New Research on Stored Product Pest Pheromones

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1890 Research & Extension

Outline

- Stored product insects and pheromones
- Pheromone-based approaches for pest management:

  Recent developments

  - Insect monitoring
  - Mass trapping
  - Attract and kill
  - Mating disruption
  - A push-pull system
- Future approaches for stored products

Grains, legumes, root crops dried fruits and nuts=80% of human food

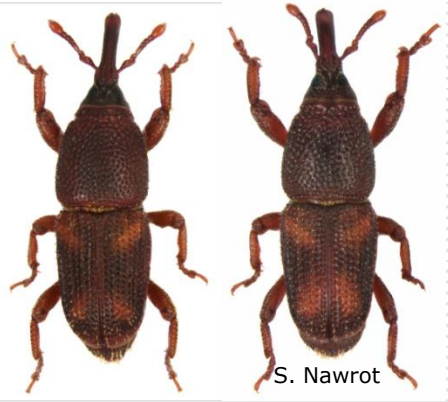
12% losses in USA

Beetles and moths

Stored product species for which pheromones have been identified and available as formulated lures*

Cigarette/drugstore beetle

Lesser/larger grain borer



Rice/maize weevil

Carpet/khapra/warehouse beetle

Red/confused flour beetle

Indianmeal/almond/tobacco/raisin/ Mediterranean flour/webbing cloth/ Angoumois grain moth

*Formulated lures are commercially available

Pheromone Systems

- Sex pheromones produced by females-males respond (short-lived adults)
  - Pyralid moths
  - Geliciid moths
  - Anobiidae
  - Bruchidae
  - Dermestidae
- Aggregation pheromone, both males and females respond (long-lived adults)
  - Bostrichidae
  - Silvanidae
  - Curculionidae
  - Tenebrionidae

Requirements for synthetically produced pheromones

- To produce pheromones that release structurally correct compound
- Has proper component ratio and concentration
- Release pheromone long enough time period
- Release sufficient levels

Pheromone-based approaches for pest management: *Recent developments*

Insect monitoring

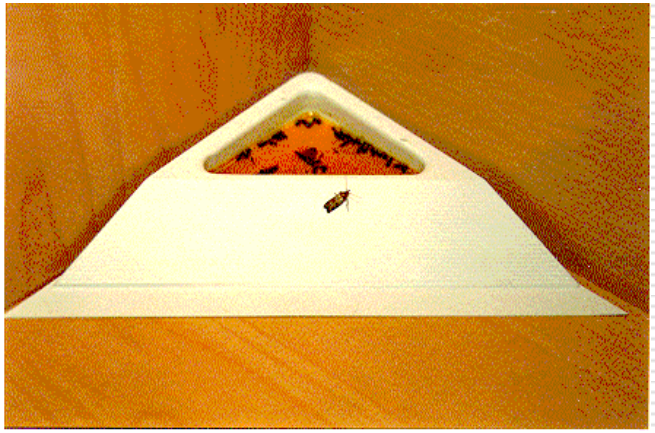
Insect Monitoring: Pheromone Traps

- Most widely used method for monitoring stored-product pests
- Use an attractant (sex pheromone, aggregation pheromone, food odor)
- Species specific response
- Wide range of trap and lure types commercially available

Traps for Flying Insects

Traps for Walking/Crawling Insects

Trécé Inc.



Pheromone Traps

Advantages

- Sample continuously
- Large active space for some attractants
- Early detection
- Species specific
- Relatively easy to use
- Quick results
- Can be used to target monitoring and management

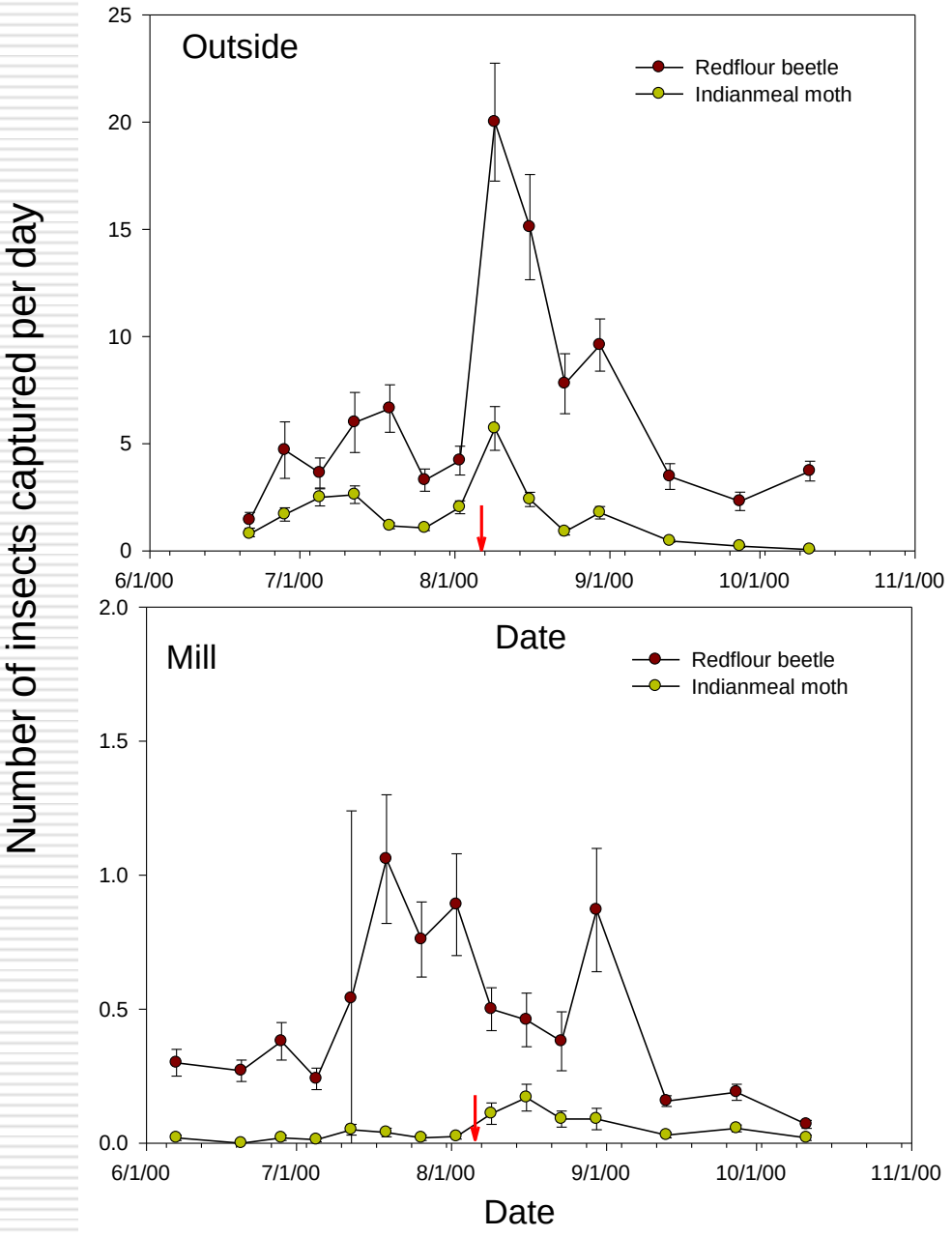
Disadvantages

- Only capture receptive insects
- Pheromones not available for all species
- Small active space for some species
- Multiple lures/traps to monitor multiple species
- Expense
- Visibility
- How to use results?

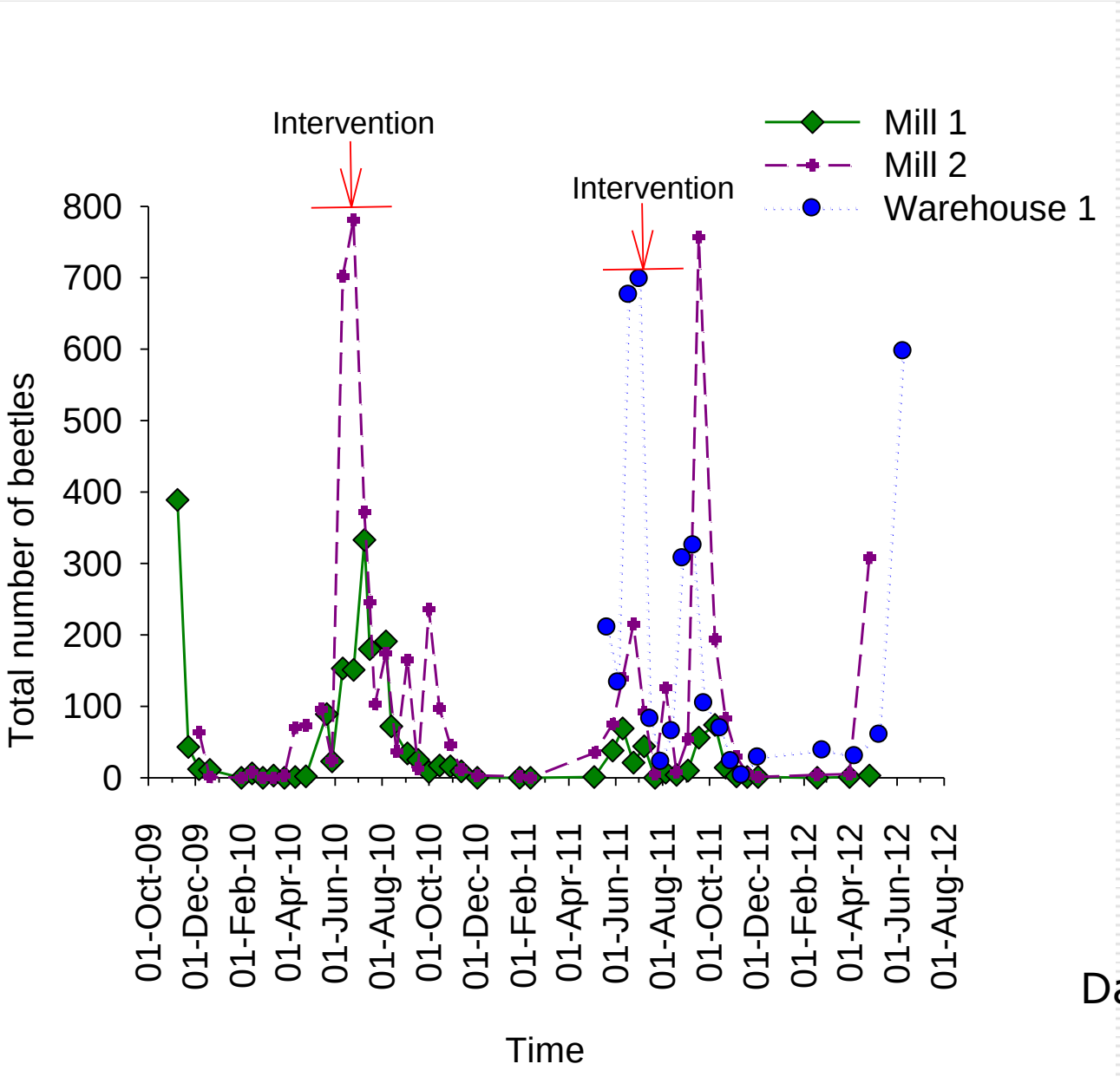
Components of a monitoring program

- Trap and pheromone type
  - Need to match trap and pheromone type with environment and target pest(s)
  - Some of the critical issues are: *target species, floor or hanging trap, amount of dust, interaction between food odor and pheromone*
- Trap placement
  - A balance of practical and scientific considerations on trap number and placement
  - Grid pattern is generally best
  - Traps placed outside are useful
- Checking traps: Servicing and replacing traps, observations and recording
- Visualization and interpretation of results: Graph averages over time to look at population trends and also can look at the spatial distribution

Comparison of inside and outside trap catches



Total number of cigarette beetles captured in sticky traps in treated facilities from 2009-2012



Data: Mahroof

Pheromone-based approaches for pest management: *Recent developments*

Mass trapping

Mass trapping: Pheromone-based suppression

- Only have significant effect if substantial adults are removed
- For aggregation pheromone-females can be removed
- For sex pheromones- critical number of males must be removed. Females are not trapped
- Need to deploy high density of traps
- Expensive

10% escape

90% caught in a trap

X

Survive to reproduce

Few un-trapped males

Mate with females

Male moths trapped

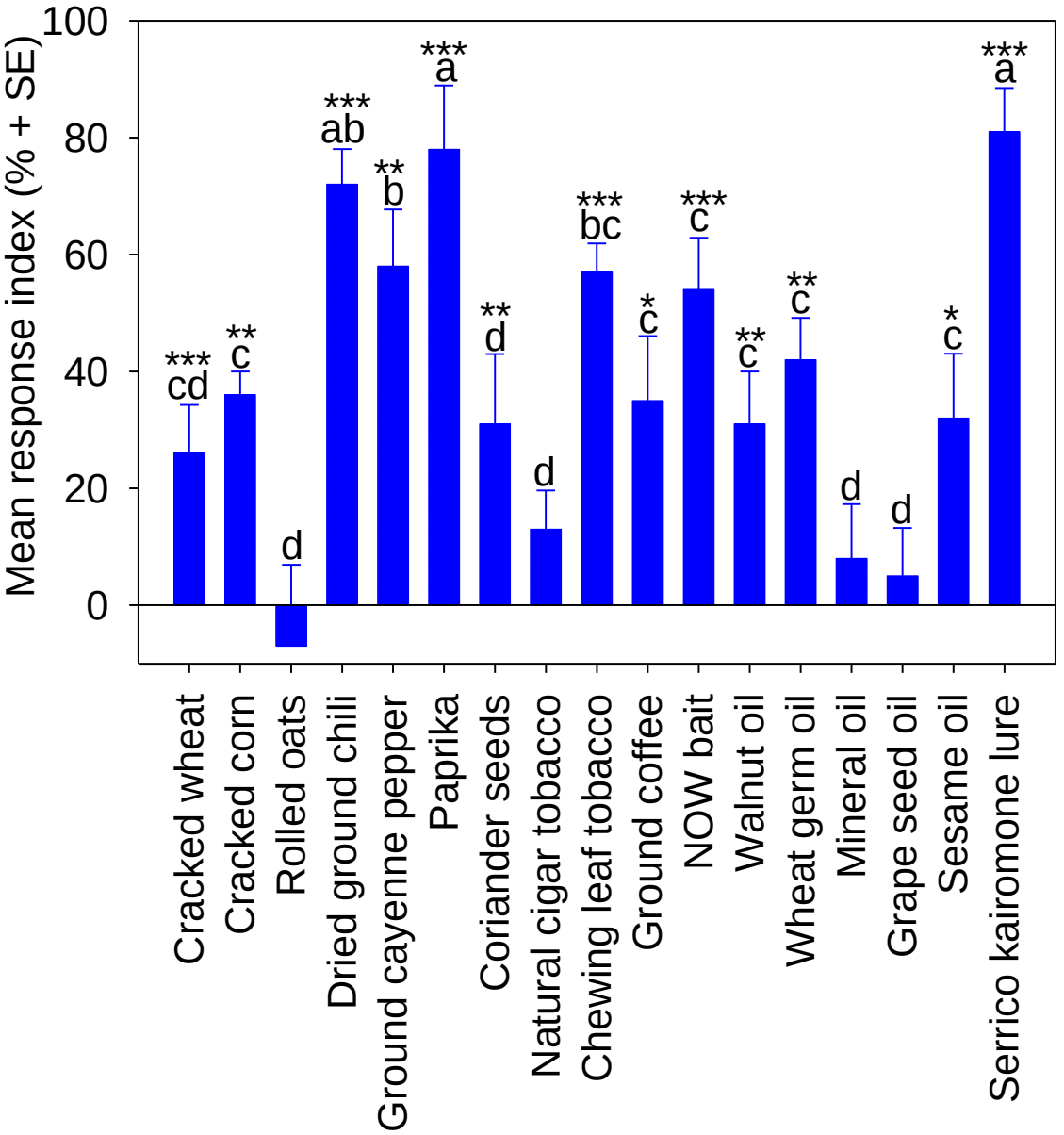
Progeny

Mass trapping

New direction

Incorporating host odor-borne attractant along with sex pheromone to reinforce trap attractiveness for both sexes

Responses of the adult CB to different host materials in two-choice bioassay



Mahroof and Phillips
(Journal of Insect Behavior 20: 99-115)

$F = 21.2$; $df = 16, 204$; $P < 0.0001$; $n = 5$ and 20 insects/n

Bioassays with extracts

Extraction: 50 g

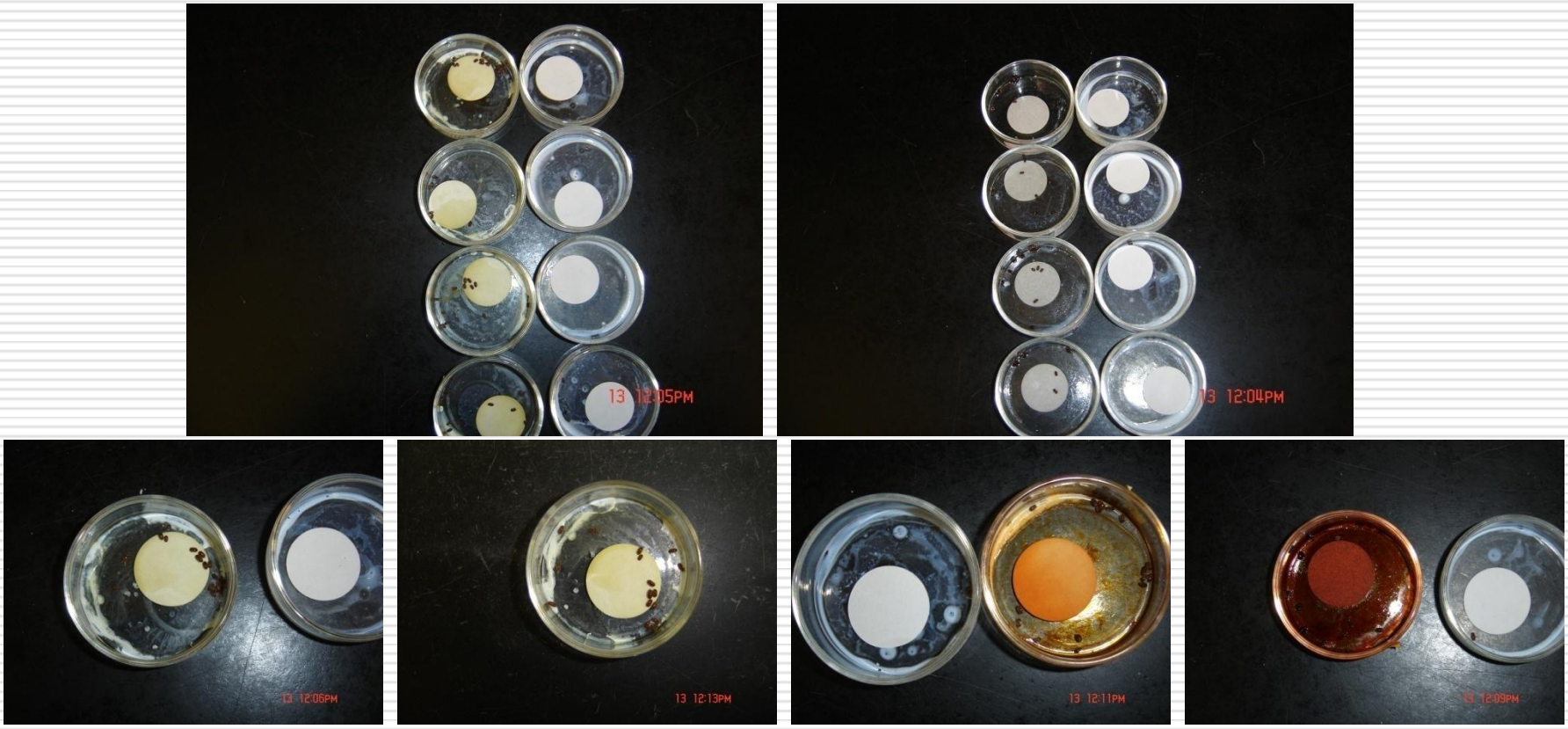
Conditions:
25°C for 48 h

Final concentration:
1g material/ml solvent (w/v)

Steel can arena

Bioassays with extracts

Two-choice, passive air, walking, pitfall bioassay



Treatment: 1 ml applied to a 4.25 cm d disk of filter paper

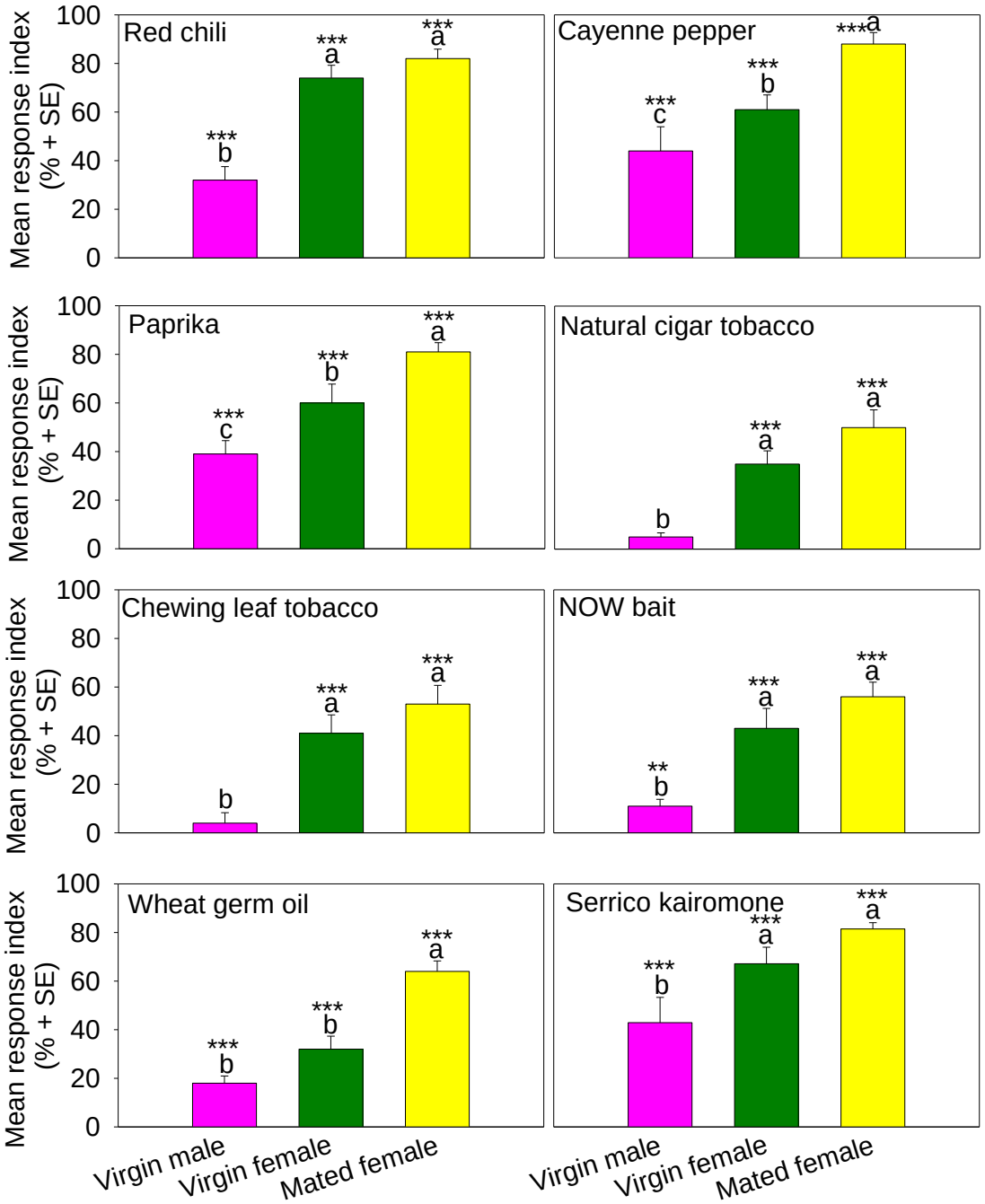
Control: 1 ml of the test solvent

Responses of virgin males, virgin females and mated females of CB two-choice bioassay

Host materials: $F = 19.8$; $df = 7, 207$; $P < 0.0001$

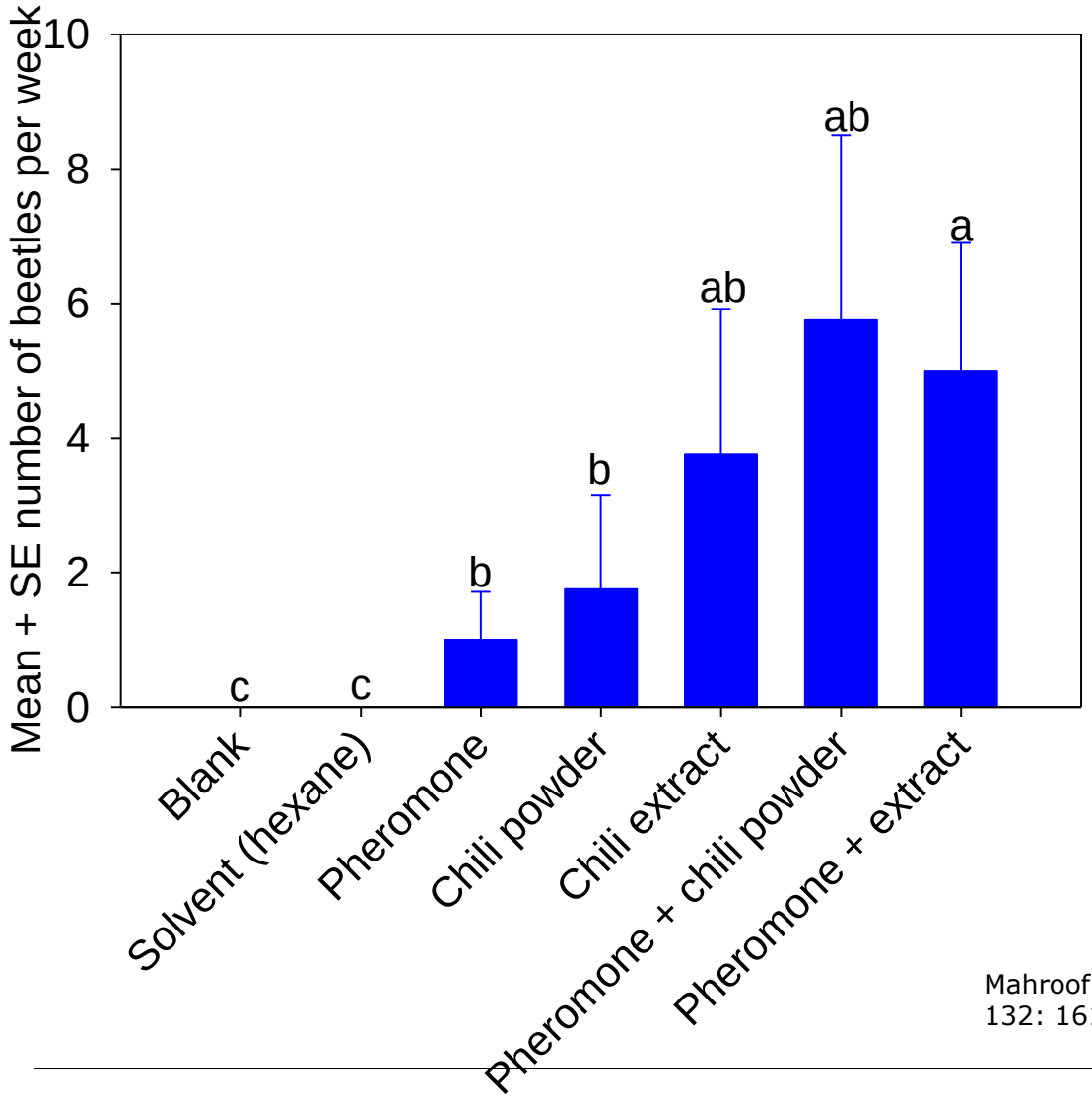
Mating status: $F = 9.0$; $df = 2, 207$; $P < 0.0001$

n = 15 and 20 insects/n



Mahroof and Phillips (Journal of Insect Behavior 20: 99-115)

Field trapping results from pheromone combined with host-odor borne attractant for cigarette beetle



$F = 3.31$;
$df = 6, 18$;
$P = 0.02$

Mahroof and Phillips (J. Appl Entomol. 132: 161-167)

Pheromone-based approaches for pest management: *Recent developments*

Attract-and-kill

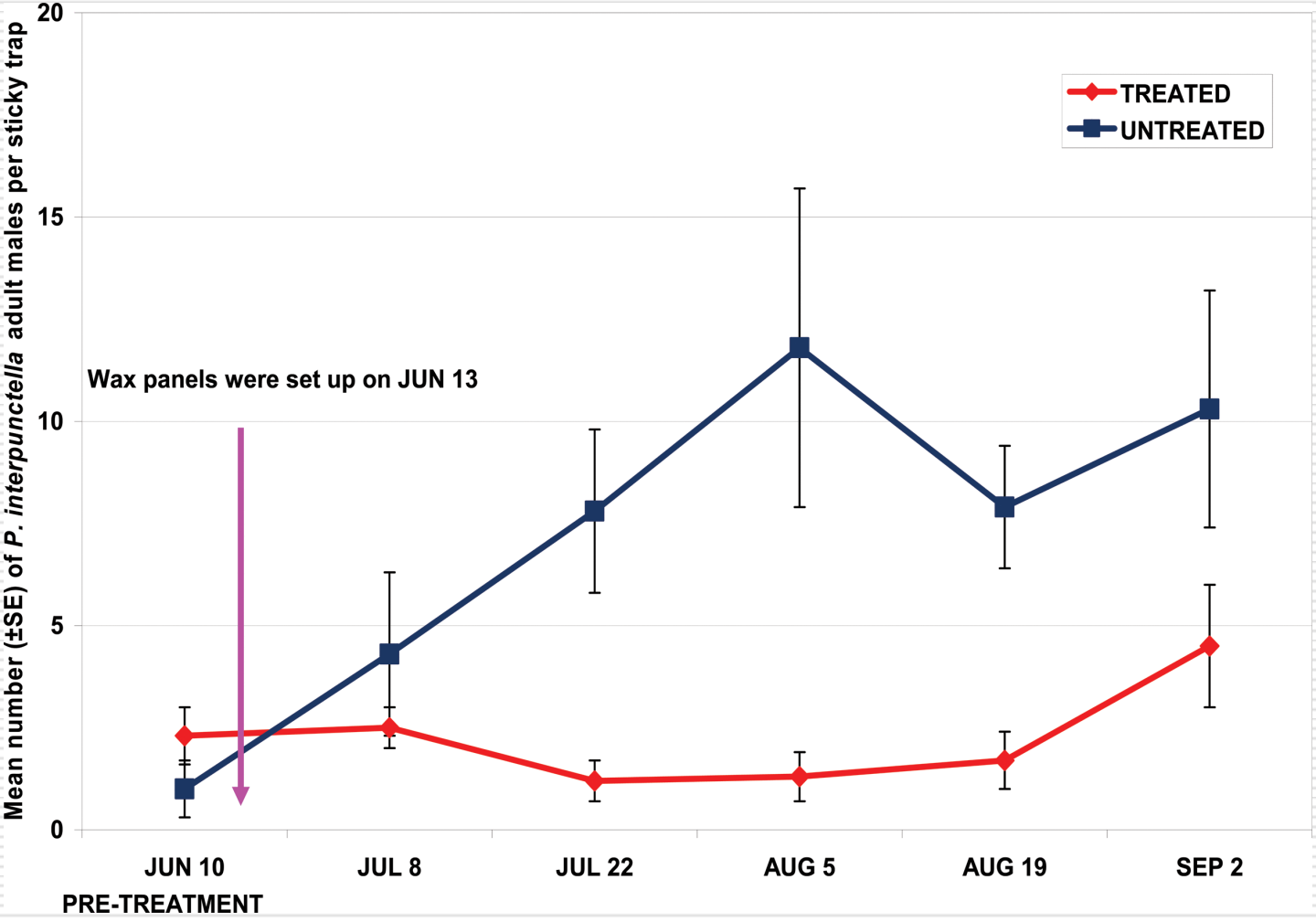
Attract and kill: Pheromone-based suppression

- Males are killed rather than "confused"
- Traps do not have to be deployed and serviced
- Many "killing stations" can be set up
- Only a very low dose of pheromone combined with pesticide
- Toxicologically benign
  - Extremely low pesticide residue
  - Need reduced-risk or bio-rational pesticide

Attract and kill: Pheromone-based suppression

- Lure-and-kill technology has had limited development in stored products pest management
- Application in SPP protection: Last-Call and Sirene
  - Gel mixed with sex pheromone and low dose of pyrethroid
  - "Lure-and-kill system achieved by battery operated time-mist foggers placed adjacent to pheromone traps (Pierce, 1994)
    - Moth captures reduced 96% in two years
  - Plastic laminar dispensers baited with 2 mg ZETA + 5 mg Cypermethrin reduced 90% moth population (Trematerra, 1994)

Mean number (±SE) of *P. Interpunctella* males per sticky trap caught in commercial buildings. Treated buildings had the attract-and-kill formulation of wax panels impregnated with permethrin at 6% a.i. deployed with a synthetic female sex pheromone Biolure.



Data: Campos and Phillips, 2014 JEE (in press)

Pheromone-based approaches for pest management: *Recent developments*

Mating disruption

Pheromone-based mating disruption

- **Mechanism of mating disruption**
  - Pheromone dispensers generate a "fog" of synthetic pheromone
    - ✓ False trail-following to artificial sources
    - ✓ Masking of natural female pheromone by overwhelming unfocused "cloud"
    - ✓ Habituation of olfactory receptors to higher levels
  - Males can no longer distinguish the pheromone emitted by a female
  - Males spend time and energy locating "false females"
  - *Male elimination* method

Pros and Cons

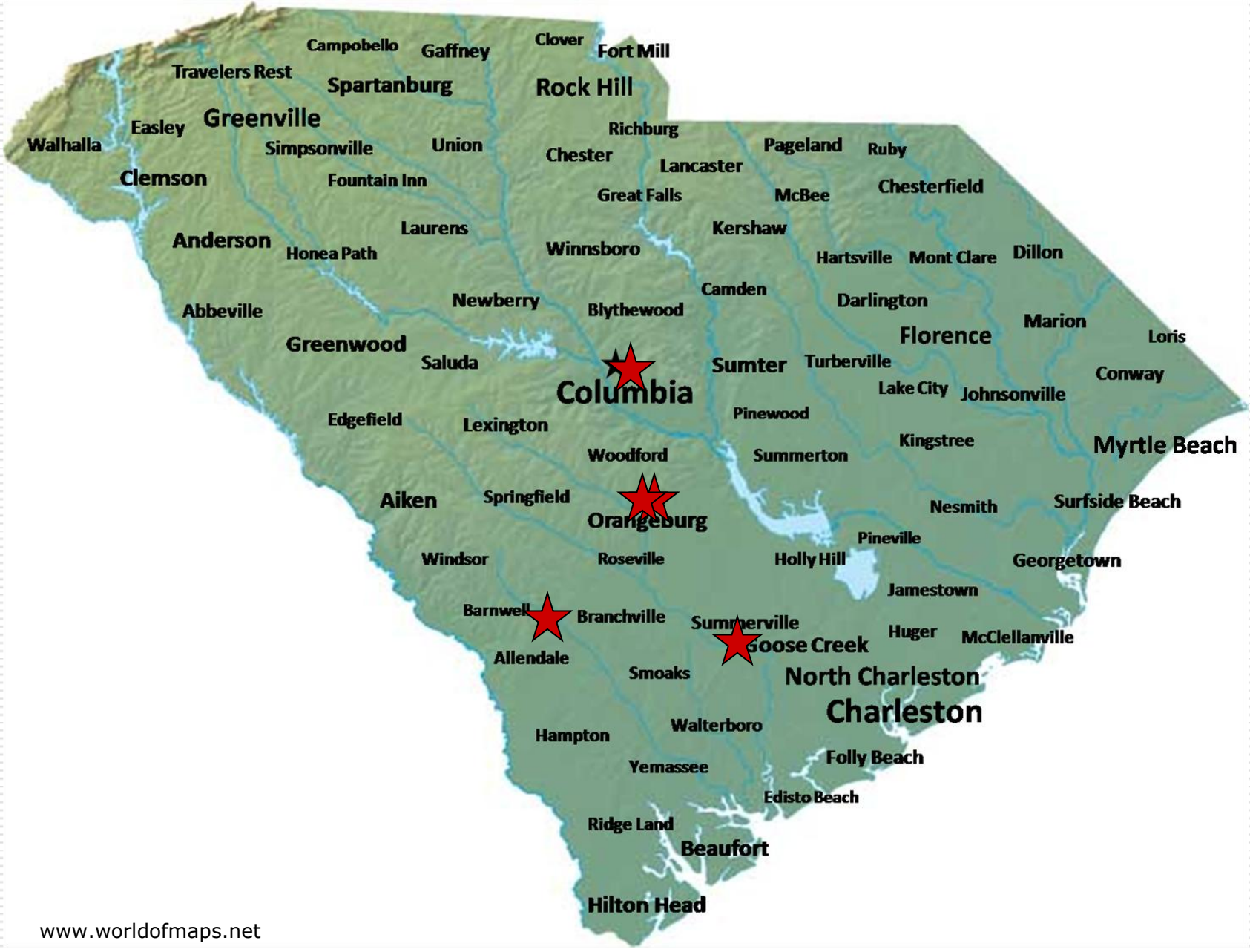
- No detectable residues in many dispensing systems
- Highly selective for primary target species
- The need to supplement the pheromone program in high pest-pressure situations
- EPA registration and government approval in many countries

Stored product beetle: *Lasioderma serricorne*

To evaluate the efficacy of synthetically produced serricornin for mating disruption in *Lasioderma serricorne* (F.) in different stored-products environments

Pioneering efforts for stored product beetles

Locations selected for the study



www.worldofmaps.net

Population assessment methods

- Trapping using monitoring lures (sex pheromone/ kairomone)
  - ✓ Sticky traps
- Measuring the size of the larval population
  - ✓ Food stations (oviposition cups)
- Determining female mating rates
  - ✓ Dissecting females to look for the presence of male spermatophores
  - ✓ Sentinel females


30 11:05AM


30 11:38AM


30 11:05AM


30 10:58AM

Methodology

- Pheromone impregnated to plastic block

- **Trial I:** Pheromone Incorporated in a square rubber block having a bundle of 3 (Trece Inc.)

- **Trial II:** Pheromone Incorporated in a single rectangular plastic block (Trece Inc.)

Methodology

Site	Treated	Not treated	Treatment time
Feed mill 1	yes		July 14, 2010
Feed mill 2	yes		July 14, 2010
Feed mill 3		yes	
Flour mill		yes	
Feed mill 1	yes		July 6, 2011
Feed mill 2	yes		July 6, 2011
Feed mill 3		yes	
Flour mill		yes	
Seed warehouse	yes		June 30, 2011

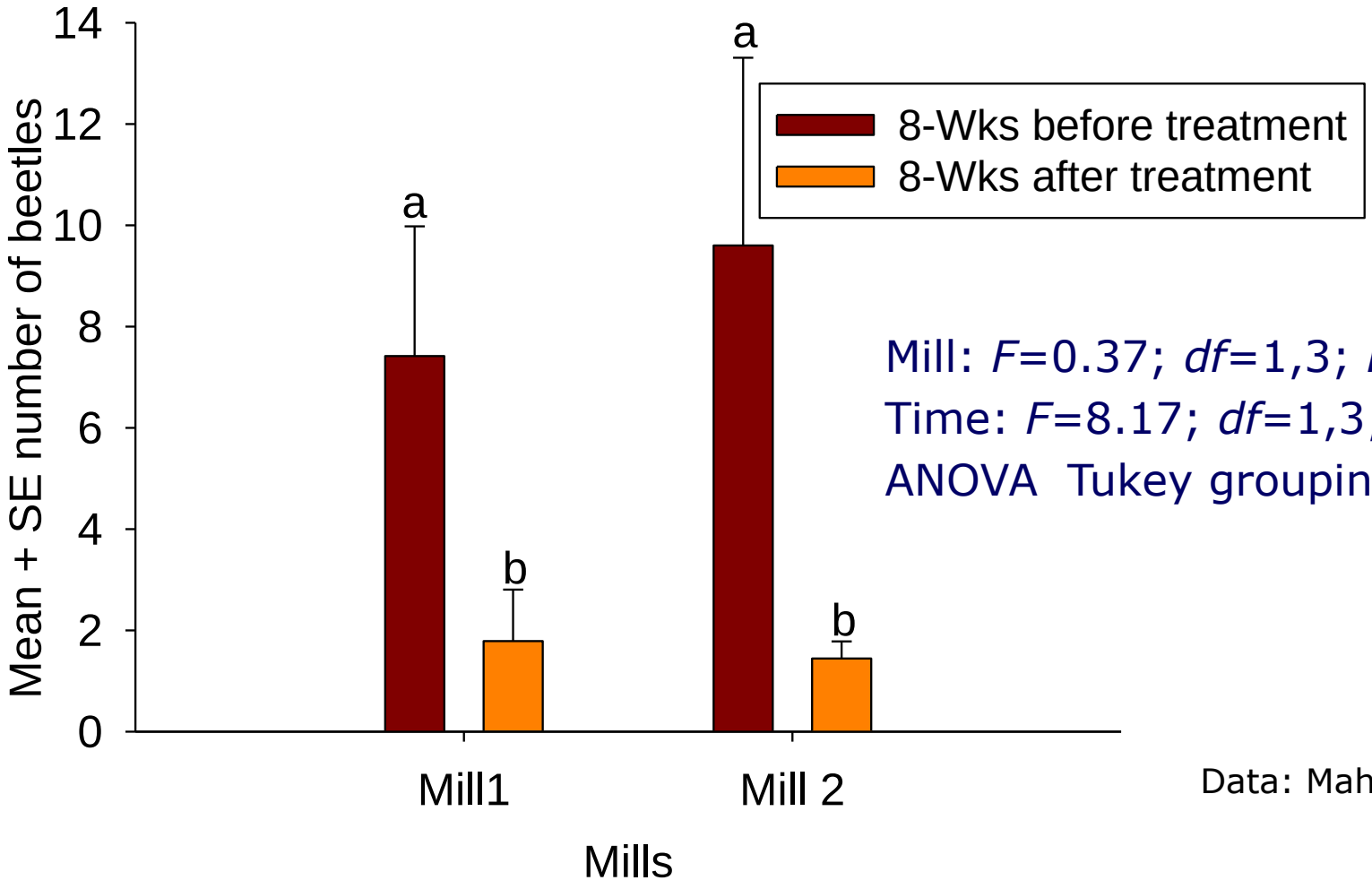
Methodology

Pheromone dispensers were deployed as 1 MD dispenser/225 ft^2

Post-treatment activities

- Beetle populations were monitored post-treatment
  - ✓ Sticky traps lured with monitoring pheromone and kairomone
  - ✓ Oviposition cups (2 wks)

Fig 4: Mean ± SE number of cigarette beetles captured in sticky traps in treated mills eight weeks before and after mating disruption in 2010



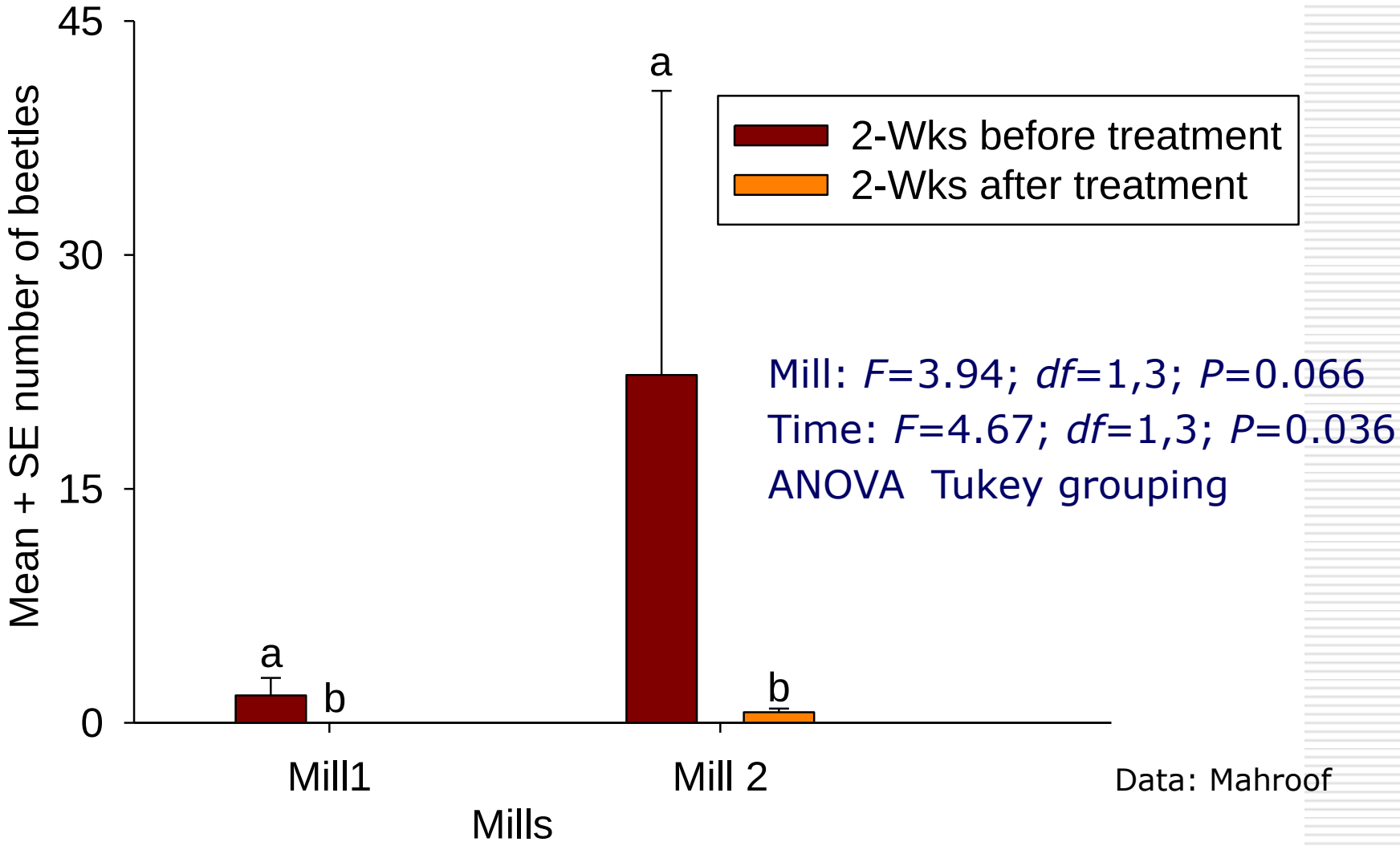
Mill: F=0.37; df=1,3; P=0.547

Time: F=8.17; df=1,3; P=0.006

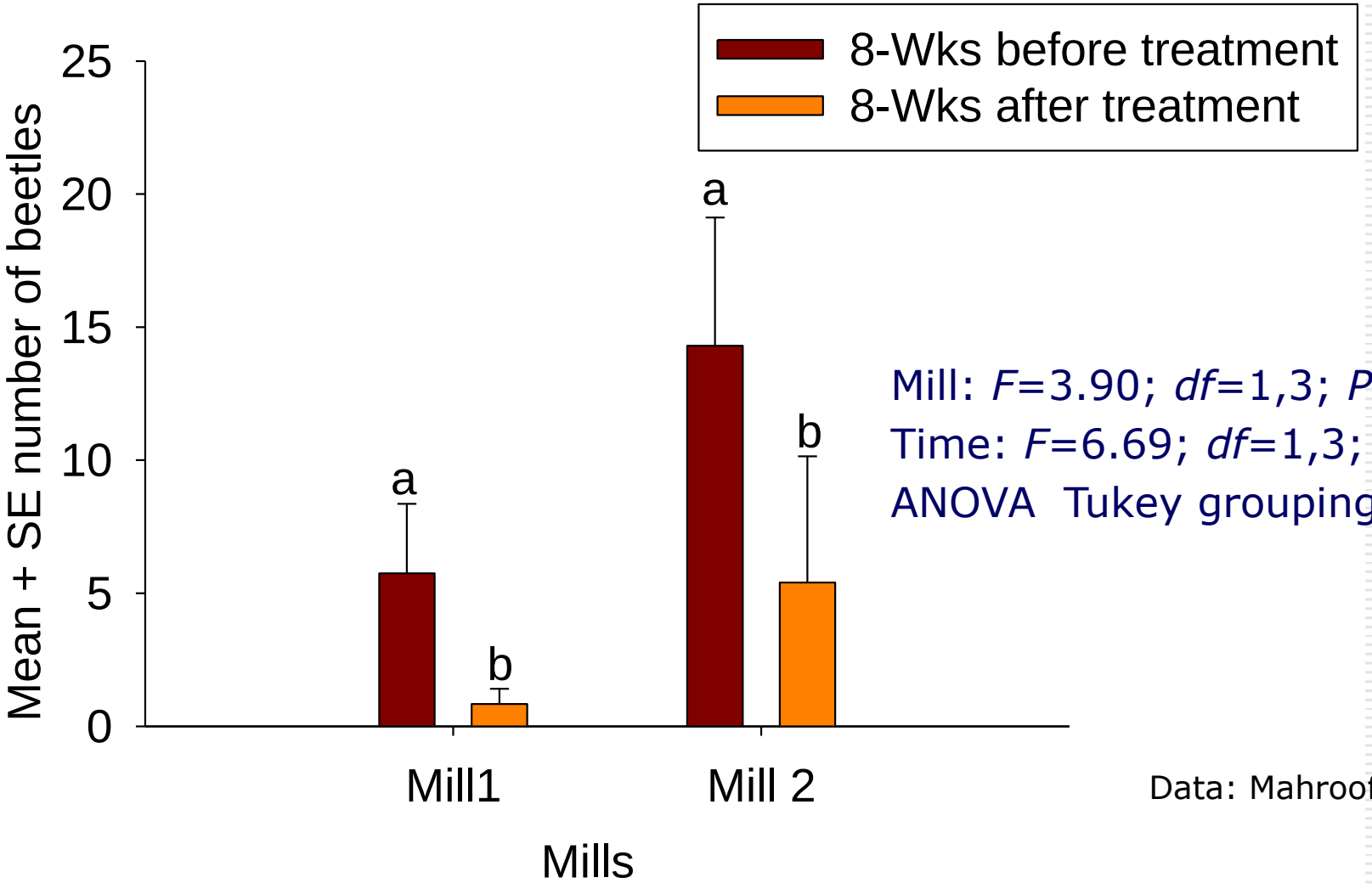
ANOVA Tukey grouping

Data: Mahroof

Mean ± SE number of cigarette beetles captured in sticky traps in treated mills two weeks before and after mating disruption in 2011



Mean ± SE number of cigarette beetles captured in sticky traps in treated mills eight weeks before and after mating disruption in 2011



Mill: F=3.90; df=1,3; P=0.055
Time: F=6.69; df=1,3; P=0.013
ANOVA Tukey grouping

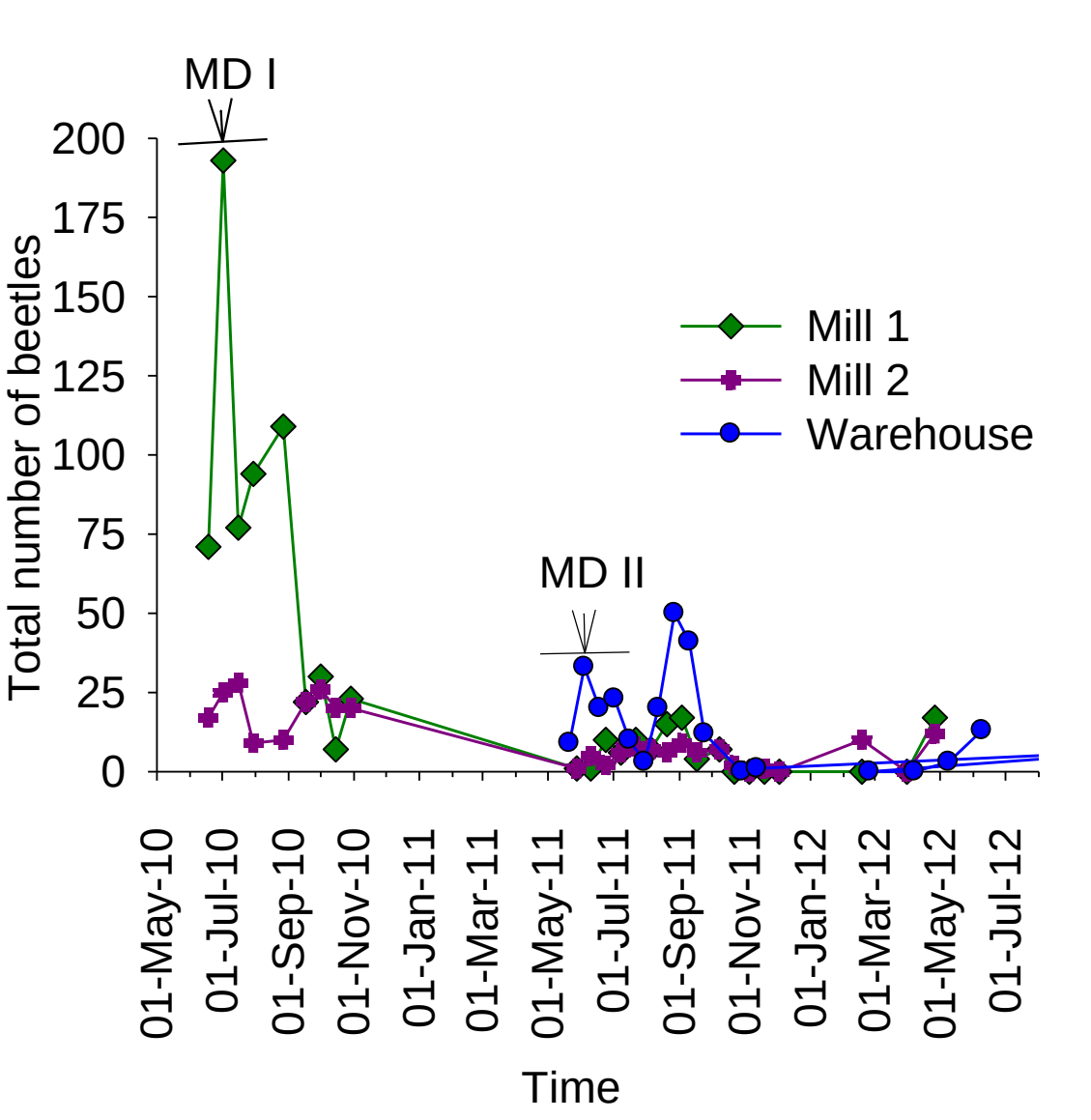
Data: Mahroof

Mean ± SE number of cigarette beetles captured in sticky traps in treated warehouse two and eight weeks before and after mating disruption in 2011

Time	Mean±SE of *L. serricorne* before treatment *n*=25	Mean±SE of *L. serricorne* after treatment	*t*-Vaue (*df*)	*P*-Value
2 weeks	27.04±9.03	3.28±3.08	4.47 (24)	0.0002
8 weeks	8.75±3.53	2.60±1.09	3.43 (23)	0.0023

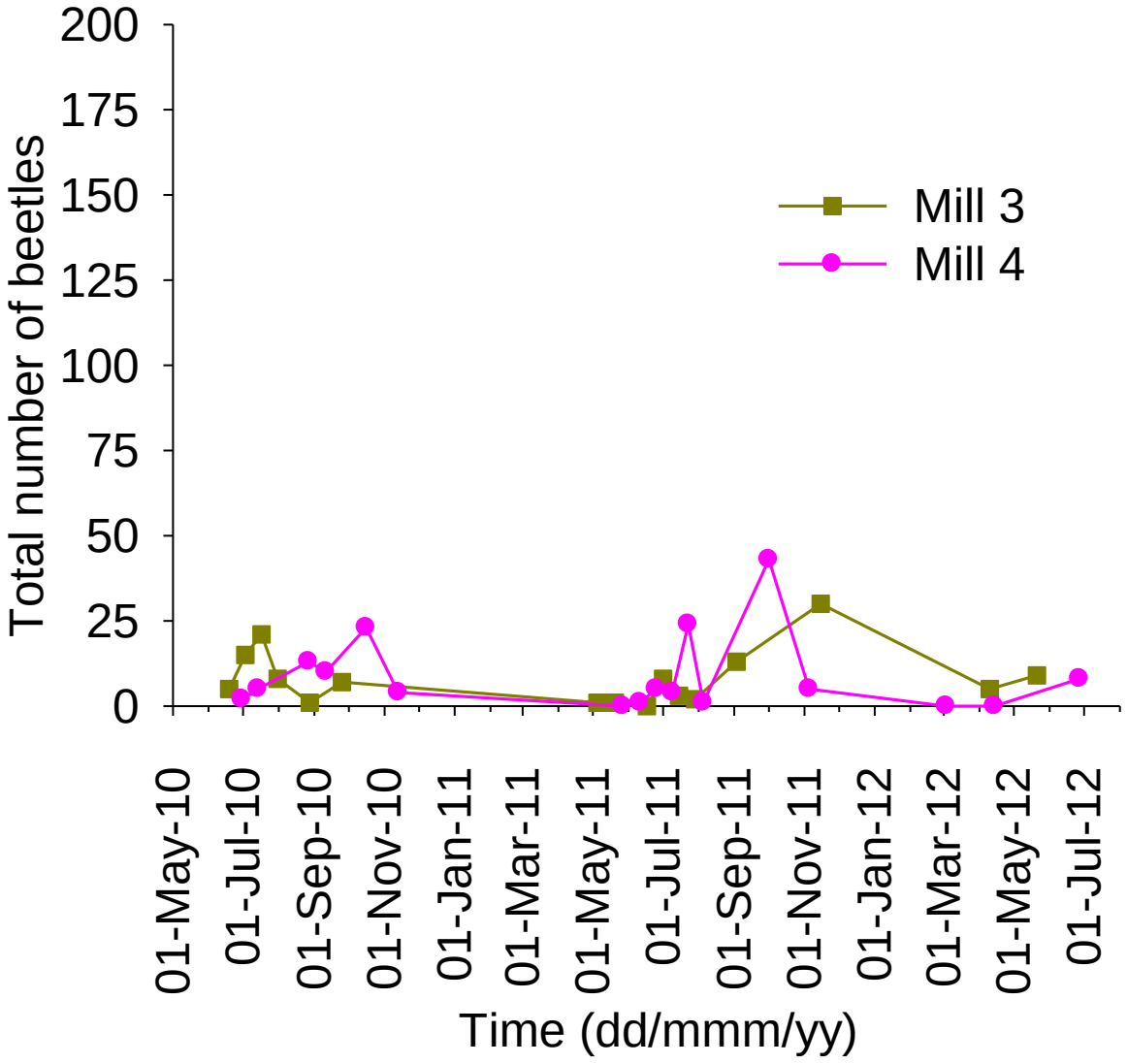
Data: Mahroof

Total number of cigarette beetles recorded in oviposition cups incubated for one month in treated facilities from 2010-2012



Data: Mahroof

Total number of cigarette beetles recorded in oviposition cups incubated for one month in control facilities from 2010-2012



Data: Mahroof

Stored product moth: *Plodia interpunctella*

To evaluate the efficacy of Exosex tablets containing ZETA for mating disruption in *Plodia interpunctella* (Hubner) and *Ephestia kuehniella* (Zeller) in stored-products environments

ZETA already registered

A powder delivery system for dispensing pheromone

- Food grade wax powder
- Powder formulated with pheromone ZETA
- Exosex tablets produced by Exosect® Limited, UK

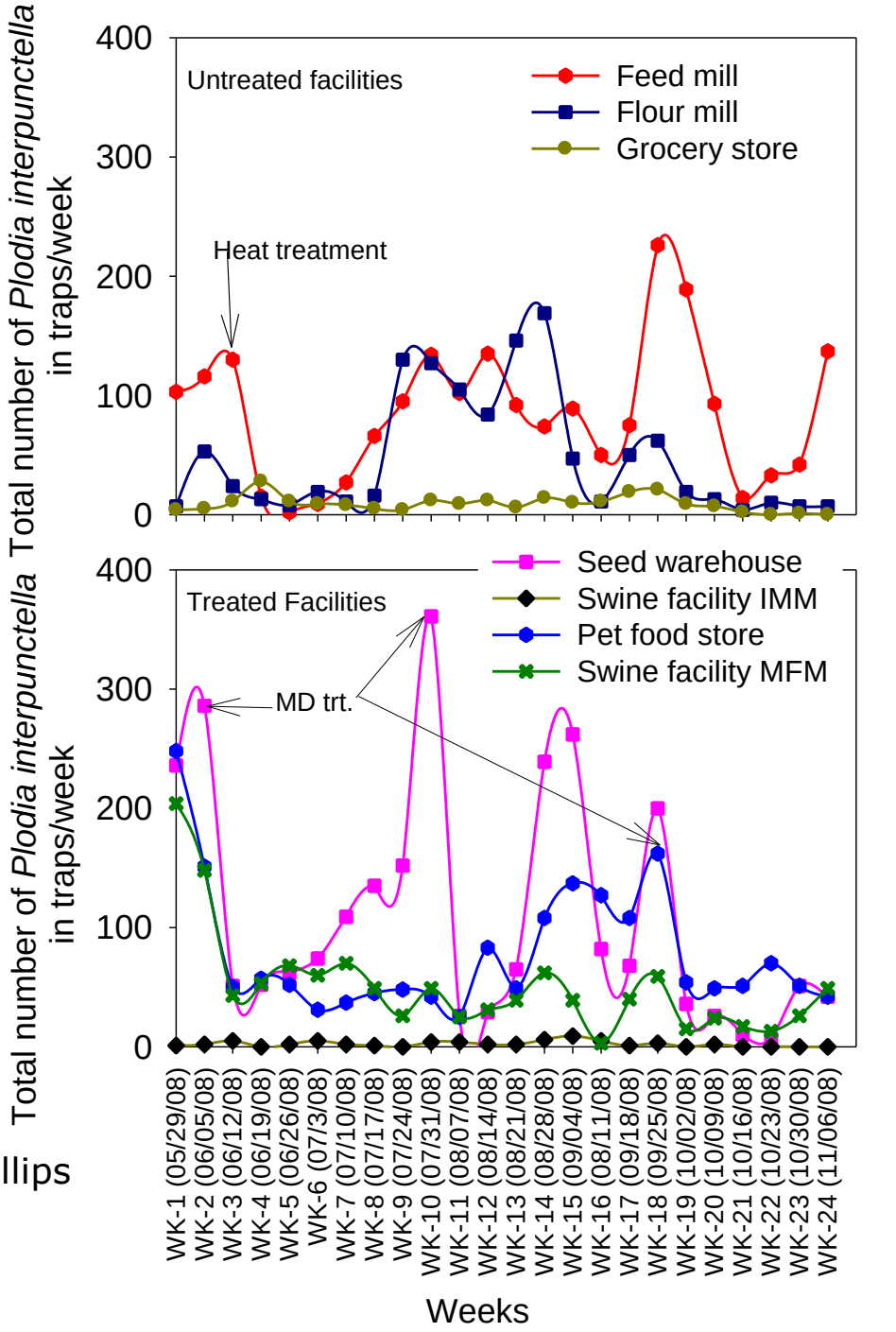
A powder delivery system for dispensing pheromone

- Male moths attracted to exosex tablets dispense ZETA
- Powder adheres to male cuticle via electrostatic attraction - flies away carrying ZETA
- Powder sustains contact between pheromone and insect body
- Powder can also be transferred between individuals contact/Pheromone is spread through population
- Male receptors become overloaded/habituated and male unable to locate mate

Study sites and methods

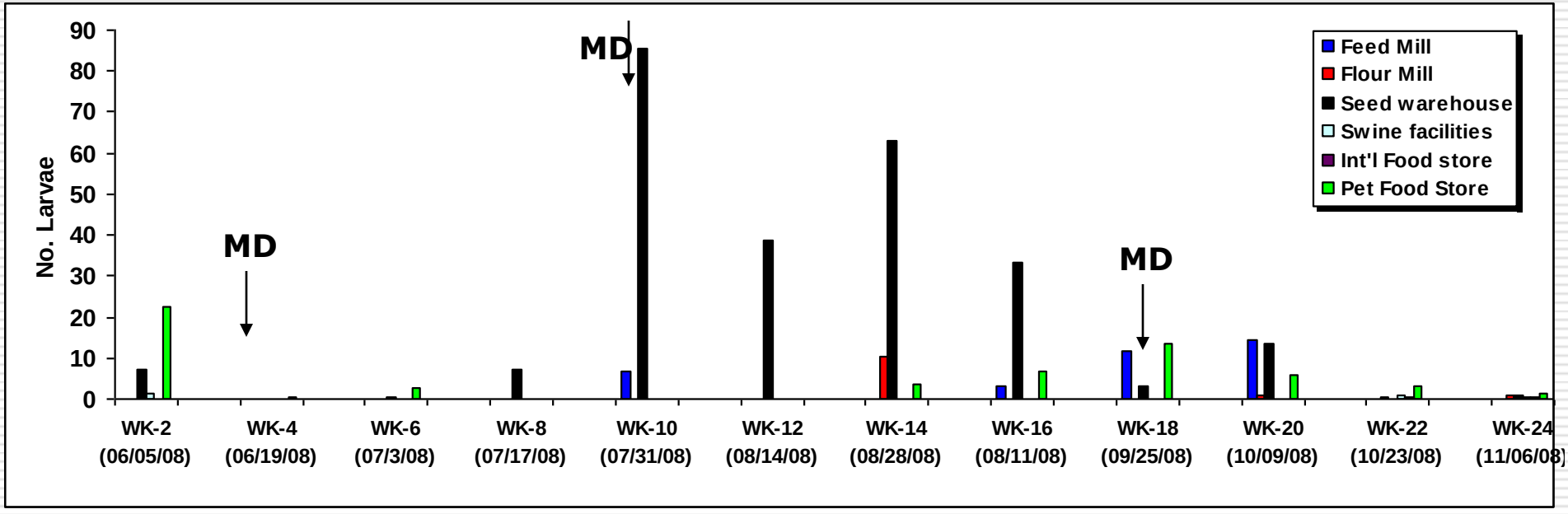
- Studies were conducted in six facilities in (flour mill, feed mill, grocery stores, retail pet food stores, seed warehouses)
- Moth population monitored in treated and control facilities prior and after (traps and oviposition cups)
- One exosex tablet/25 m^2
- Exosex tablets were changed on week 10 and week 18 in the treated facilities

P. interpunctella and *E. kuehniella* adult populations monitored using sticky traps in the treated and untreated facilities



Data: Mahroof, Hasan, Atkins and Phillips

Number of *P. interpunctella* larvae counted in food cups after 1 week of incubation



Data: Mahroof, Hasan, Atkins and Phillips

Cost of using mating disruption/pheromones

- Pest monitoring with pheromone traps is a *necessary expenditure*
- Monitoring devices purchased in bulk is reasonably priced
- Mating disruption treatments are no more expensive than fogging every 3-months
- Substantial cost associated with
  - Cost of labor (deploy & service traps)
  - Effort to interpret and act on trap data

Future approaches for stored product pest management

- Antagonist semiochemicals to prevent infestations
  - Repellents/anti-feedants
  - Packaging/apply to structures
  - Host odor-borne
  - Insect-borne
- "Push-Pull" system
  - Commodity protected with antagonist semiochemicals
  - Diverted insects are eliminated by attracting to traps
  - Trap commodities, bait bags, poison bait stations release attractants
- Mating disruption for Dermestidae and Bruchidae

Funding:

USDA-NIFA Evans-Allen Research Program

Exosect® Limited, Hampshire, UK

USDA Risk-Avoidance and Mitigation Program (RAMP)

Study sites is SC

Trece Inc. (MD dispensers)

McCloud Services

Collaborators