Best Cocktails for BMSB

Results from two years of attraction

Brown Marmorated Stink Bug Workshop
29 November 2017, Winchester, Virginia

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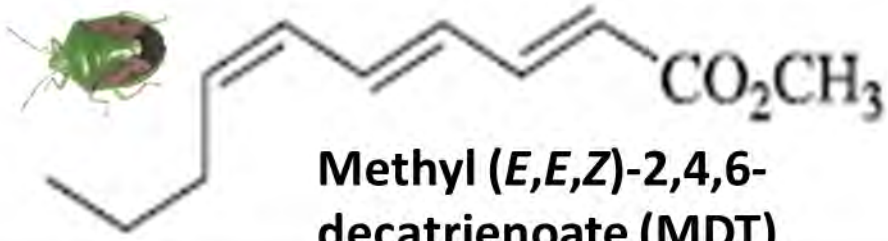
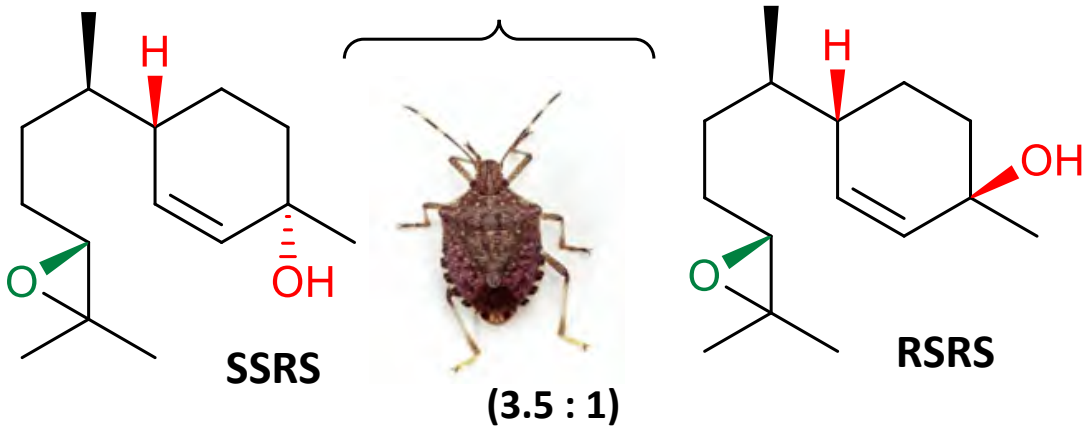
BMSB attractants

Plautia stali pheromone



Methyl (*E*,*E*,*Z*)-2,4,6-decatrienoate (MDT)

Halyomorpha halys pheromone



10,11-epoxy-1-bisabolen-3-ol
(chiral centers: carbons 3,6,7,10)

Ratios (=mixology), doses, and purity !

- **ratio between pheromone components**
  - **two stereoisomers (SSRS and RSRS) of 10,11-epoxy-1-bisabolen-3-ol**
  - **stereospecific synthesis is challenging & expensive**
  - **racemic mixtures are way cheaper, but impure mixes may not be attractive (or as attractive)**
- **ratio between pheromone & other attractants**
  - **BMSB pheromone with MDT (*P. stali* pheromone) (others with e.g. plant volatiles)**
  - **optimal mix may change seasonally**
  - **economic issues for trapping, attract & kill**

Ratios, doses, and purity! – ISSUE$

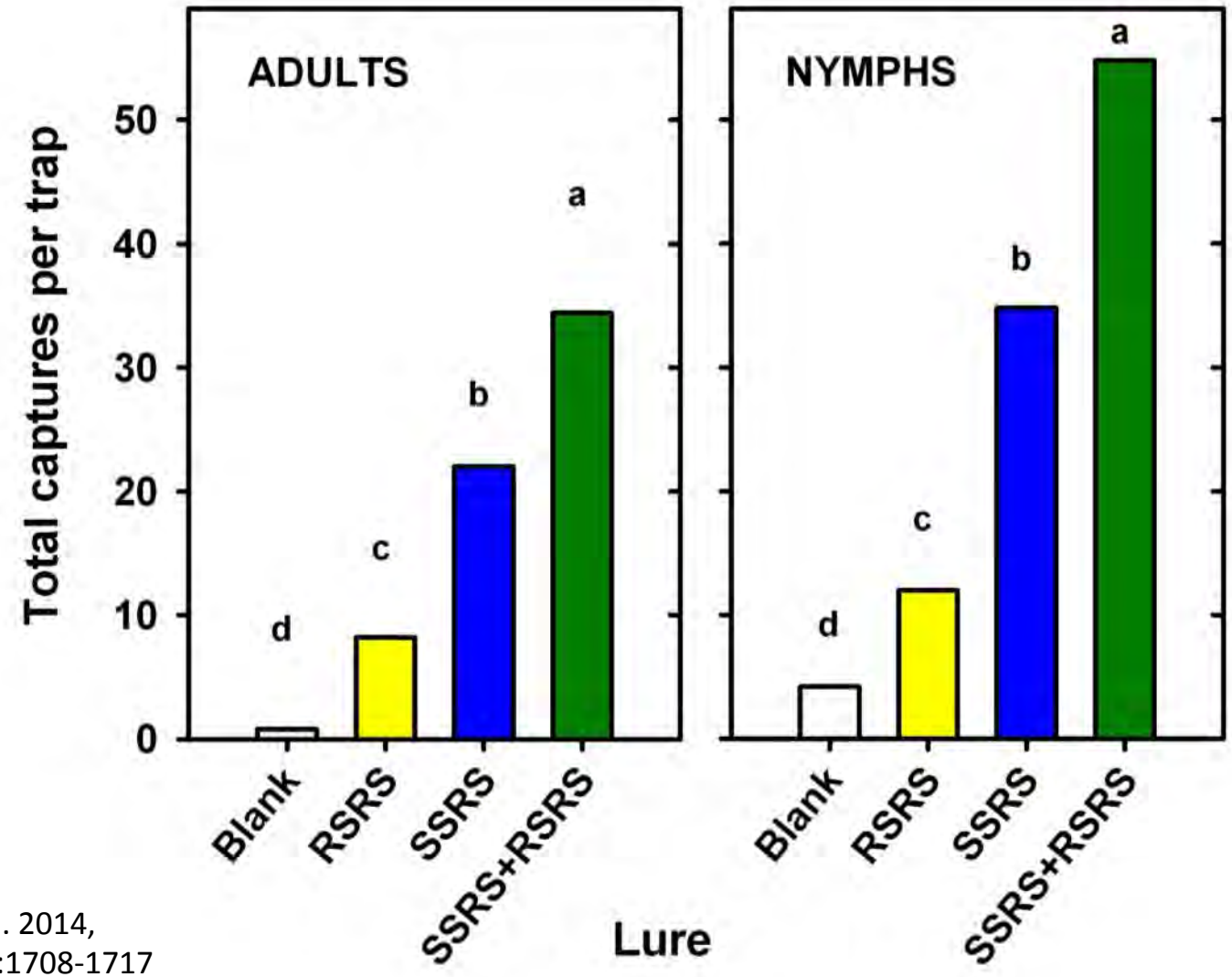
- issue: individual stereoisomers are expensive; better to use a mixture – but only *if* it works!
- economical synthesis from *R*-citronellal produces 8 isomers – for each species, that's 6 that are not part of pheromone
- synthesis also produces a different ratio than that emitted by male marmorated bugs:
  - synthesis produces SSRS:RSRS as 1:1.7, but
  - male produces SSRS:RSRS in 3.5:1 mix!

Best to have both: but only natural ratio tested initially

H. halys captures in pyramid traps with pheromone components

loading: RSRS, 4mg; SSRS, 4mg; SSRS+RSRS, 4mg+1.1mg

5 randomized blocks, 8 June through 30 July 2013, Beltsville, Maryland



Khrimian et al. 2014,
J.Nat.Prod.77:1708-1717

Purity: How important for attraction? Not so much!

For BMSB, mixed-isomer preparations with equivalent principal component, (3*S*,6*S*, 7*R*,10*S*)-10,11-epoxy-1-bisabolen-3-ol, attract comparable numbers of adult (equal male/female) and nymphal bugs in the field

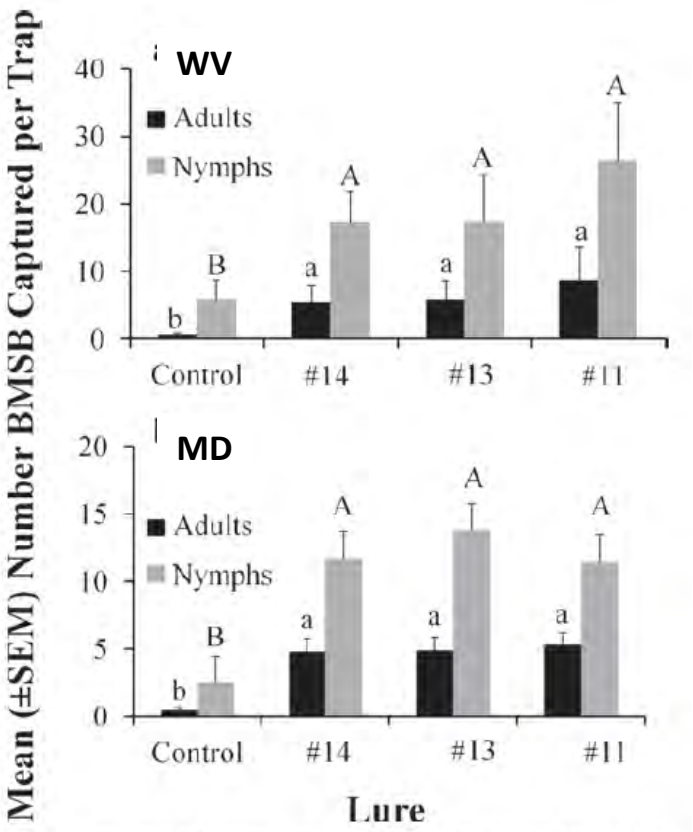


Fig. 4 Purity trial showing mean catches of *Halyomorpha halys* (± SE) in a West Virginia and b Maryland from 12 Aug—4 Sep 2013 for lures that were synthesized using racemic citronellal and were minimally purified by one or no chromatographic separations. Bars with shared

Leskey et al. 2015, J. Chem. Ecol 41: 418-429

Halyomorpha halys
Brown marmorated stink bug

Our original factorial experiment (what we call now, 1:1 ratio):


BMSB pheromone (mixed isomer with ~2mg of SSRS)


MDT (66mg)


Both

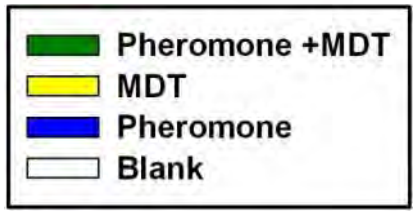

Neither

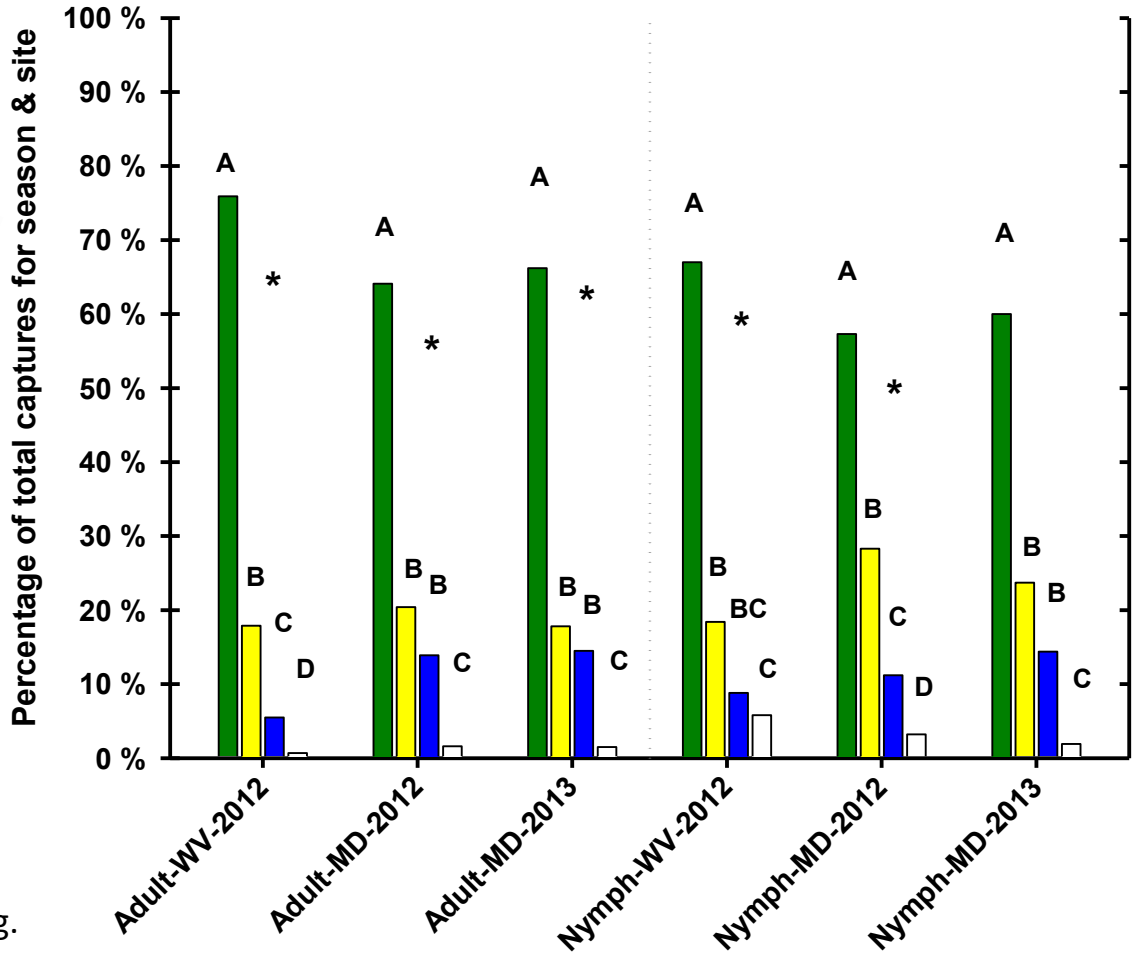
(black pyramid traps, MD & WV, randomized complete blocks, season-long 2012 & in MD 2013)

pheromone is mixed-isomer synthetic lure with
~2mg of SSRS-murgantiol; MDT loaded 60-66mg.
Weber et al. 2014, J.Econ.Entomol. 107: 1061–1068.

Use of pheromone together with MDT produces synergistic attraction ...

Halyomorpha halys
Brown marmorated stink bug



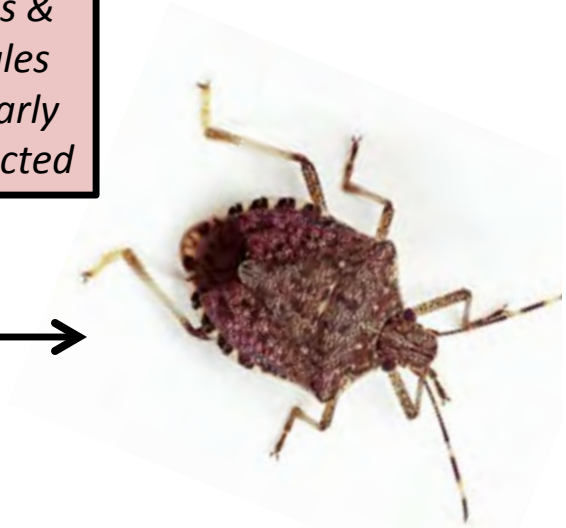


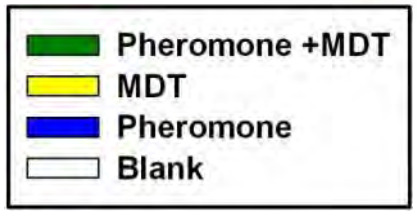
pheromone is mixed-isomer synthetic lure with ~2mg of SSRS-murgantiol; MDT loaded 60-66mg.
Weber et al. 2014, J.Econ.Entomol. 107: 1061–1068.

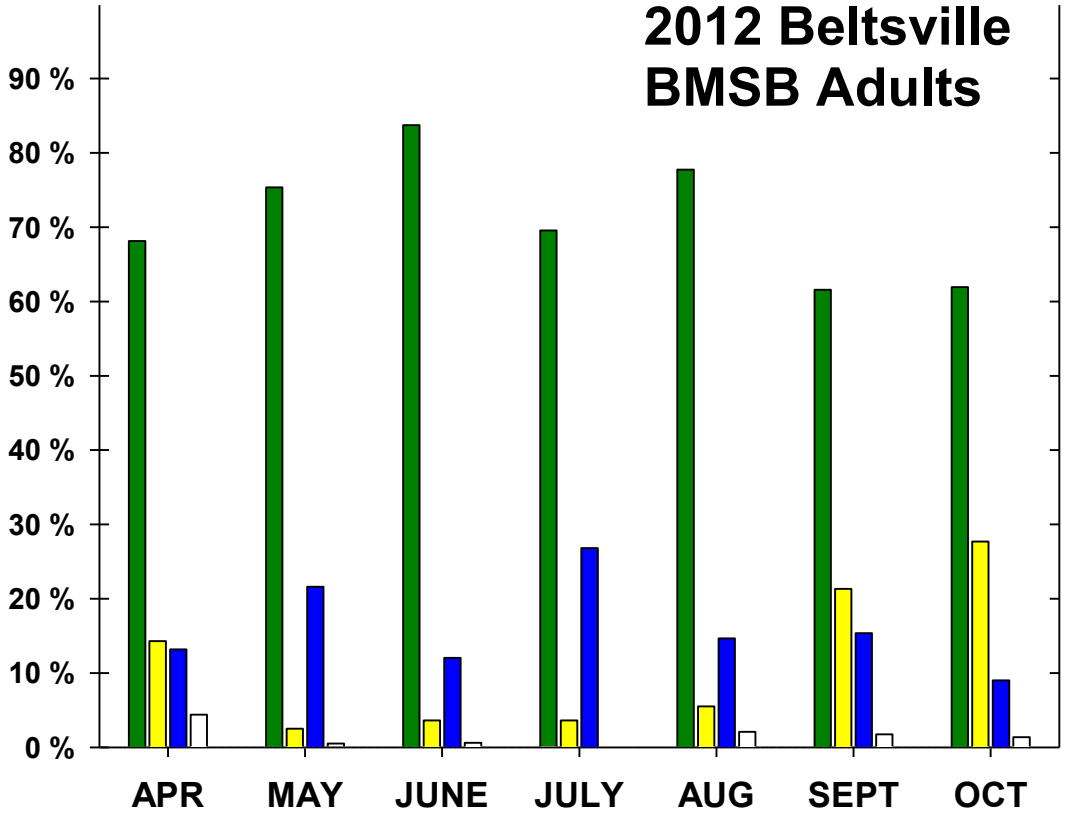
Combined lure is superior over the entire season for adults

Halyomorpha halys
Brown marmorated stink bug

males & females similarly attracted



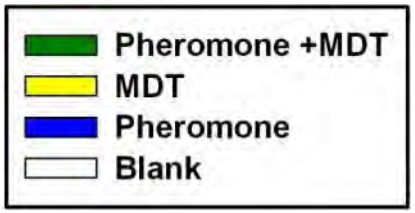


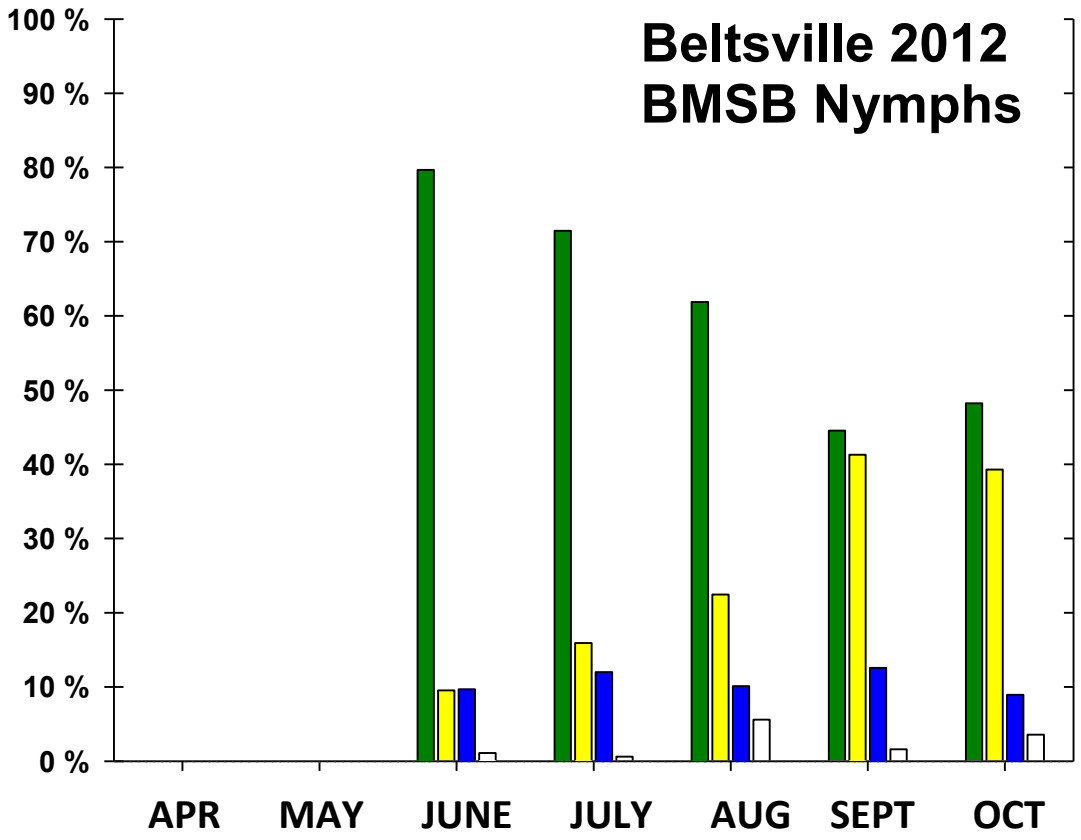


Weber et al. 2014, J.Econ.Entomol. 107: 1061–1068

Halyomorpha halys
Brown marmorated stink bug

... and also provides superior season-long attraction in nymphs

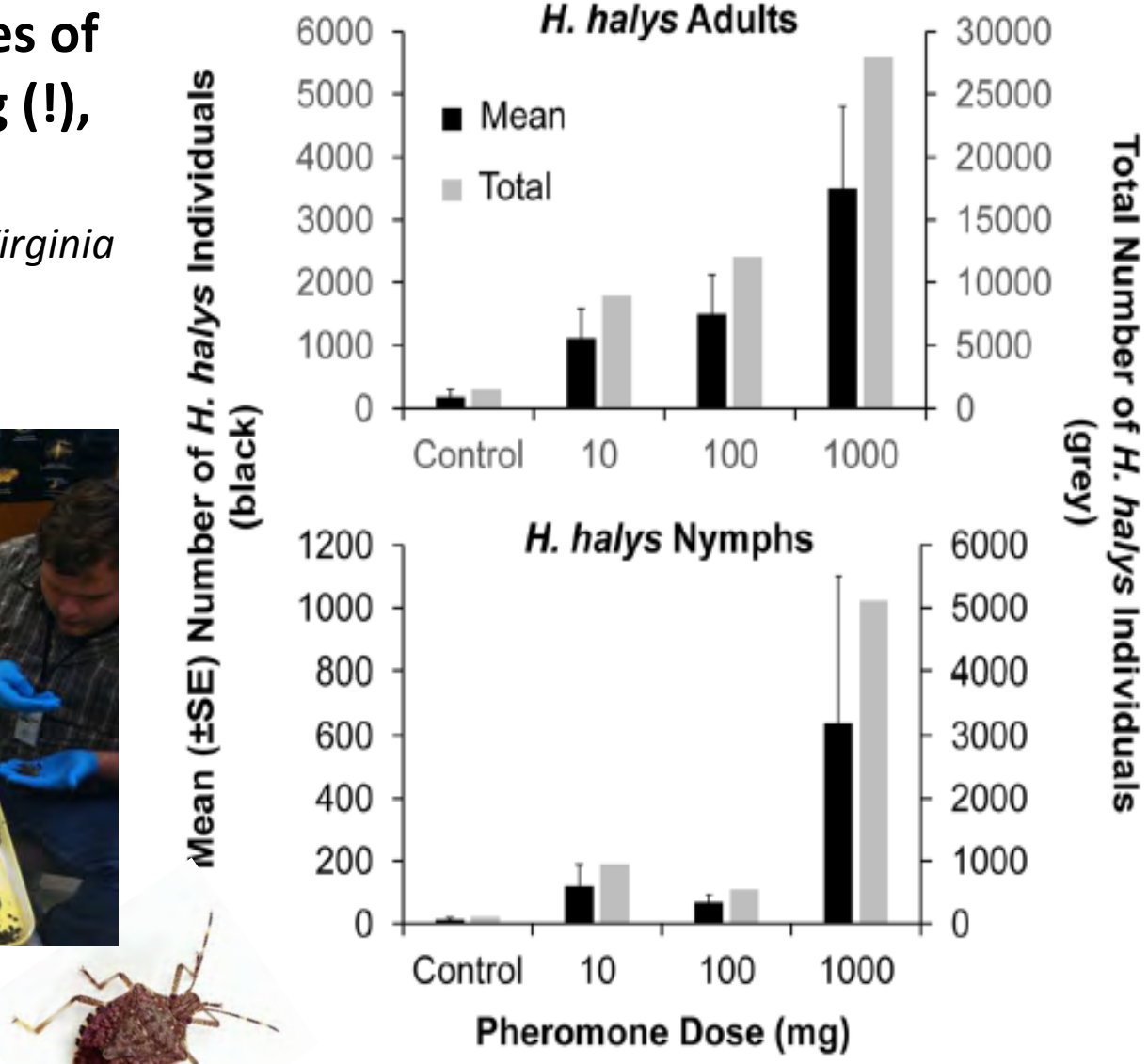




Weber et al. 2014, J.Econ.Entomol. 107: 1061–1068

H. halys attraction to mixed-isomer pheromone lures of 0, 10, 100, and 1000mg (!), with 66mg MDT

August 2013, soybean, West Virginia



pheromone is mixed-isomer synthetic lure
Morrison et al. 2016, J. Pest Sci. 89: 81-96.

Detailed Ratio Field Trials
2016 and 2017, Maryland and West Virginia

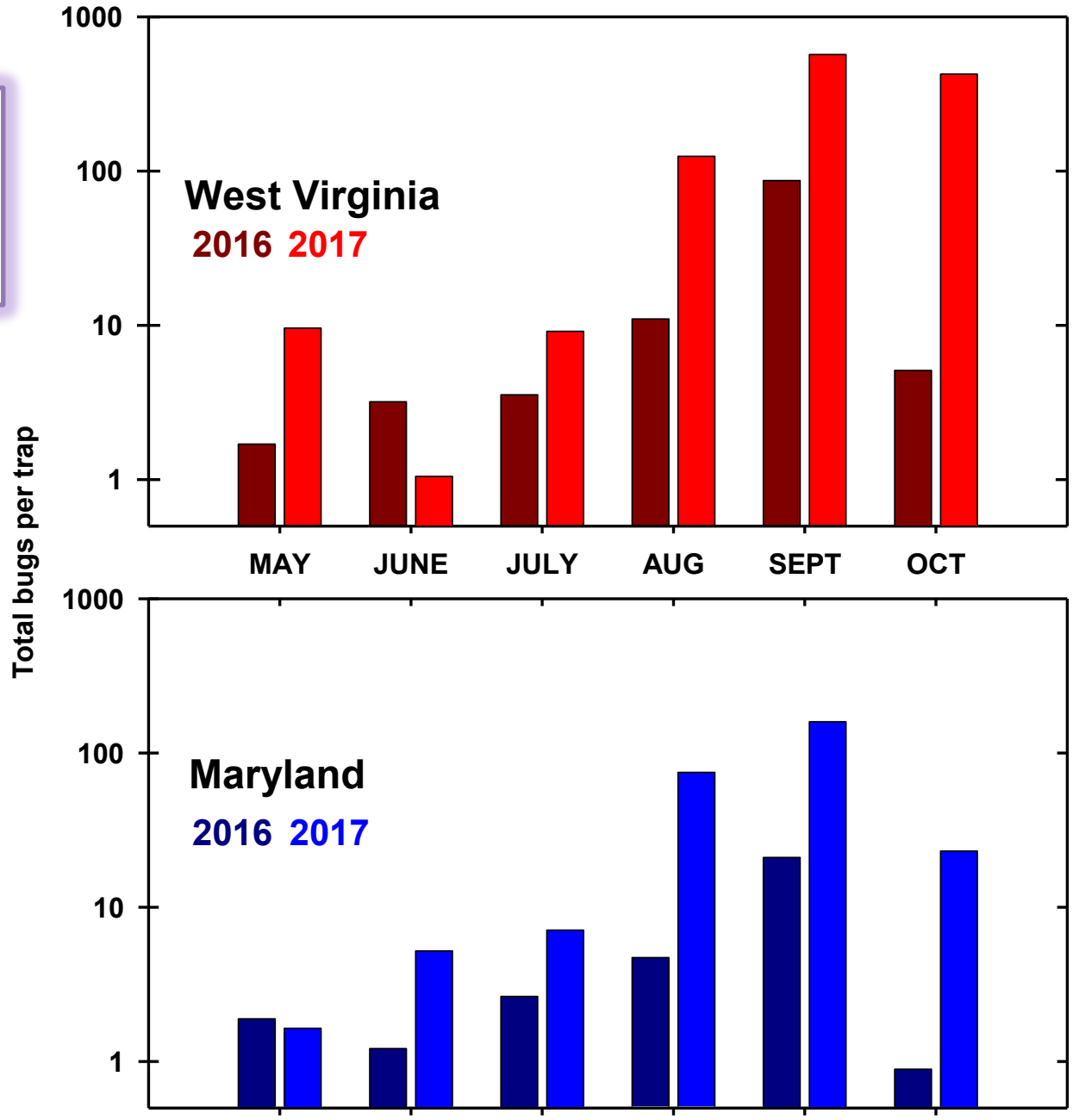
- **Season-long tests of different ratios of BMSB pheromone, mixed murgantiols (=BMSB) and MDT:**
  - **BMSB: MDT as 1:1 (original ratio), plus 3:1, 10:1, 3:3, 1:3, 1:10, and blank**
  -
- **Month-long trials of ratios of the two BMSB pheromone components (SSRS and RSRS):**
  - **without MDT: SSRS only, 3.5:1 SSRS:RSRS (natural ratio), 1:1.7 SSRS:RSRS (synthetic output), RSRS only, and blank (3 trials)**
  - **with MDT: same as above (1 trial)**
- **All experiments run with 4 RCB, full-sized black pyramid traps, collected & re-randomized weekly.**

Season-long Trial of Ratio of BMSB pheromone and MDT 2016 Maryland & West Virginia

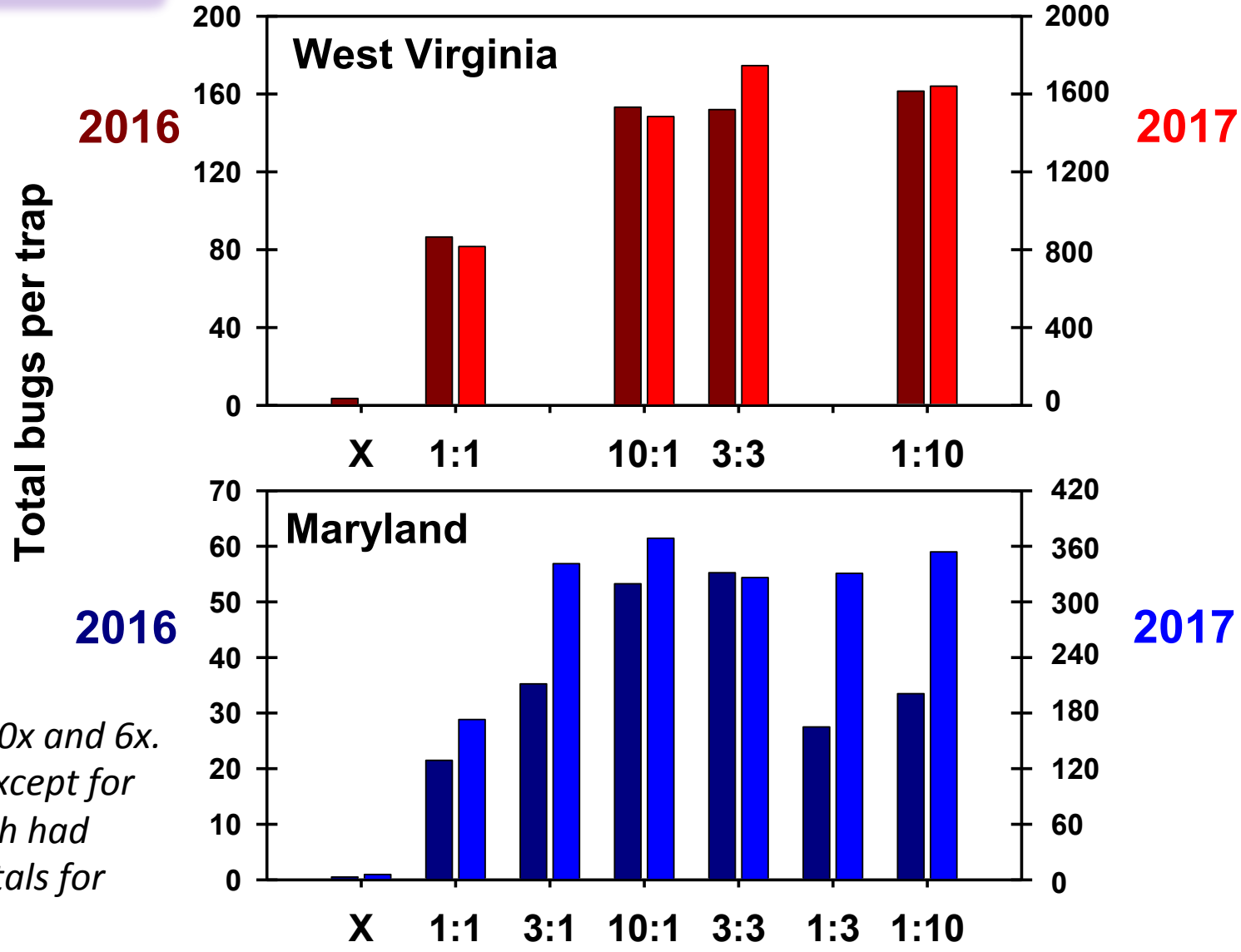
- **Default starting point was one mixed pheromone lure (#20) which contains ~2mg of SSRS-murgantiol, plus 66mg (*E,E,Z*)-2,4,6-MDT = "1:1"**
- **7 treatments in Maryland, 5 in West Virginia:**
  - **1:1, (1:3), (3:1), 3:3, 1:10, 10:1, and blank**
  - **May to October, 4 RCB, full-sized black pyramid traps, collected & re-randomized weekly**
  - **to see if 1:1 starting point was best for season-long capture, or would additional pheromone or MDT result in higher captures?**

Totals for all traps by month 2016 and 2017

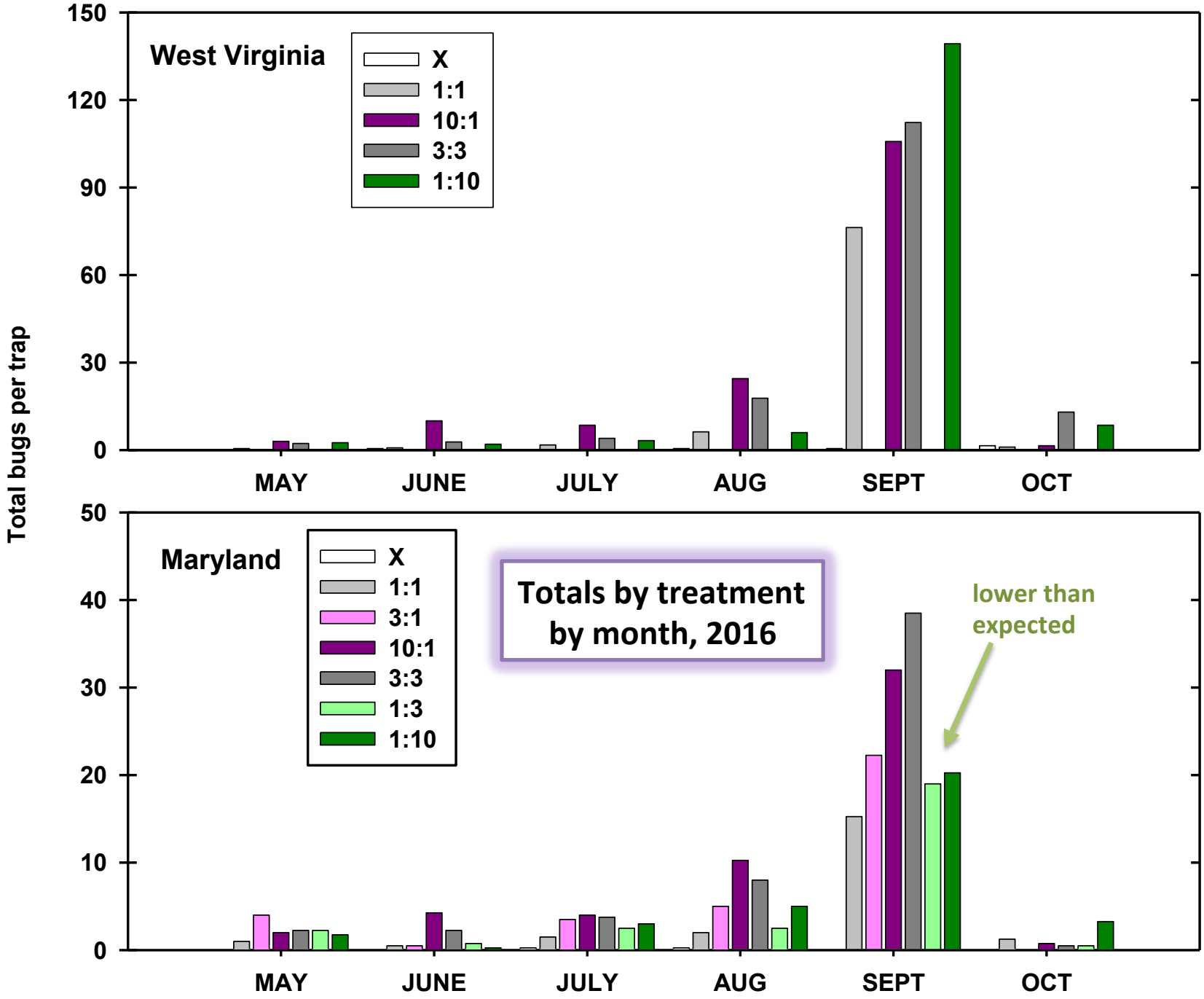
Notice the log scale. Numbers much higher in 2017, especially in late season.

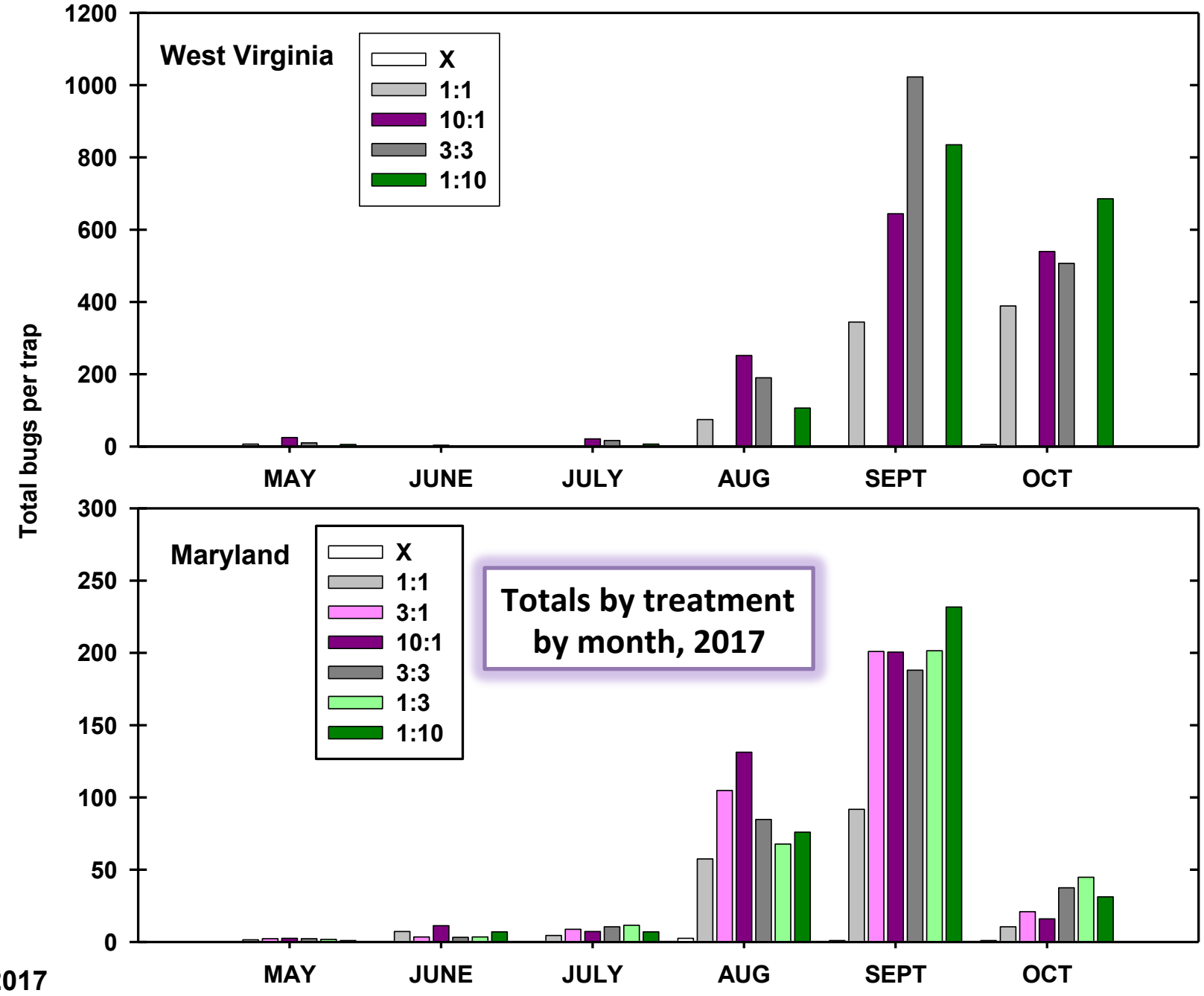


Totals by treatment 2016 and 2017



Scales differ by 10x and 6x. similar pattern except for MD in 2016 which had lower relative totals for high MDT ratios.


West Virginia
X
1:1
10:1
3:3
1:10
150
120
90
60
30
0
Total bugs per trap
MAY
JUNE
JULY
AUG
SEPT
OCT
Maryland
X
1:1
3:1
10:1
3:3
1:3
1:10
50
40
30
20
10
0
Totals by treatment by month, 2016
lower than expected
MAY
JUNE
JULY
AUG
SEPT
OCT


West Virginia
X
1:1
10:1
3:3
1:10
Total bugs per trap
1200
1000
800
600
400
200
0
MAY
JUNE
JULY
AUG
SEPT
OCT
Maryland
X
1:1
3:1
10:1
3:3
1:3
1:10
Totals by treatment by month, 2017
300
250
200
150
100
50
0
MAY
JUNE
JULY
AUG
SEPT
OCT
2017

Cost effectiveness of commerical attractants

Trécé, 2017, with one lure change per season,
at price of $3.12/ BMSB lure and $1.22/MDT lure

Shows that we are in a relatively cost-effective position with the current "1:1" ratio, relative to alternative ratios and loadings

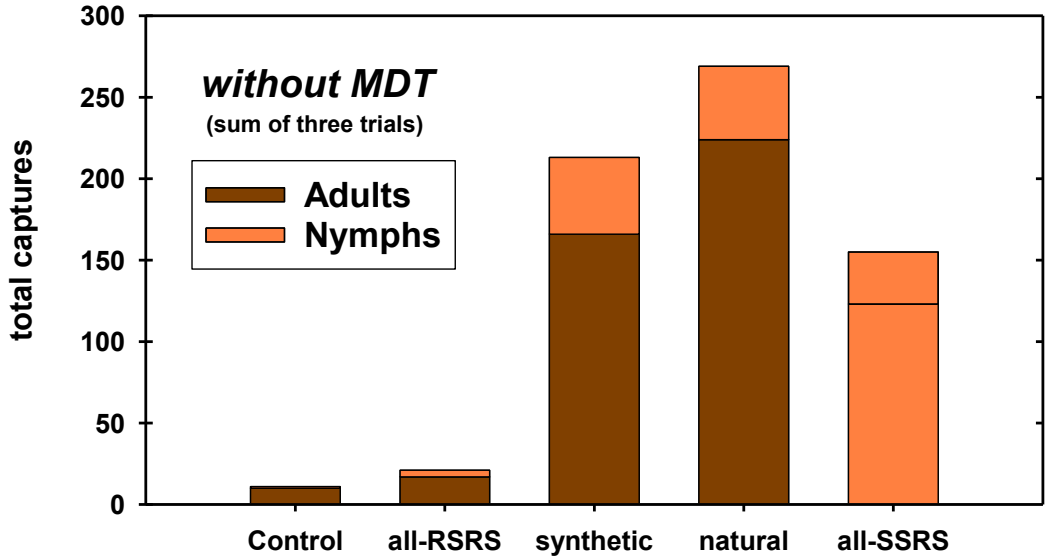
LURE RATIO (MDT:BMSB)	LURE COST per Season	LURE COST / BUG CAUGHT (MD)	bugs/$ (MD)	LURE COST / BUG CAUGHT (WV)	bugs/$ (WV)
1:1	$ 8.68	5.0 ¢	20	1.1 ¢	94
3:1	$ 21.16	6.0 ¢	17		
10:1	$ 64.84	19.6 ¢	5	4.4 ¢	23
3:3	$ 26.04	7.1 ¢	14	1.5 ¢	67
1:3	$ 13.56	4.0 ¢	25		
1:10	$ 30.64	9.4 ¢	11	1.9 ¢	54
X	--				

bugs are expensive in Md.!

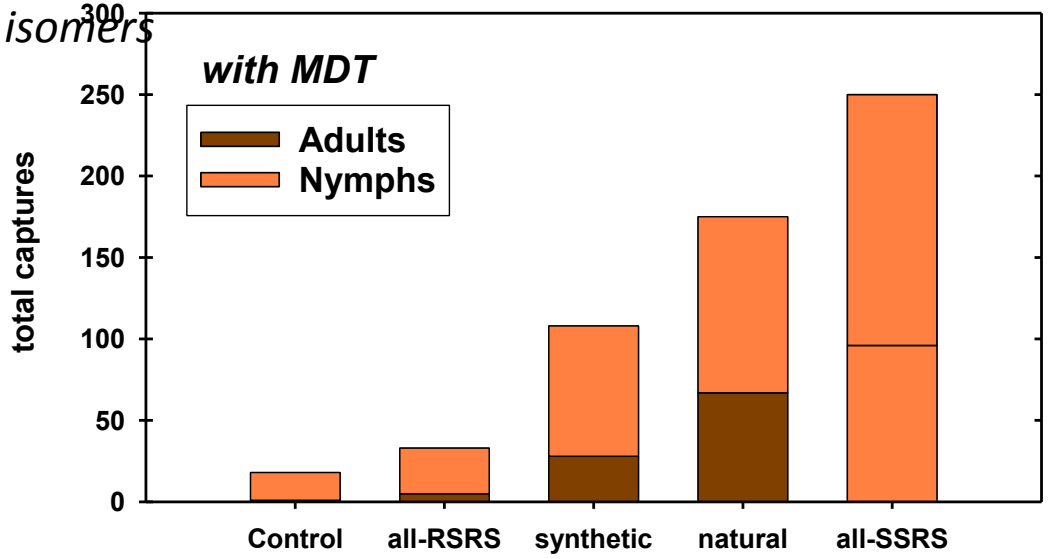
bugs are cheap in W.Va.!

Month-long trials of ratios of the two BMSB pheromone components (SSRS and RSRS)

Natural ratio preferred



Respond to the quantity of major isomers



Conclusions from BMSB Semiochemical Ratio trials 2016-2017 in Maryland and W.Va.

- As a season-long lure, the *current combination* ("1:1") of mixed pheromone lure with ~2mg of SSRS-murgantiol, plus 66mg (*E,E,Z*)-2,4,6-MDT, is *reliably attractive throughout the season* (note which AI's are quantified here).
- Attraction is not very sensitive to the exact ratio ("more gives more"). *Deviations from current ratio are not critical,* but high ratios of BMSB:MDT tend to attract more in mid-season, whereas low ratios, more in late season.
- *Exact pheromone ratio* (SSRS:RSRS) *is not critical for attraction in the presence of MDT.* The important factor is the quantity of SSRS, not RSRS or any other non-pheromone murgantiol stereoisomer. The somewhat higher attractiveness of the natural stereoisomeric ratio, compared to the synthetic stereoisomeric mix is apparently only important in the absence of MDT.
- *Individual bugs probably differ in their responses* (to be lab-tested), but overall attraction to our current two-lure combination is strong in all seasons for males, females, and nymphs!


Have we got the right ratio?


Have we got the right ratio?
pretty much, yes!

Many thanks ....

- **Tony Rugh, Chris Hott, Lee Carper, John Cullum, Liz Fread, Emma Thrift, Treva Rowley, Jeremy Turner, Kayla Pasteur, Nate Erwin, Fil Guzman, Shyam Shiraly, and others!**
- **USDA NIFA SCRI**
- **USDA ARS**