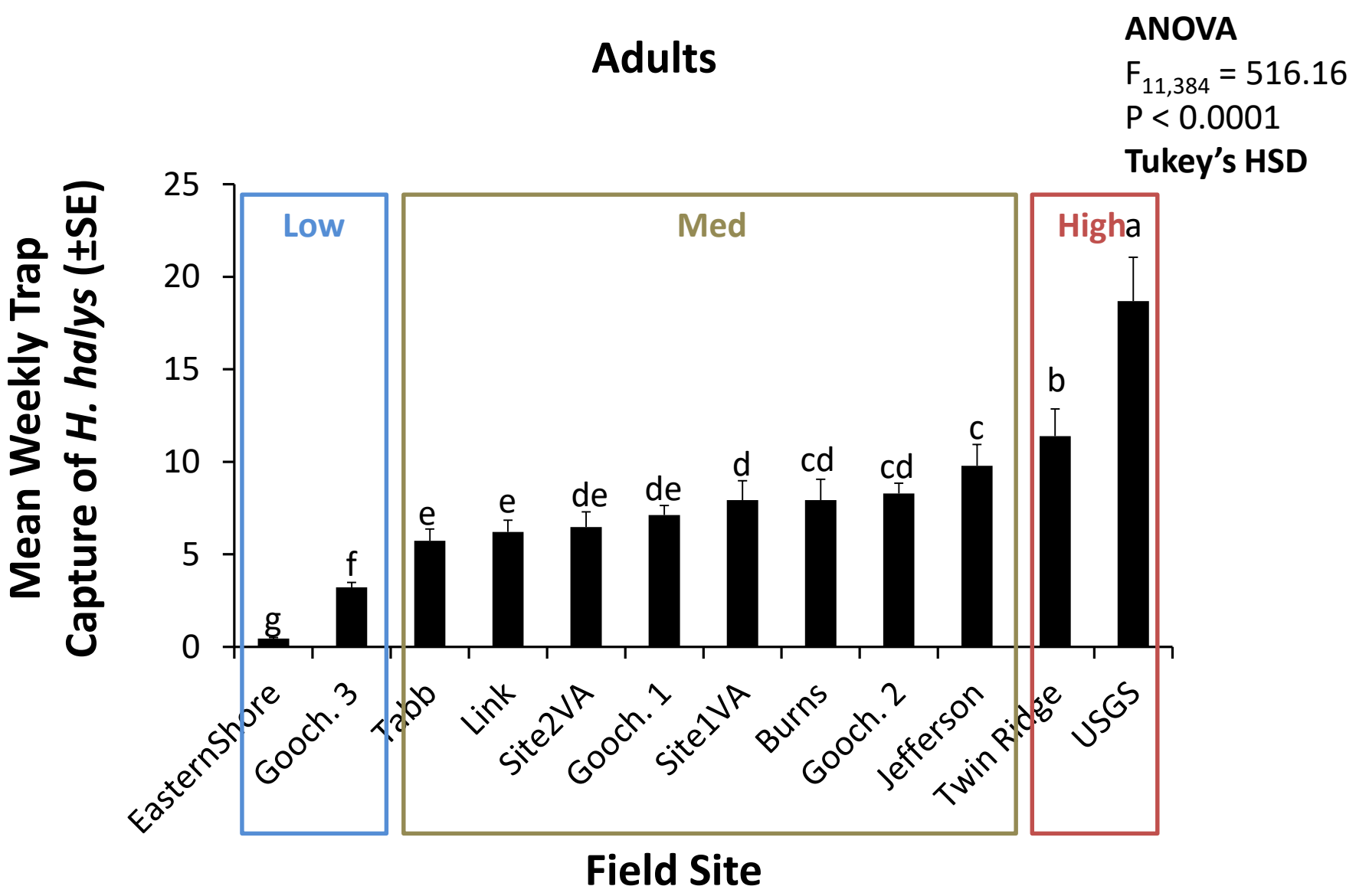
Standard Pyramid vs. All Others

Delta Trap	Yellow Sticky Card	Standard Coroplast Pyramid	Small Black Pyramid	Pipe Trap	Modified Jar Top Pyramid
					
SIG.	SIG.		SIG.	SIG.	SIG.
NS	NS		SIG.	SIG.	SIG.

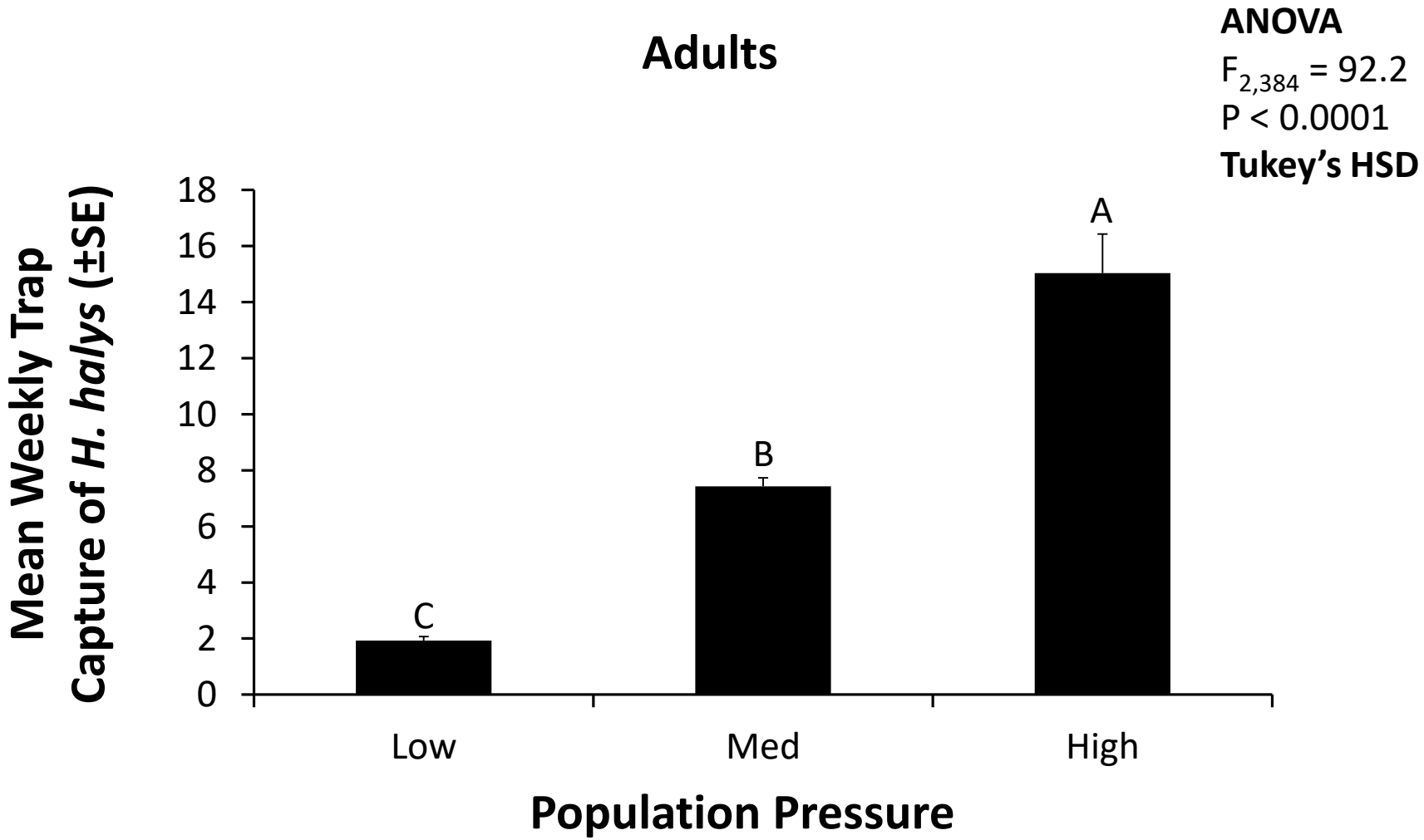
Standard Traps vs. Clear Sticky Cards

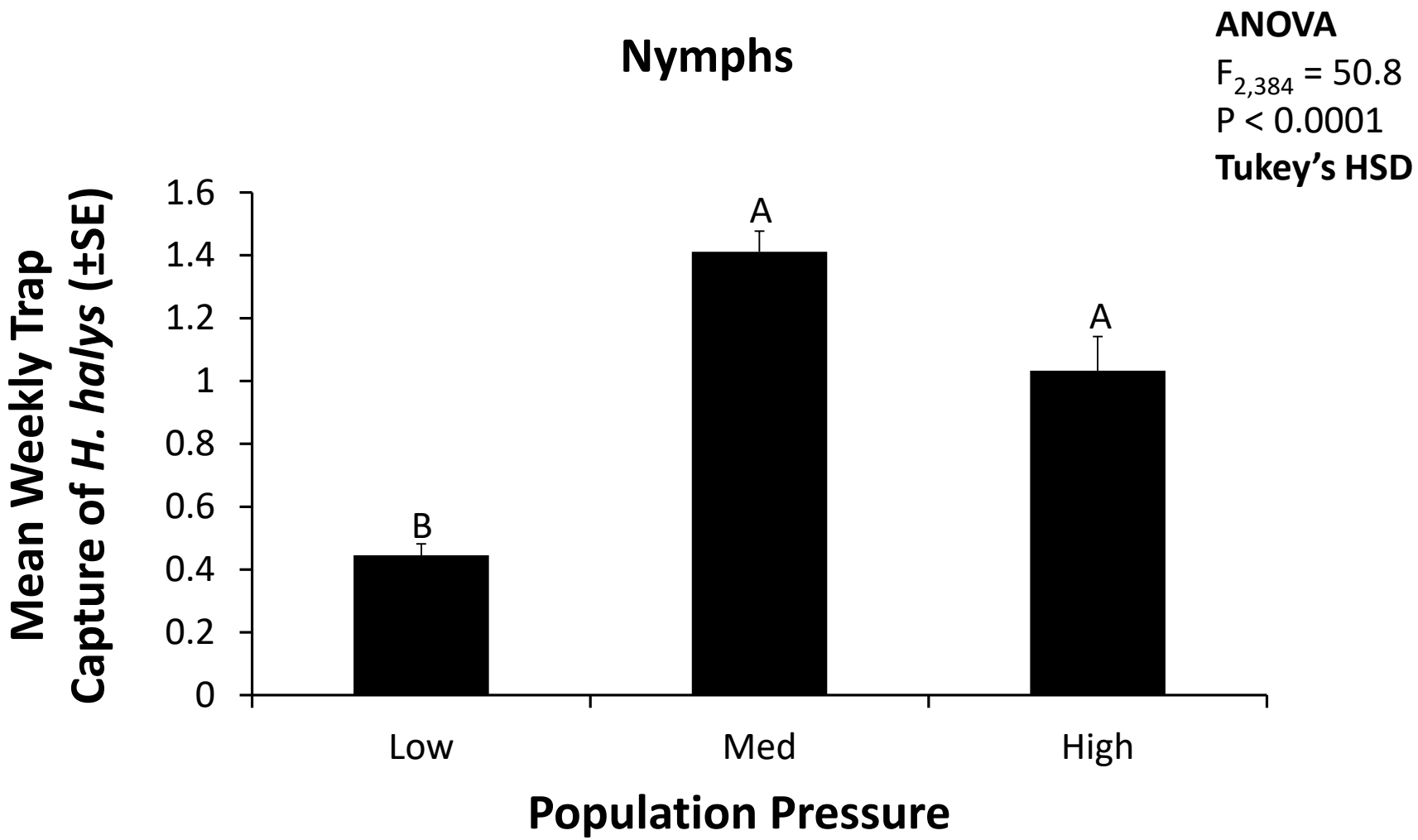
- Monitoring Loading (1x, 5/50) and Surveillance Loading (4x, 20/200) loading.
- Twelve sites in WV, MD and VA.
- Season-long trap captures.

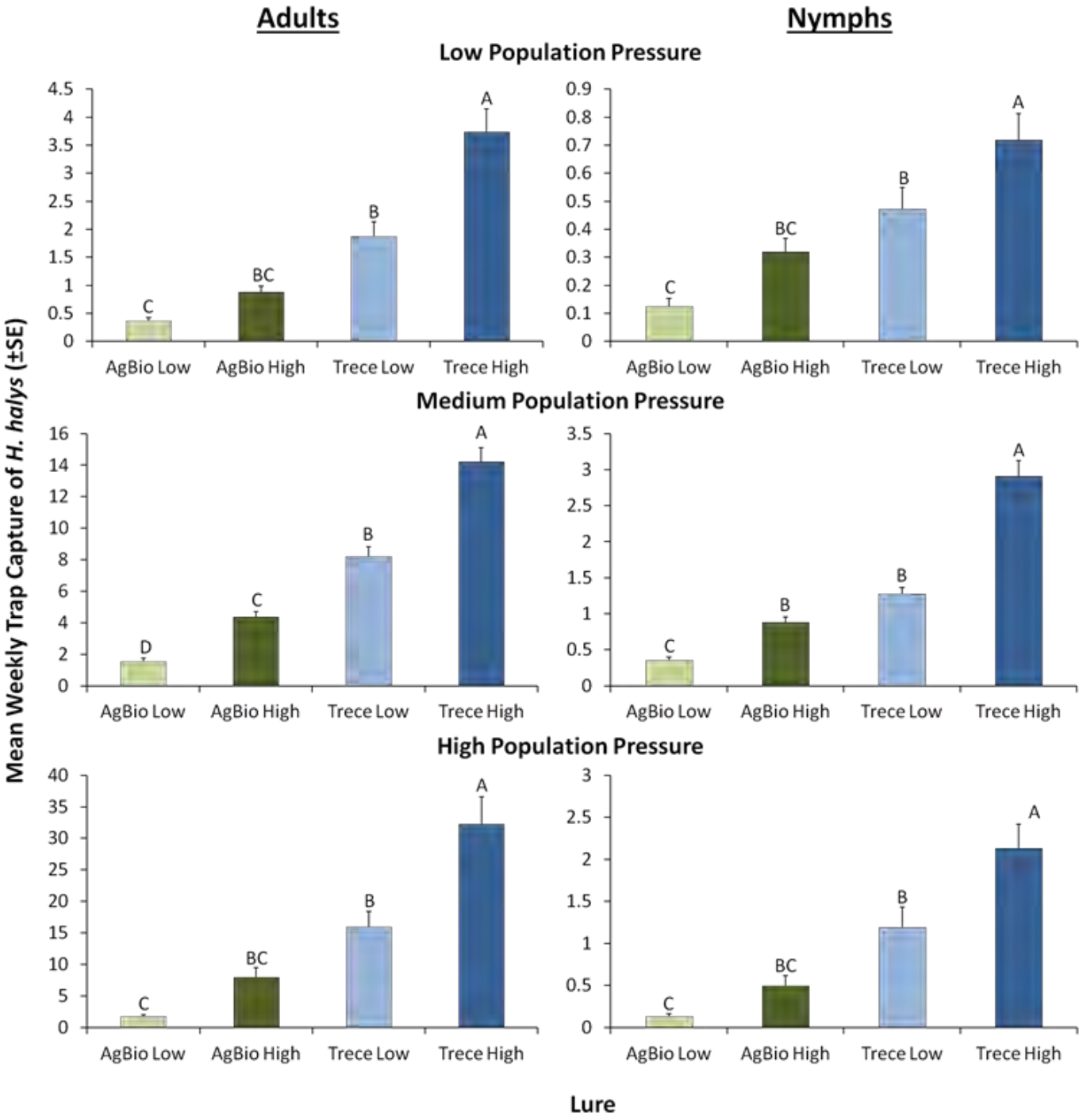
Ministry for Primary Industries
Manatū Ahu Matua

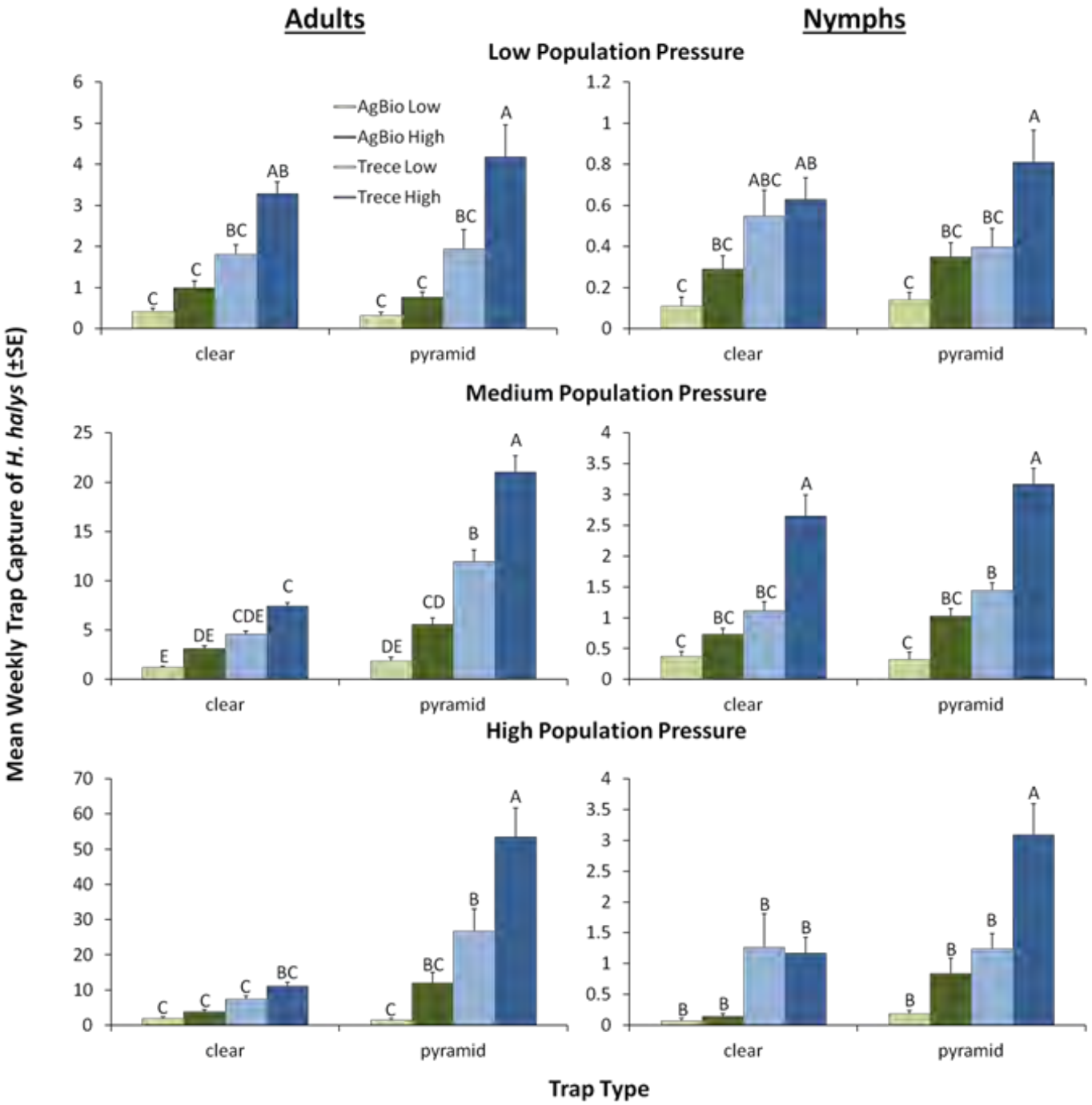

Adults
ANOVA
$F_{11,384}$ = 516.16
P < 0.0001
Tukey's HSD
Mean Weekly Trap Capture of *H. halys* (±SE)
25
20
15
10
5
0
Low
Med
High
g
f
e
e
de
de
d
cd
cd
c
b
a
EasternShore
Gooch. 3
Tabb
Link
Site2VA
Gooch. 1
Site1VA
Burns
Gooch. 2
Jefferson
Twin Ridge
USGS
Field Site

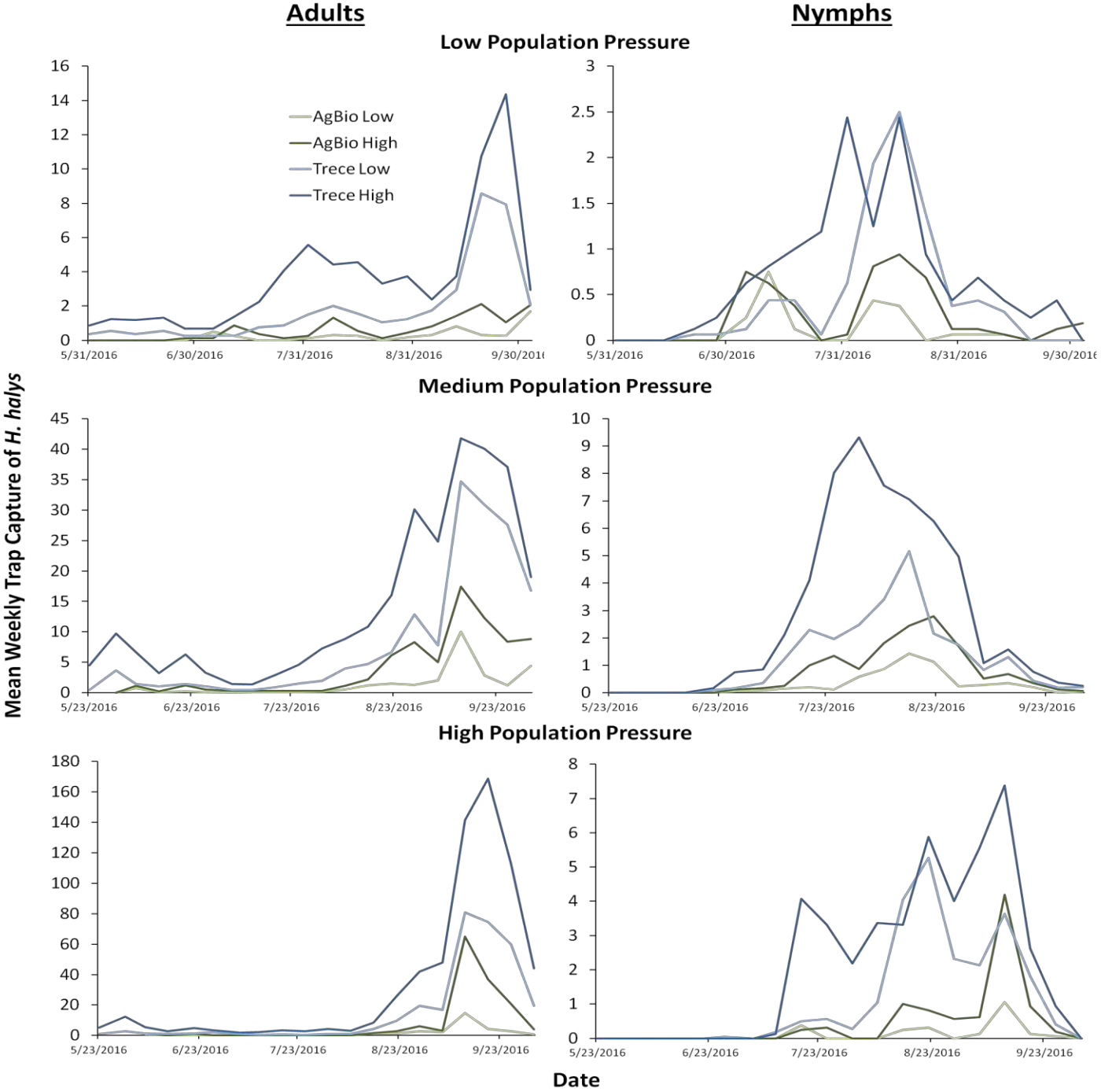
Based on New Classification Scheme: Population Pressure




Nymphs
ANOVA
$F_{2,384}$ = 50.8
P < 0.0001
Tukey's HSD
Mean Weekly Trap Capture of *H. halys* (±SE)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
A
A
B
Low
Med
High
Population Pressure


Adults
Nymphs
Low Population Pressure
Medium Population Pressure
High Population Pressure
Mean Weekly Trap Capture of H. halys (±SE)
Lure
AgBio Low
AgBio High
Trece Low
Trece High
A
B
BC
C
D


Adults
Nymphs
Low Population Pressure
Medium Population Pressure
High Population Pressure
AgBio Low
AgBio High
Trece Low
Trece High
clear
pyramid
Mean Weekly Trap Capture of H. halys (±SE)
Trap Type


Adults
Nymphs
Low Population Pressure
Medium Population Pressure
High Population Pressure
AgBio Low
AgBio High
Trece Low
Trece High
Mean Weekly Trap Capture of H. halys
Date
5/31/2016
6/30/2016
7/31/2016
8/31/2016
5/23/2016
6/23/2016
7/23/2016
8/23/2016
9/23/2016

Correlations Between Pyramid Traps and Sticky Cards

Table 1. Pearson correlation coefficients between captures of *H. halys* in pyramid traps compared to clear sticky cards under low, medium, and high population pressure

	Adults			**Nymphs**		
Population Pressure	r	df	*P*	r	df	*P*
Trece Low						
Low	0.777	37	0.0001	0.883	37	0.0001
Med	0.617	158	0.0001	0.499	158	0.0001
High	0.663	40	0.0001	0.414	40	0.007
Trece High						
Low	0.740	37	0.0001	0.703	37	0.0001
Med	0.528	158	0.0001	0.462	158	0.0001
High	0.673	40	0.0001	0.322	40	0.04

Correlations Between Sticky Cards Baited With Trece High and Low

- Significant correlations for captures on clear sticky cards baited with high and low Trece lures for adults and nymphs at low, moderate and high populations.

- Lower loading rate (1x) provides the same phonological information as the higher loading rate (4x).

Key Components of Trap-Based Monitoring

- **Visual Stimulus**
  - Upright wooden post
- **Olfactory Stimulus**
  - Trece 1x Lure
- **Capture Mechanism**
  - Double sided sticky card attached to top of post
- **Deployment Strategy**
  - In border regions between wild host habitat and agricultural production or other habitat.

What Are Our Next Steps For Monitoring?

- **Trap Style.** Can we develop a more user-friendly trap design?
- **Lure Efficiency.** What is the distance of response? How many traps do we need?
- **Trap Location.** Where should traps be deployed? What is the impact of surrounding vegetation?
- **Decision support tools**. Can we develop thresholds with these modified designs and for other crops?

Other Practical Considerations

- **Patent.** Dual lures and EDT.
- **Other Companies.** Commercialization and refinement.
- **Host Plant Volatiles.** Inexpensive improvements.
- **Attract and Kill**. Can we make it affordable?