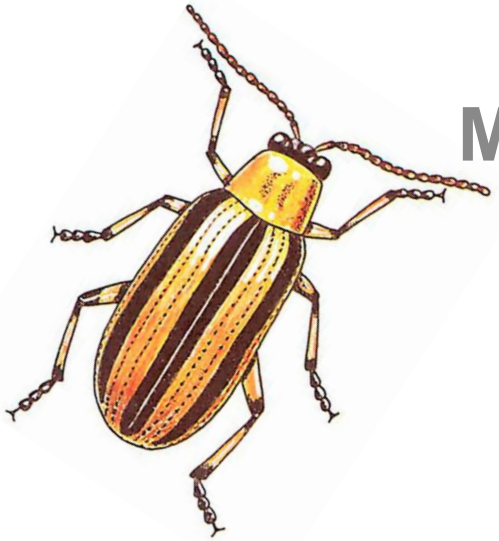
Molecular identification of arthropod predators of cucumber beetles



Molly Dieterich Mabin

Celeste Welty

Mary M. Gardiner

THE OHIO STATE UNIVERSITY

COLLEGE OF FOOD, AGRICULTURAL, AND ENVIRONMENTAL SCIENCES

Images: pesthoreca.com

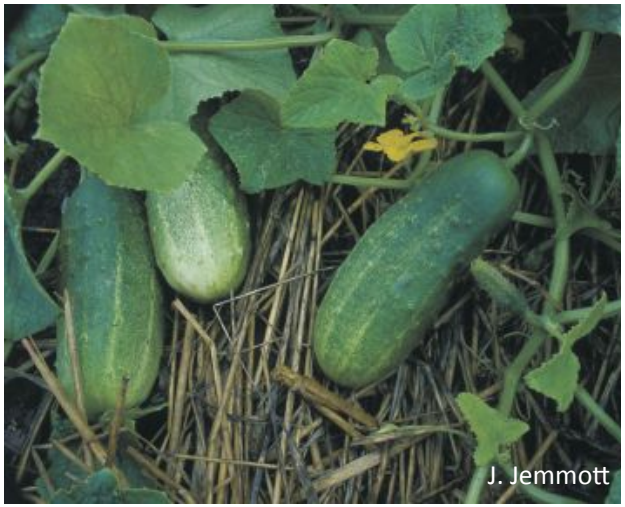
Cucumber beetles

Coleoptera: Chrysomelidae

Acalymma vittatum

Diabrotica undecimpunctata howardi

Cucurbits



Cucumber beetles

Bacterial wilt (*Erwinia tracheiphila)*

Fleischer et al. 1999; Ellers-Kirk & Fleischer 2006; Smyth & Hoffmann 2010

Vegetable Production

- High input systems
  - Pesticides
  - Fertilizers
  - Water
  - Plastic mulch
  - Frequent tilling

Vegetable Production

- High input systems
  - Pesticides
  - Fertilizers
  - Water
  - Plastic m

Conservation Biological Control

Increase activity, abundance, & diversity of predatory natural enemies

- Reduced tillage
- Crop rotations
- Cover crops
- Refuge habitats
  - Natural areas
  - Fallow fields

Batra 1982; Wissinger 1997; Gardiner et al. 2009; Maisonhaute et al. 2010
Hummel et al. 2002; Lee et al. 2001; Werling & Gratton 2008; Saska et al. 2007

Strip tillage

- Reduced disturbance
- Organic matter
- Structural & species diversity of vegetation

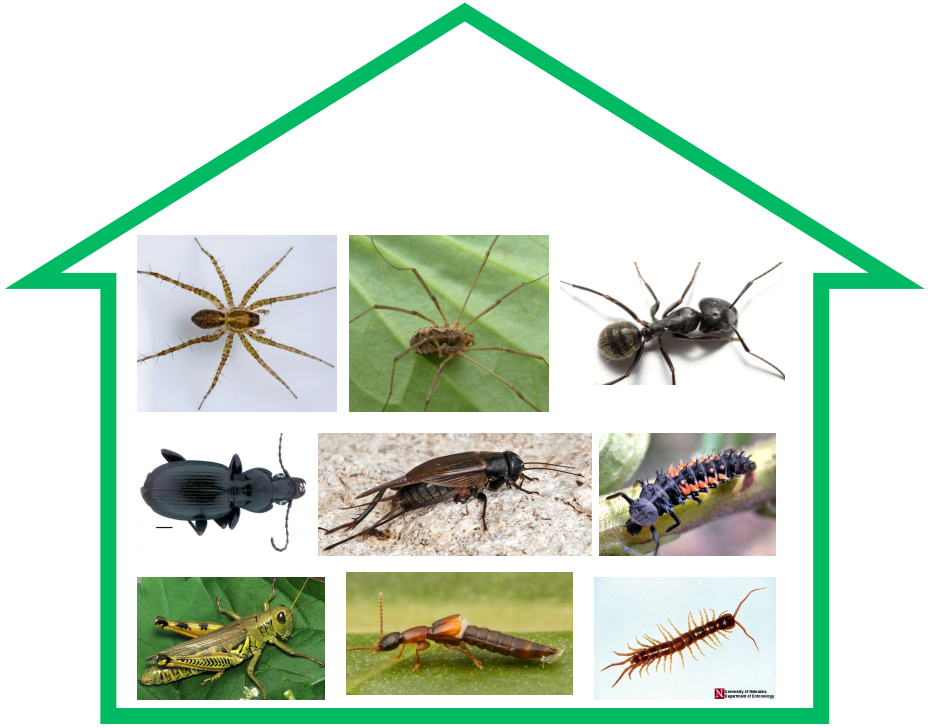
Strip tillage

- Reduced disturbance
- Organic matter
- Structural & species diversity of vegetation

↑ Natural enemies

Bottenberg et al. 1999; Luna & Staben 2002; Brainard & Corey Noyes 2012
Stinner & House 1990; Marino & Landis 1996; Bryant et al. 2013

- Does this increase in natural enemy abundance and diversity result in greater biological control?



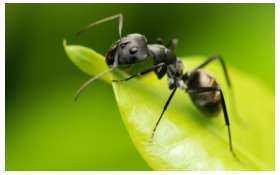
Ant © M Marlow. Wolf spider © I Cret. Harvestmen © GR Sapcote. Ground beetle © DH Kavanaugh. Rove beetle © E Gofreed. Lady beetle © L Ruth. Cricket © R Cohutta. Grasshopper © JP Michaud. Centipede © UNL Entomology. Cucumber beetles © M Spring.

Hypothesis

Complex vegetative habitats

Abundant, diverse, & active NE community







Greater biological control of cucumber beetles

2013 & 2014

Strip Tillage

Plastic Mulch

- organic & conventional management
- natural enemy community & biological control

Experiments

1. Pitfall traps
2. Sentinel egg study
3. Video surveillance
4. Molecular gut content analysis

Experiments

1. Pitfall traps
   - Abundance, richness, diversity
2. Sentinel egg study

3. Video surveillance
4. Molecular gut content analysis

Experiments

1. Pitfall traps
   - Abundance, richness, diversity
2. Sentinel egg study
   - Predation rates
3. Video surveillance

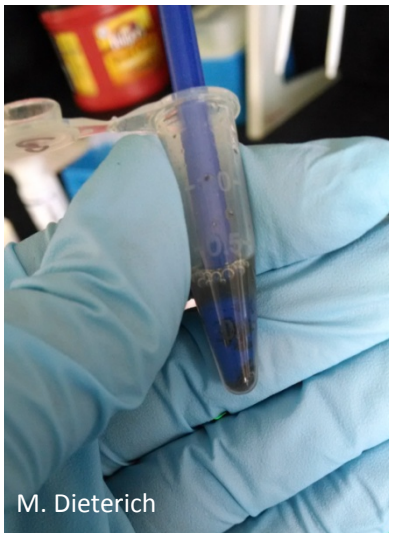
4. Molecular gut content analysis

Experiments

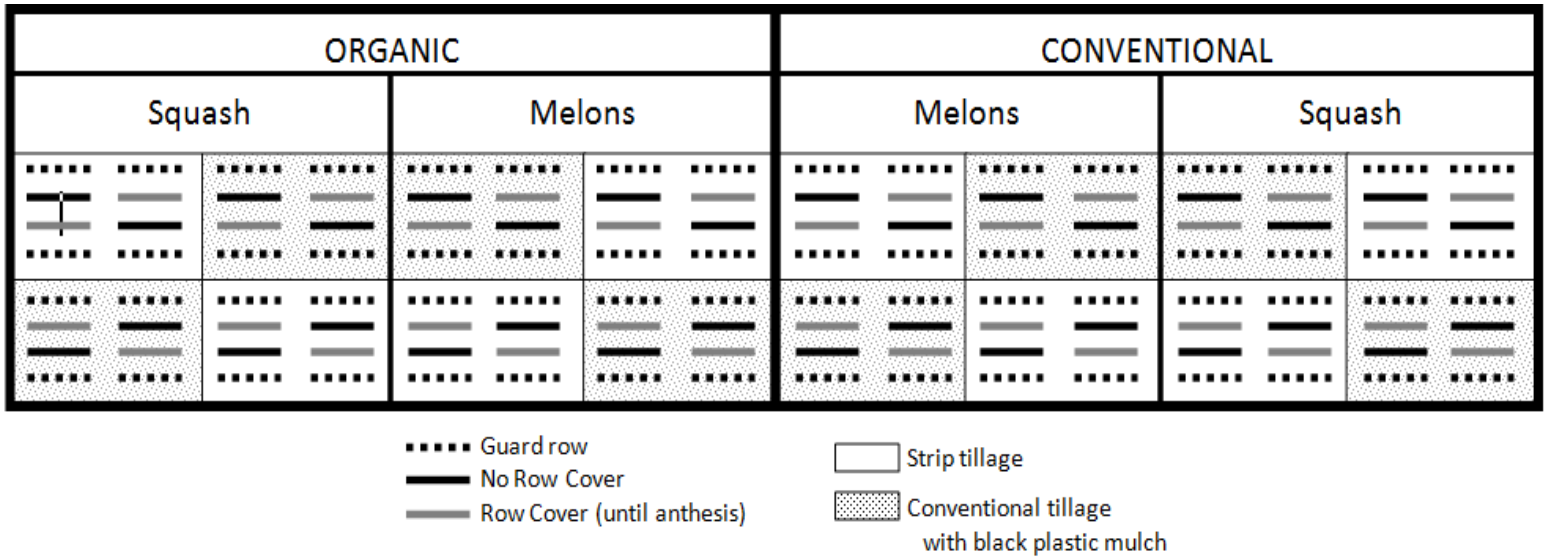
1. Pitfall traps
   - Abundance, richness, diversity
2. Sentinel egg study
   - Predation rates
3. Video surveillance
   - Who's eating the eggs?
4. Molecular gut content analysis

Experiments

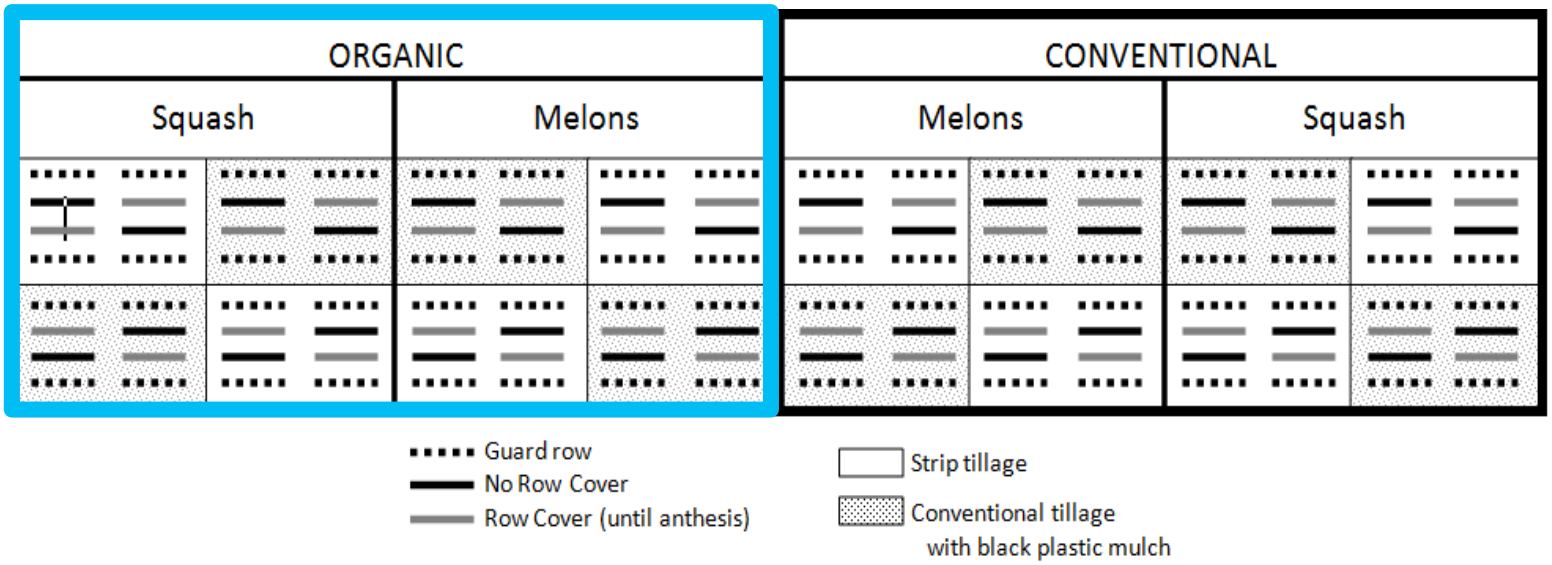
1. Pitfall traps
   - Abundance, richness, diversity
2. Sentinel egg study
   - Predation rates
3. Video surveillance
   - Who's eating the eggs?
4. Molecular gut content analysis
   - Who contributes to biocontrol


M. Dieterich

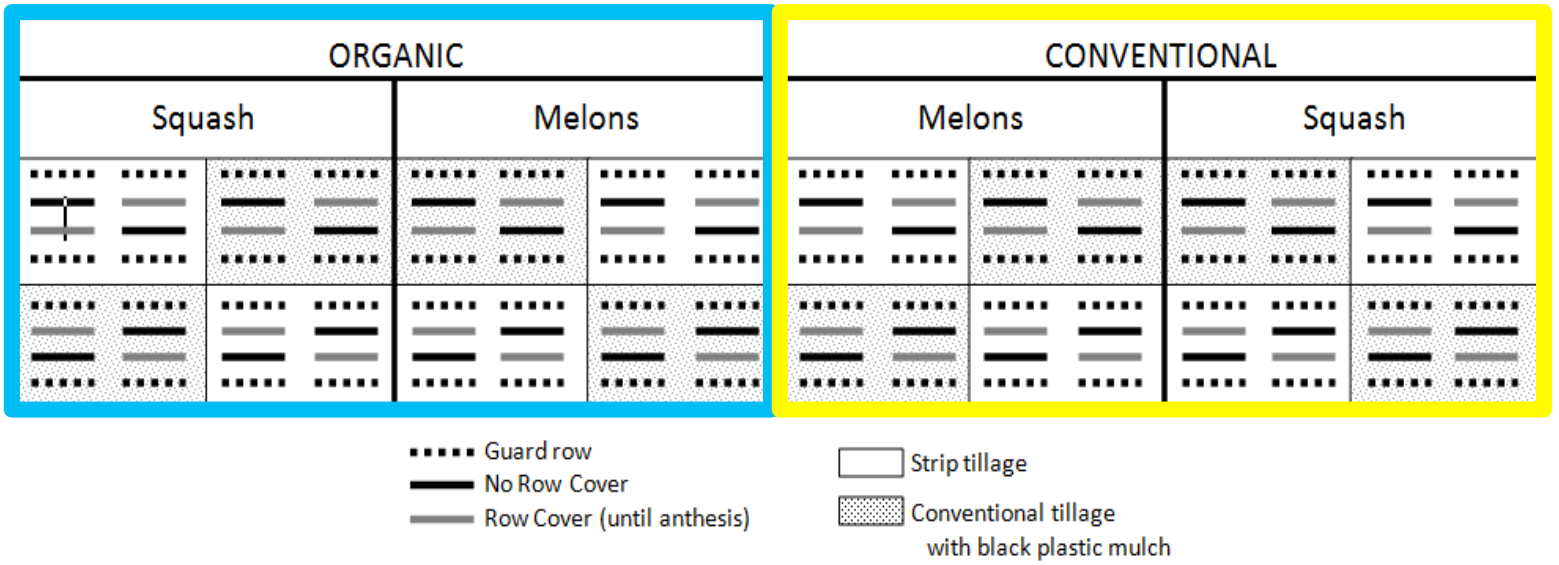
Field Sites


ORGANIC
CONVENTIONAL
Squash
Melons
Melons
Squash
Guard row
No Row Cover
Row Cover (until anthesis)
Strip tillage
Conventional tillage
with black plastic mulch

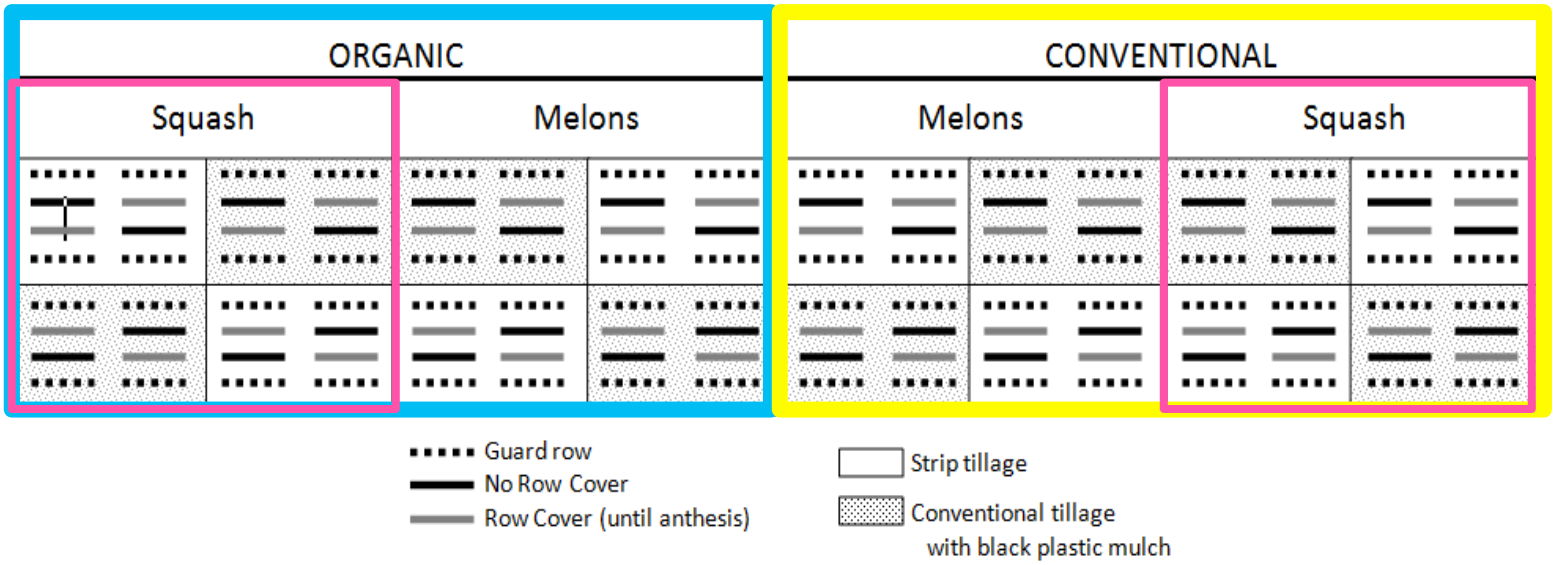
Field Sites


ORGANIC
Squash
Melons
CONVENTIONAL
Melons
Squash
Guard row
No Row Cover
Row Cover (until anthesis)
Strip tillage
Conventional tillage
with black plastic mulch

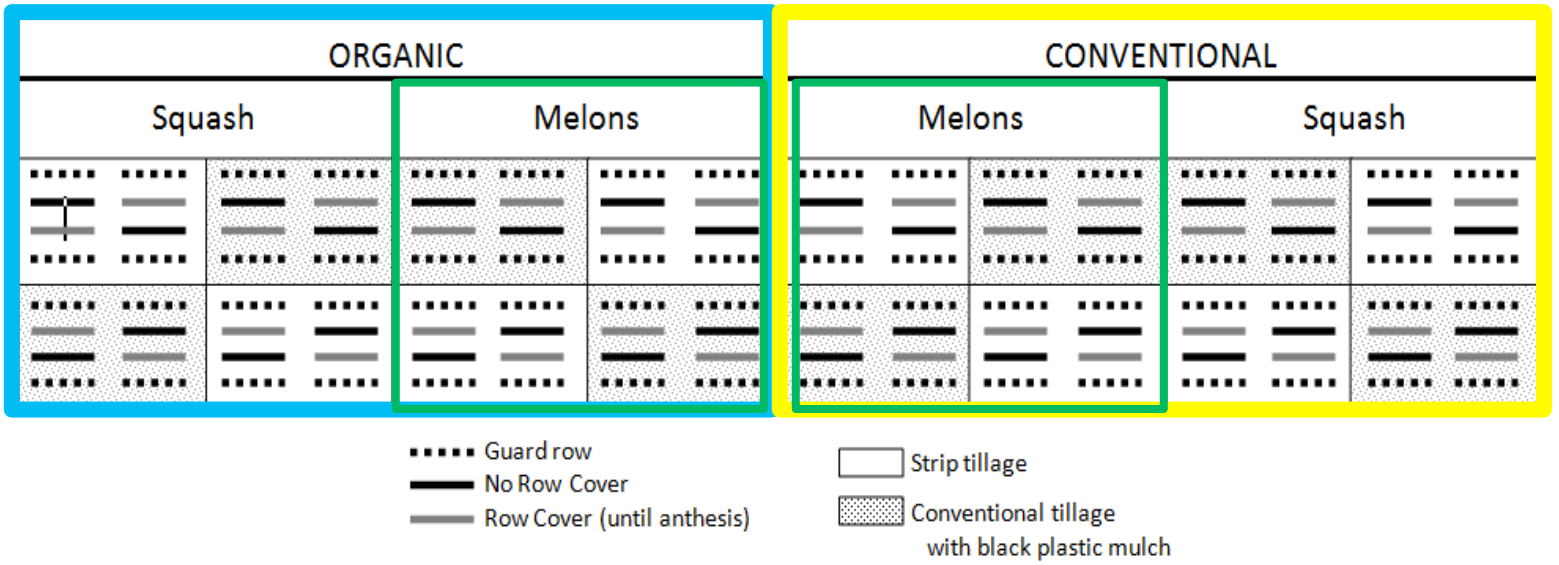
Field Sites


ORGANIC
Squash
Melons
CONVENTIONAL
Melons
Squash
Guard row
No Row Cover
Row Cover (until anthesis)
Strip tillage
Conventional tillage
with black plastic mulch

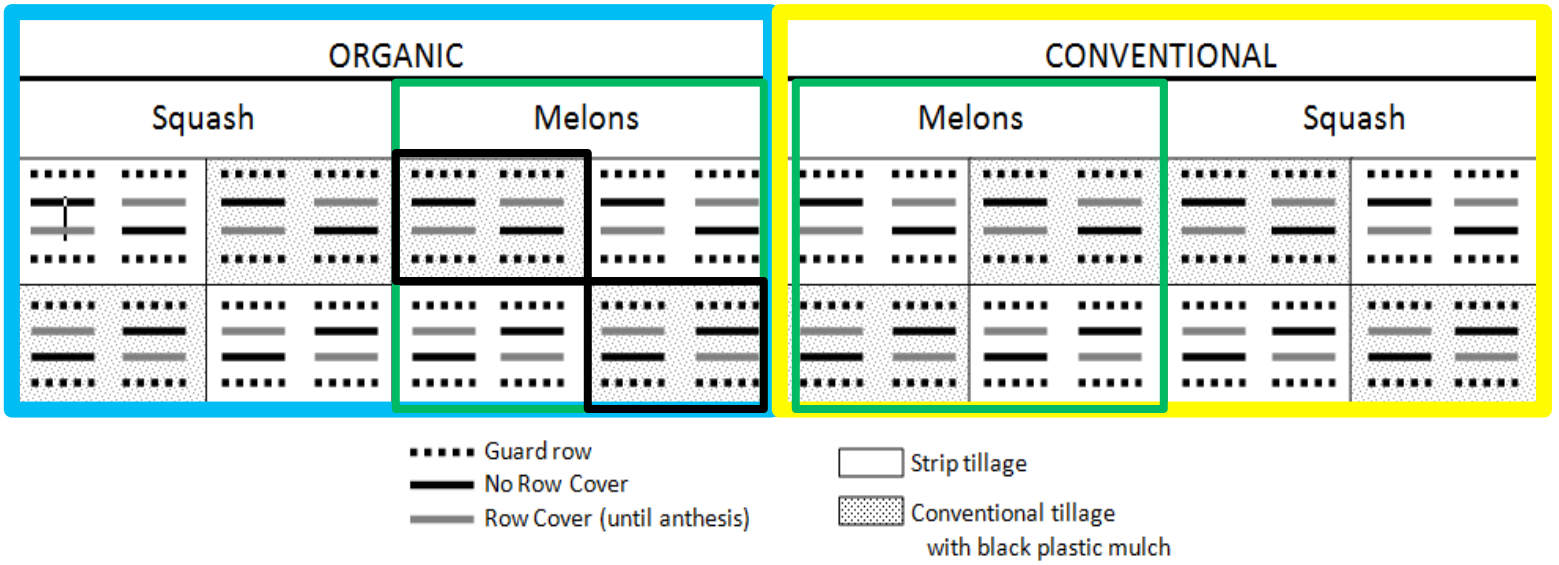
Field Sites


ORGANIC
CONVENTIONAL
Squash
Melons
Melons
Squash
Guard row
No Row Cover
Row Cover (until anthesis)
Strip tillage
Conventional tillage
with black plastic mulch

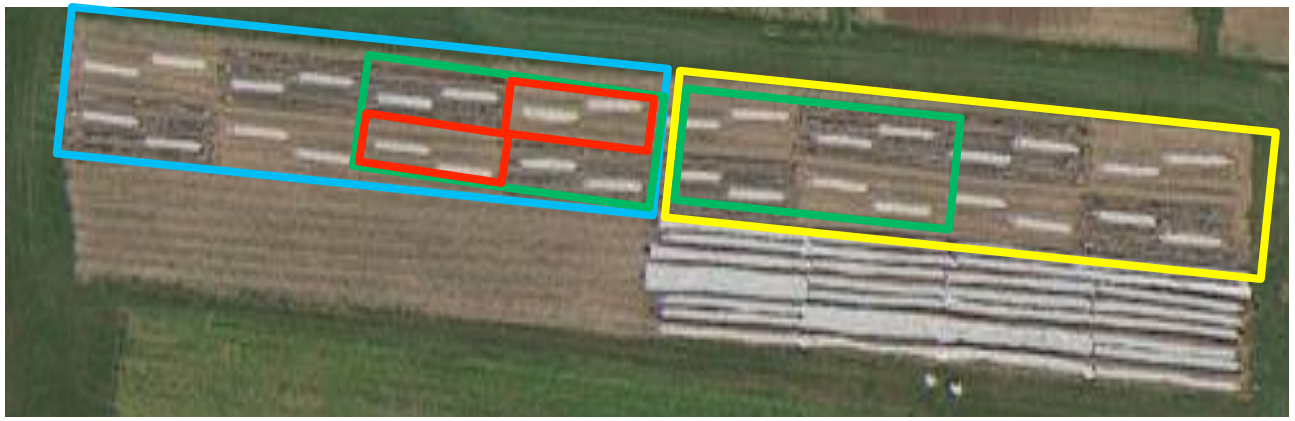
Field Sites

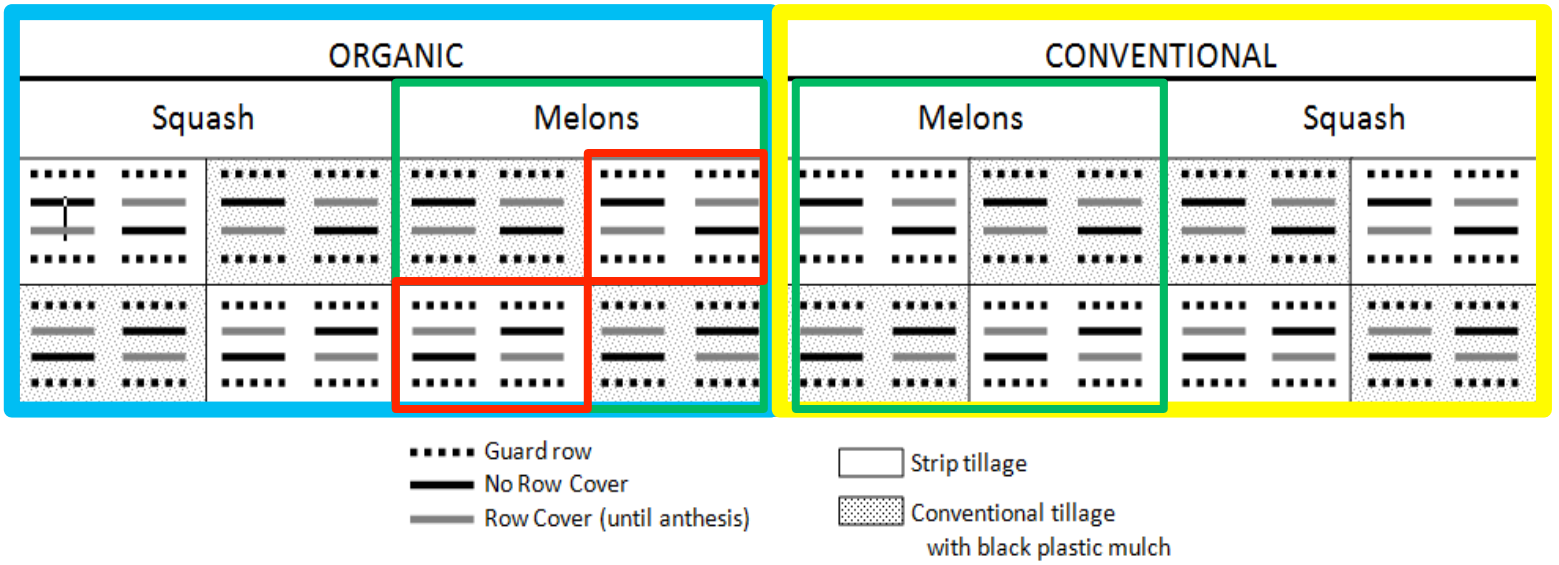

ORGANIC
CONVENTIONAL
Squash
Melons
Melons
Squash
Guard row
No Row Cover
Row Cover (until anthesis)
Strip tillage
Conventional tillage
with black plastic mulch

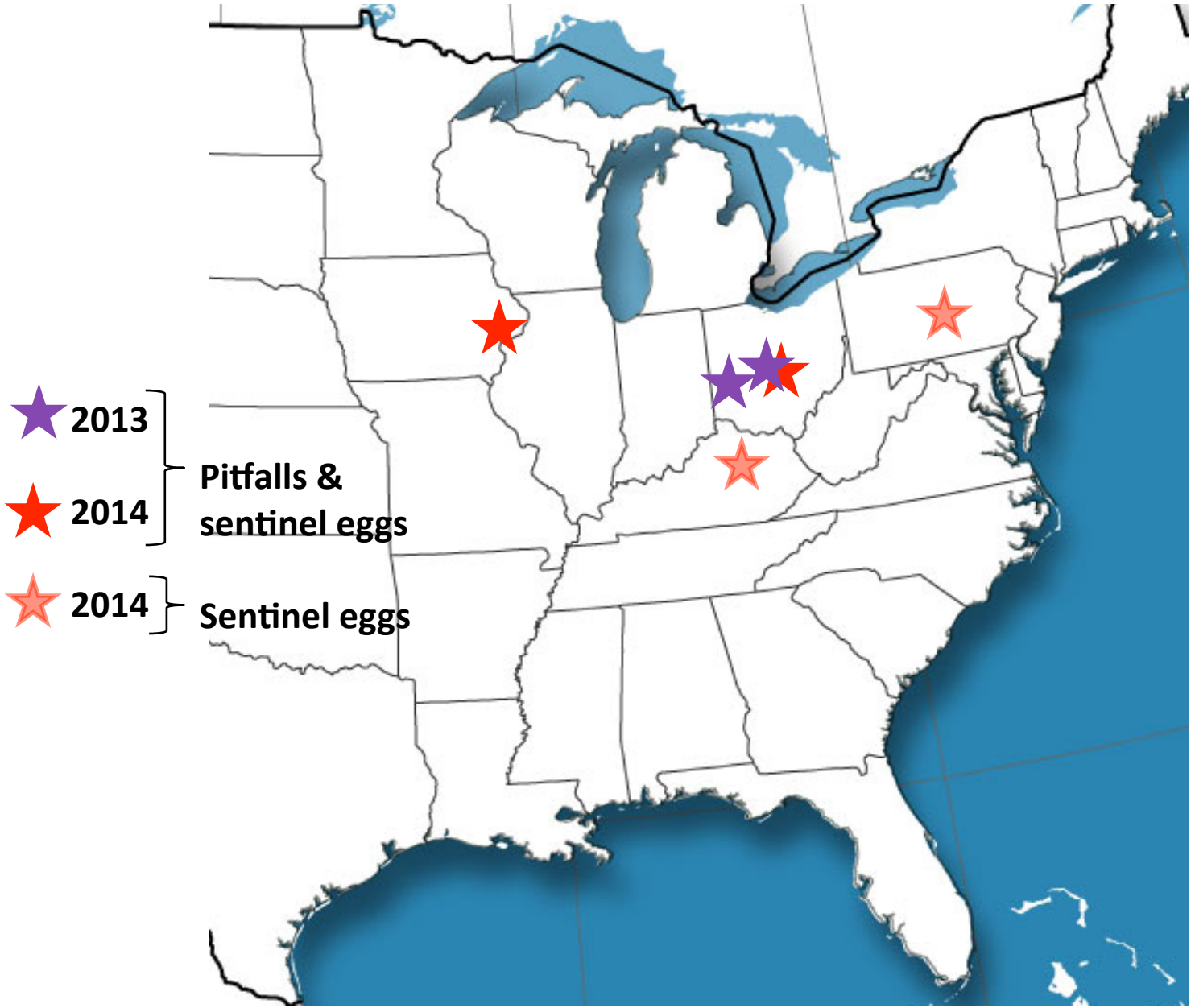
Field Sites


ORGANIC
CONVENTIONAL
Squash
Melons
Melons
Squash
Guard row
No Row Cover
Row Cover (until anthesis)
Strip tillage
Conventional tillage
with black plastic mulch

Field Sites



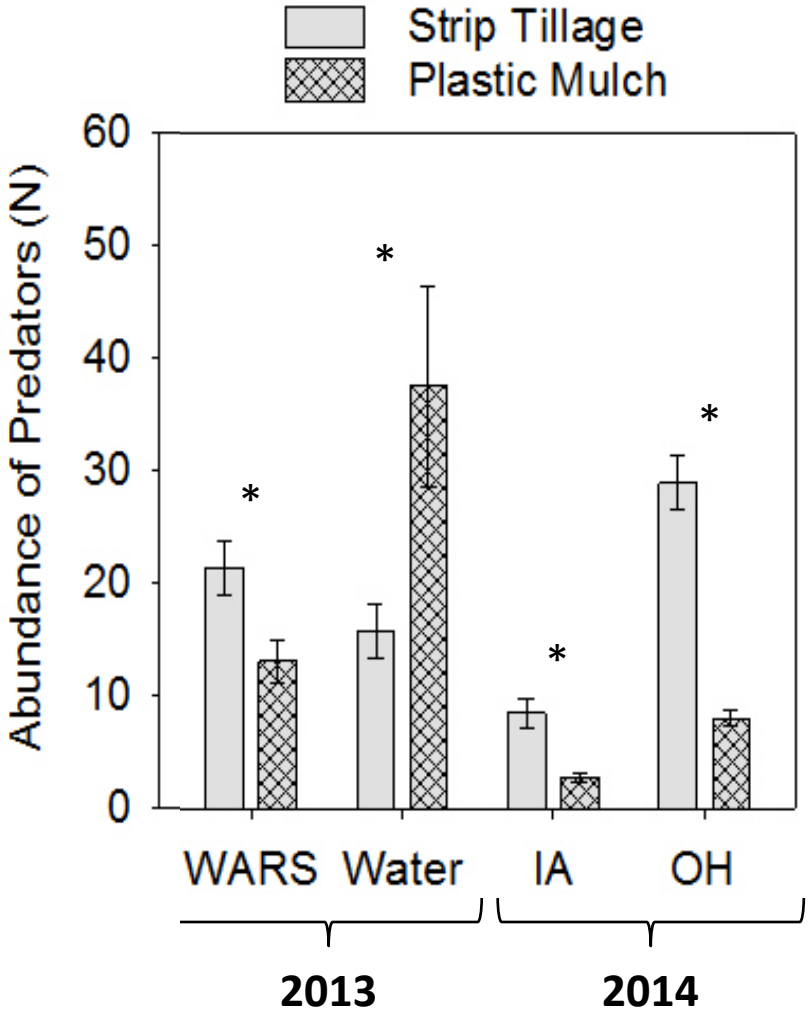

ORGANIC
CONVENTIONAL
Squash
Melons
Melons
Squash
Guard row
No Row Cover
Row Cover (until anthesis)
Strip tillage
Conventional tillage
with black plastic mulch


2013
2014
Pitfalls &
sentinel eggs
2014
Sentinel eggs

Predator Abundance

- *Expected:* greater abundance in **strip tillage** plots than in plastic mulch plots

Predator Abundance

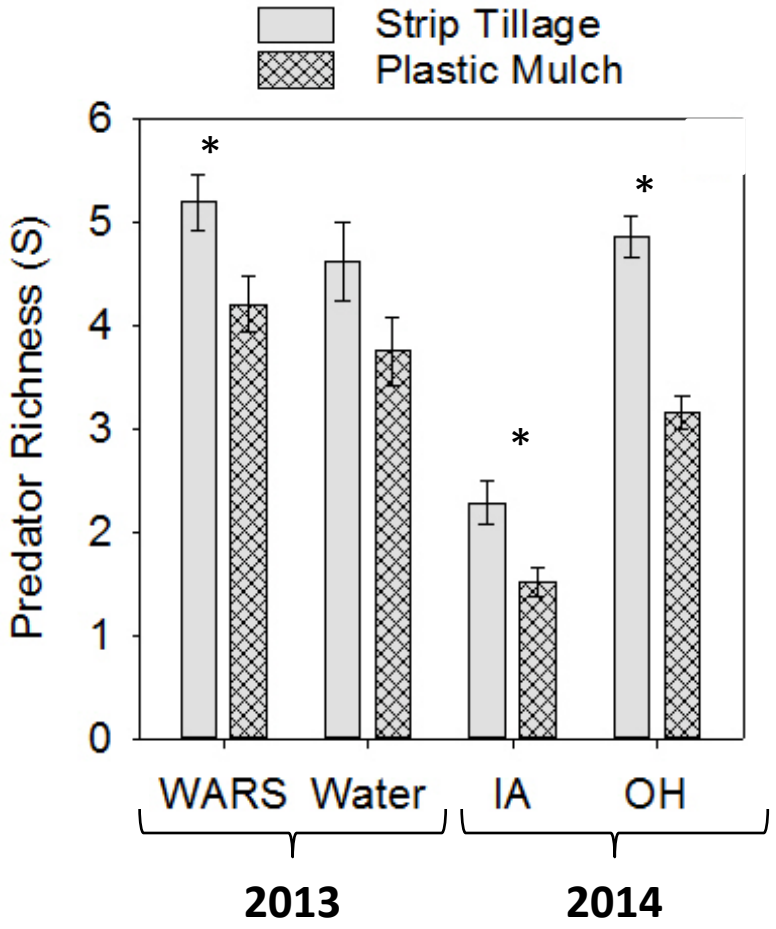


- *Expected:* greater abundance in **strip tillage** plots than in plastic mulch plots
- *Observed:* greater abundance in **strip tillage** 75% of the time & in **plastic mulch** 25% of the time

Predator Richness

- *Expected:* greater richness in **strip tillage** plots than in plastic mulch plots

Predator Richness

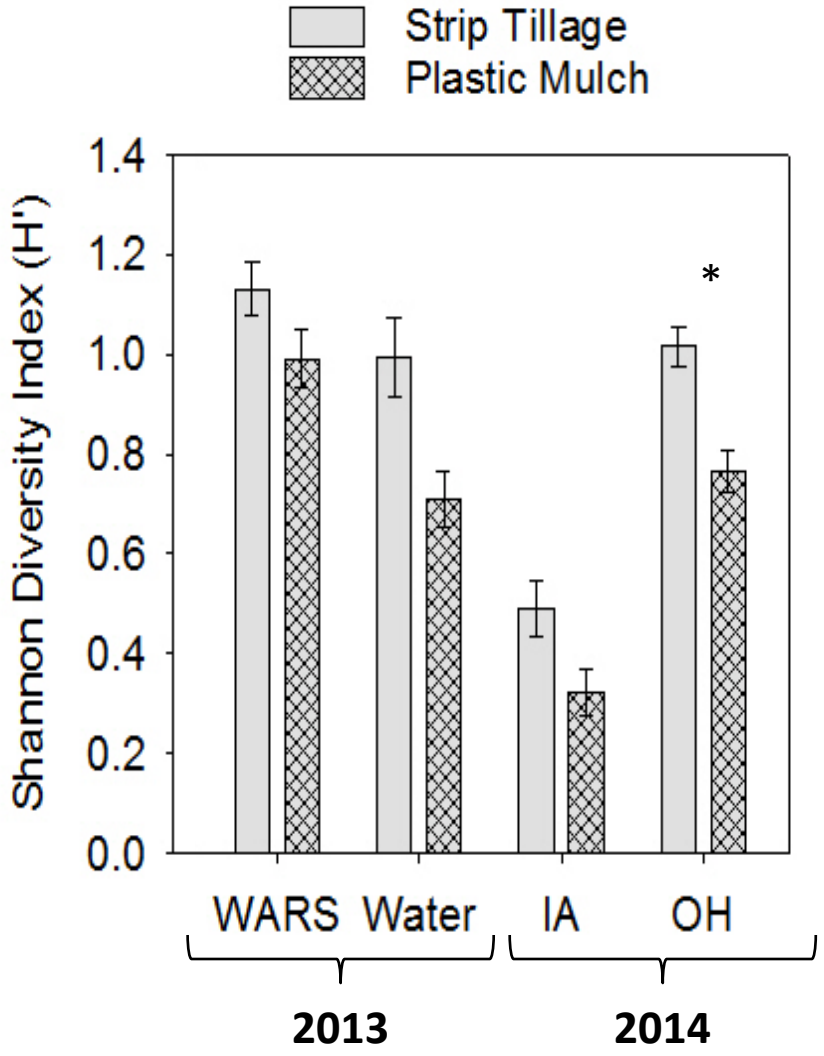


- *Expected:* greater richness in **strip tillage** plots than in plastic mulch plots
- *Observed:* greater richness in **strip tillage** plots 75% of the time

Predator Diversity

- *Expected:* greater diversity in **strip tillage** plots than in plastic mulch plots

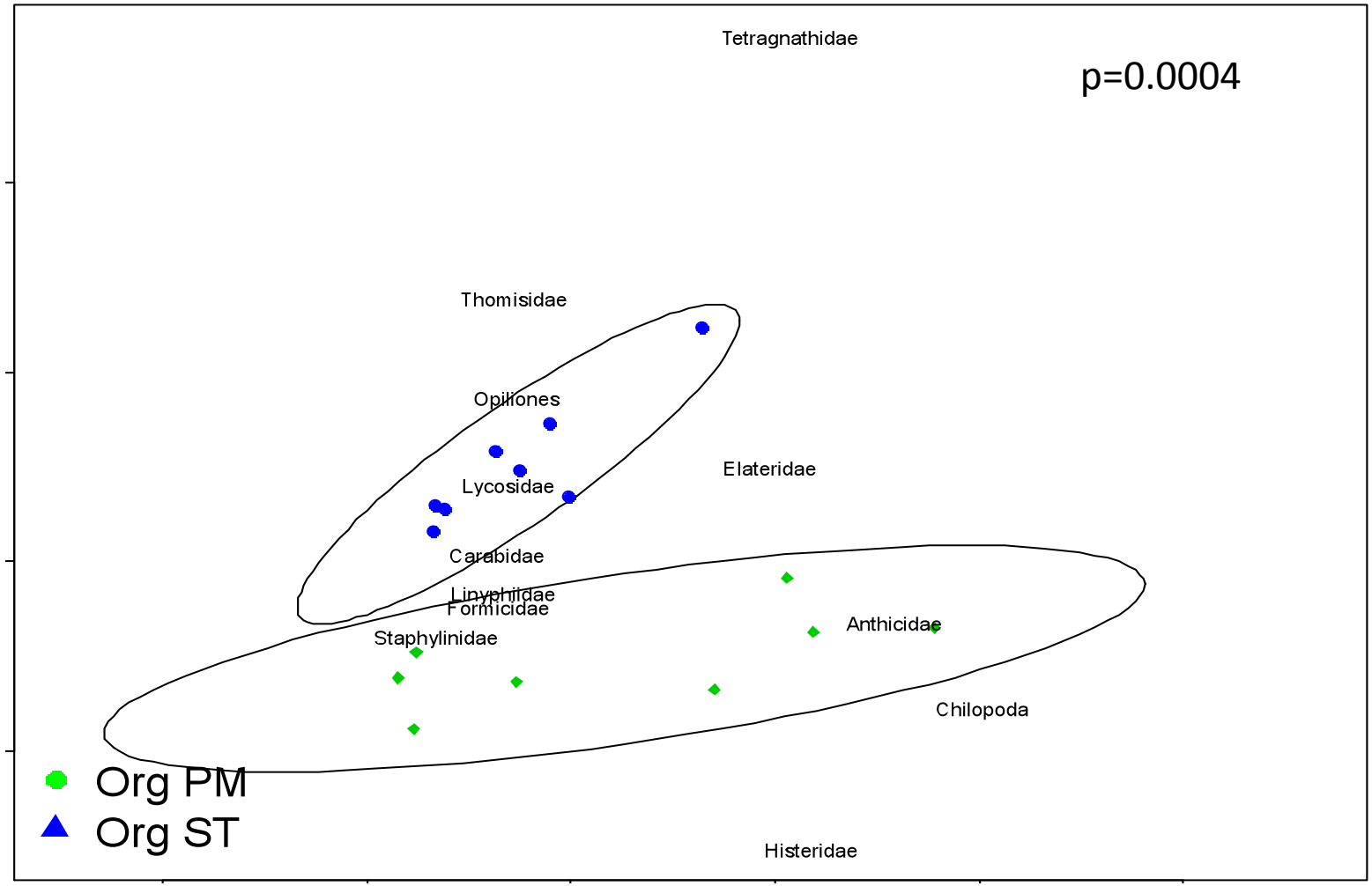
Predator Diversity



- *Expected:* greater diversity in **strip tillage** plots than in plastic mulch plots
- *Observed:* greater diversity in **strip tillage** plots 25% of the time

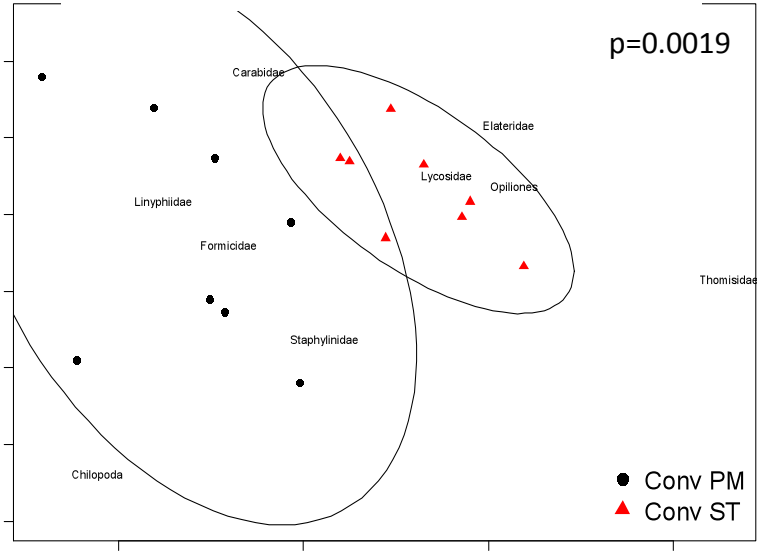
Non-metric Multidimensional Scaling (NMDS) Analysis

Organic Squash Predatory Arthropod Community (Ohio 2014)

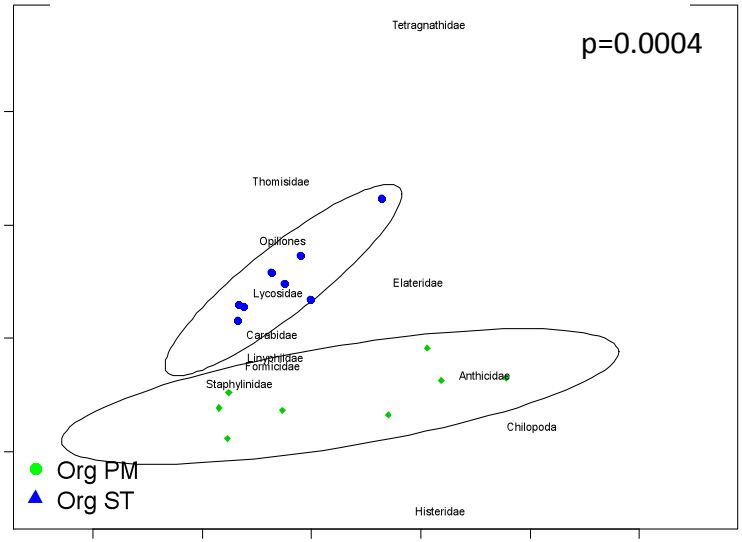


Ohio 2014

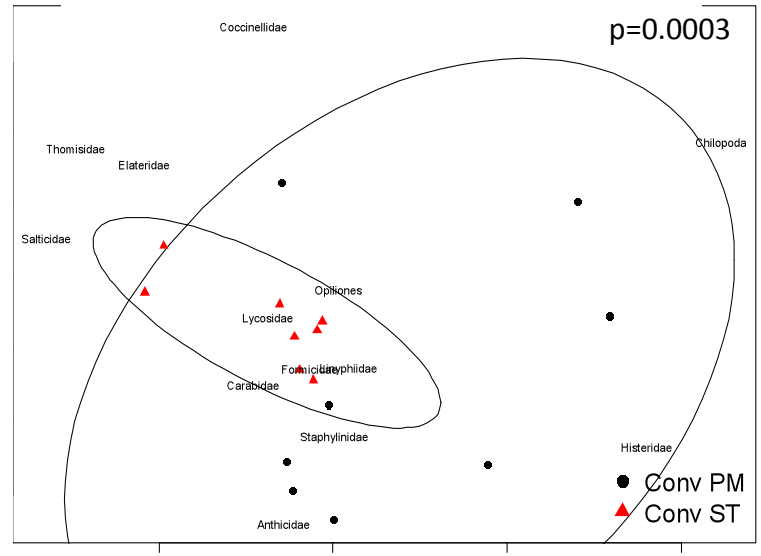
Conventional Squash



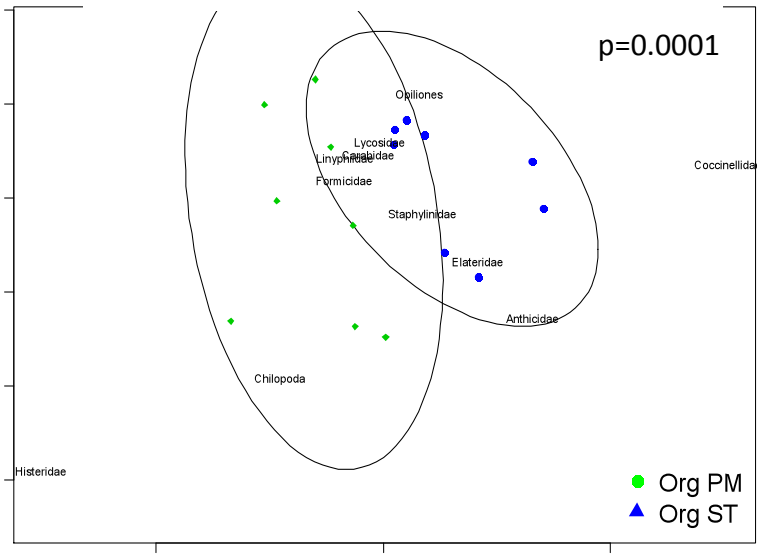
Organic Squash



Conventional Melons



Organic Melons



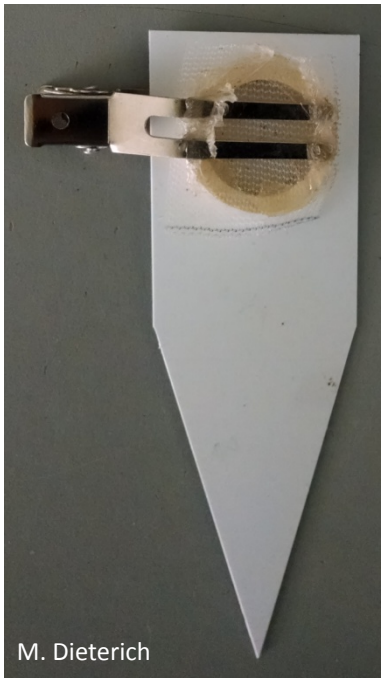
Experiments

1. Pitfall traps
   - Abundance, richness, & diversity → greater in ST
   - Community → different between ST and PM
2. Sentinel egg study
3. Video surveillance
4. Molecular gut content analysis

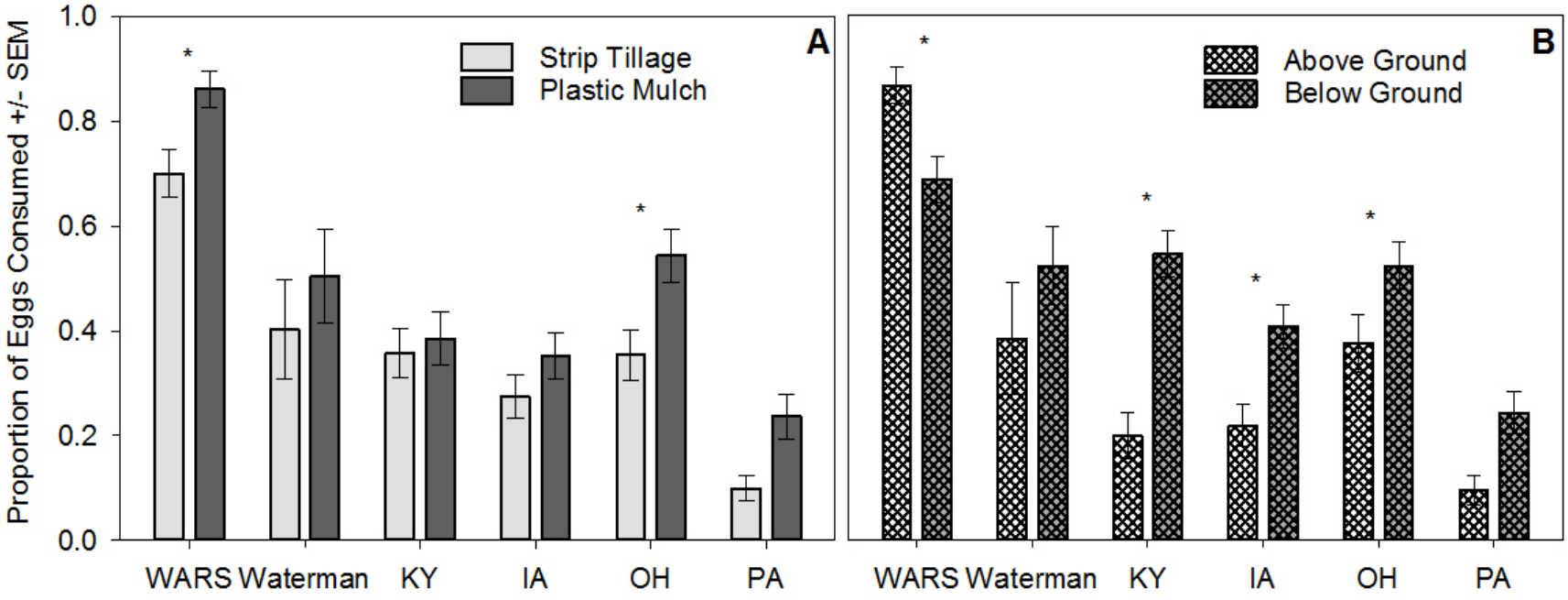
2. Sentinel Egg Study

4 sites: Ohio, Kentucky, Iowa, Pennsylvania

- 24 hours



Egg Consumption



- Greater egg consumption in plastic mulch (2/6 sites) & below ground

Experiments

1. Pitfall traps

2. Sentinel egg study
   - Egg predation rates → generally greater in PM
3. Video surveillance

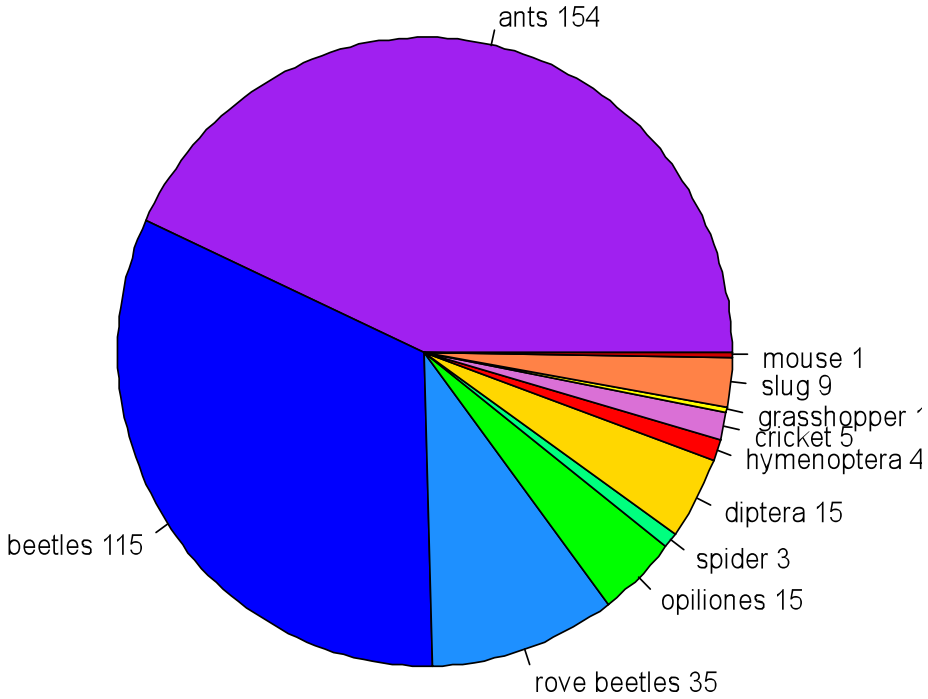
4. Molecular gut content analysis

3. Video Surveillance

- Who is eating cucumber beetle eggs?
  - Video surveillance of above ground sentinel egg cards

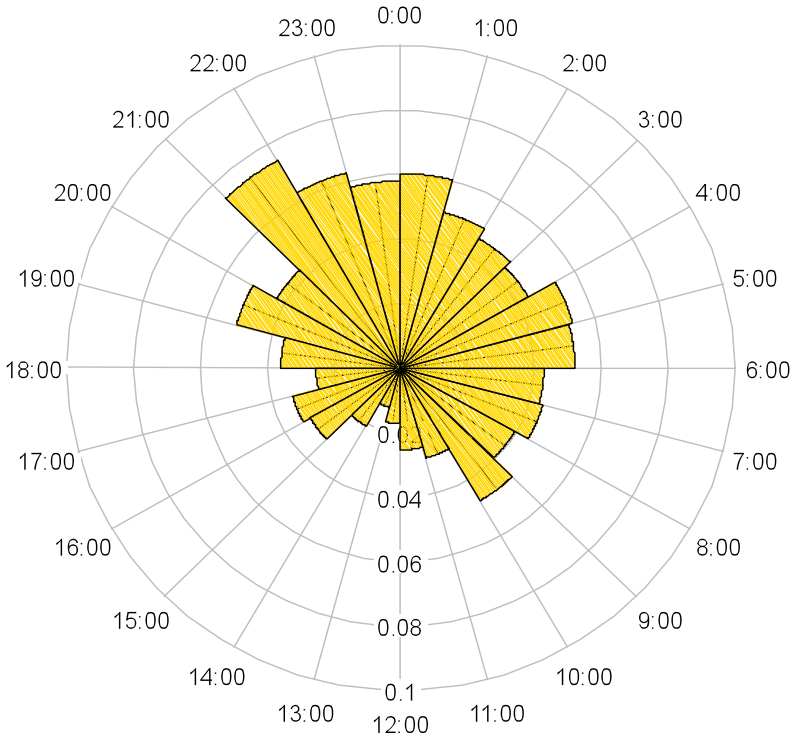
3. Video Surveillance

- **Ants & beetles**
- Harvestmen, flies, & crickets
- Spiders,
  wasps,
  grasshoppers,
  slugs, &
  a mouse

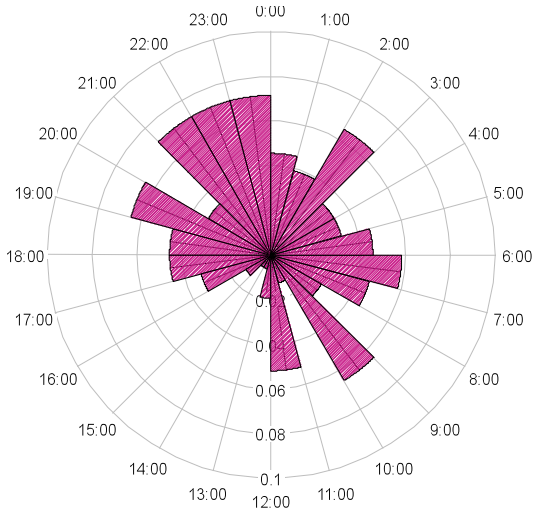


3. Video Surveillance

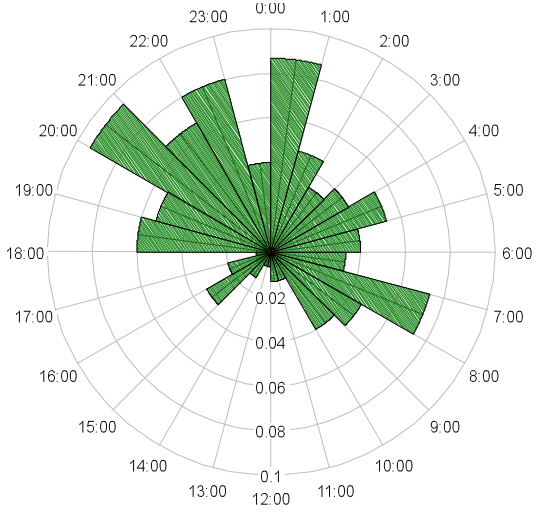
All predators



Formicidae



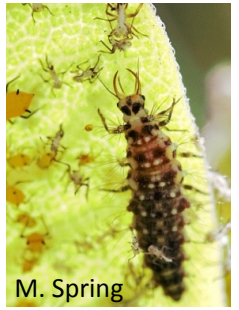
Coleoptera



Experiments

1. Pitfall traps ✓
2. Sentinel egg study ✓
3. Video surveillance ✓
   - Who's eating the eggs? → ants & beetles
4. Molecular gut content analysis

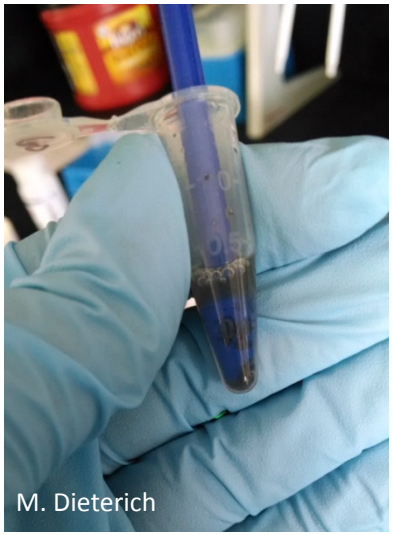
Molecular gut content analysis



Molecular gut content analysis

Collect NEs

DNA extraction



Develop primers (CO1 gene)

Chisholm et al. 2014, Rougerie et al. 2011, Harwood et al. 2009, Lundgren et al. 2009, Harwood et al. 2007, Schmidt et al. 2014

Molecular gut content analysis

PCR & gel electrophoresis

Molecular gut content analysis

- 204 wolf spiders (Araneae: Lycosidae)

Pardosa milvina (n=133)	*Pardosa pauxilla* (n=21)
Immature *Pardosa* spp. (n=50)	

Molecular gut content analysis

- 204 wolf spiders → 12.25%

Pardosa milvina (n=133)	*Pardosa pauxilla* (n=21)
Immature *Pardosa* spp. (n=50)	

Molecular gut content analysis

- 88 harvestmen (Opiliones)

Phalangium opilio (n=59)	*Opilio parietinus* (n=22)	*Leiobunum* spp. (n=4)	*Mitopus morio* (n=3)

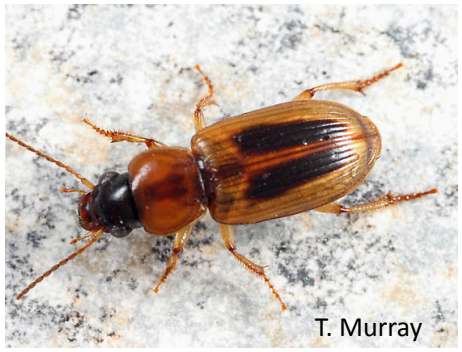
Molecular gut content analysis

- 88 harvestmen → 12.5%

Phalangium opilio (n=59)	*Opilio parietinus* (n=22)	*Leiobunum* spp. (n=4)	*Mitopus morio* (n=3)

Molecular gut content analysis

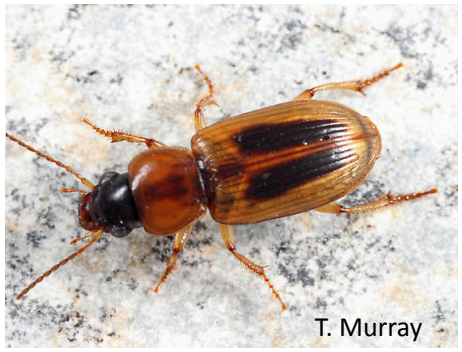
- 72 ground beetles (Coleoptera: Carabidae)



Anisodactylus sanctaecrucis **(n=36)**	***Stenolophus comma*** **(n=26)**	***Harpalus pensylvanicus*** **(n=3)**
Anisodactylus **spp. (n=1)**	***Stenolophus*** **spp. (n=7)**	***Harpalus*** **spp. (n=5)**

Molecular gut content analysis

- 72 ground beetles → 5.5%



Anisodactylus sanctaecrucis **(n=36)**	***Stenolophus comma*** **(n=26)**	***Harpalus pensylvanicus*** **(n=3)**
Anisodactylus **spp. (n=1)**	***Stenolophus*** **spp. (n=7)**	***Harpalus*** **spp. (n=5)**

Molecular gut content analysis

- 72 ants (Formicidae)

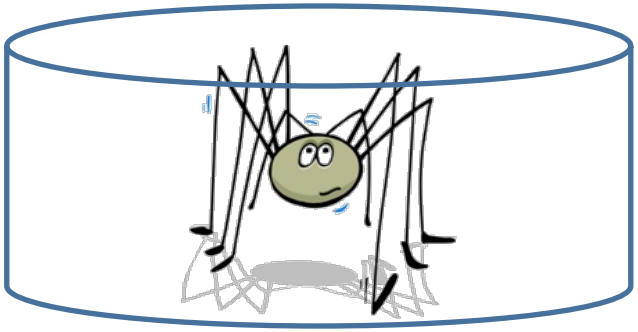
Lasius neoniger
(n=72)

Molecular gut content analysis

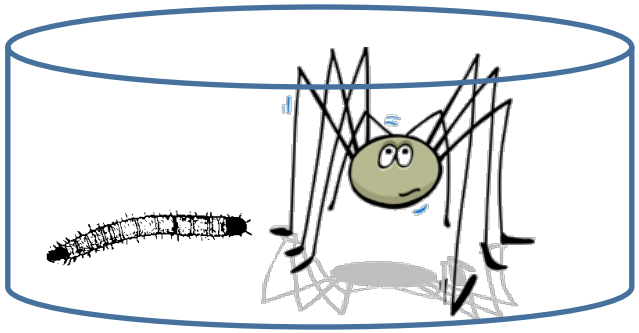
- 72 ants → 5.5%

Lasius neoniger
(n=72)

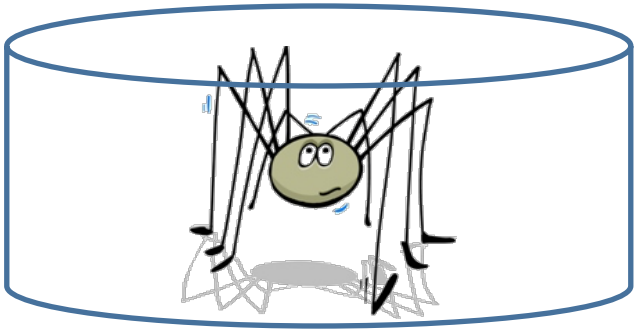
Digestion Rate Assay - Methods



starved for
3 days



+ cucumber
beetle larvae



starved for:
0, 12, 24, 36,
48, 60, 72 hrs

Digestion Rate Assay - Results

- Wolf spiders & harvestmen

- DNA is detectable for 72 hours
  - Cucumber beetles appear to metabolize slowly in arachnids

Digestion Rate Assay - Results

- Wolf spiders & harvestmen

- DNA is detectable for 72 hours
  - Cucumber beetles appear to metabolize slowly in arachnids

- In future:
  - added time points so we can start to compare
  - evaluating other species (beetles & ants)

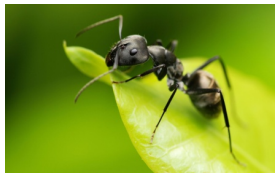
Summary

- Does strip tillage result in greater biocontrol?
  - Predator abundance & richness are often greater in strip tillage than in plastic mulch
  - We would expect to see increased biocontrol with increased natural enemy abundance & richness (Letourneau et al. 2009)

Summary

- Does strip tillage result in greater biocontrol?
  - Predator abundance & richness are often greater in strip tillage than in plastic mulch
  - But, biological control was generally greater in plastic mulch



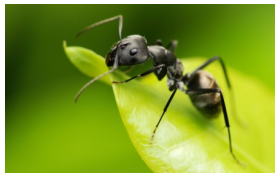




Summary

- Does strip tillage result in greater biocontrol?
  - Predator abundance & richness are often greater in strip tillage than in plastic mulch
  - But, biological control was generally greater in plastic mulch
    - Perhaps the difference in community composition between strip tillage & plastic mulch is driving this pattern



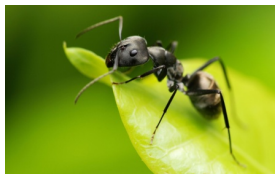




Summary

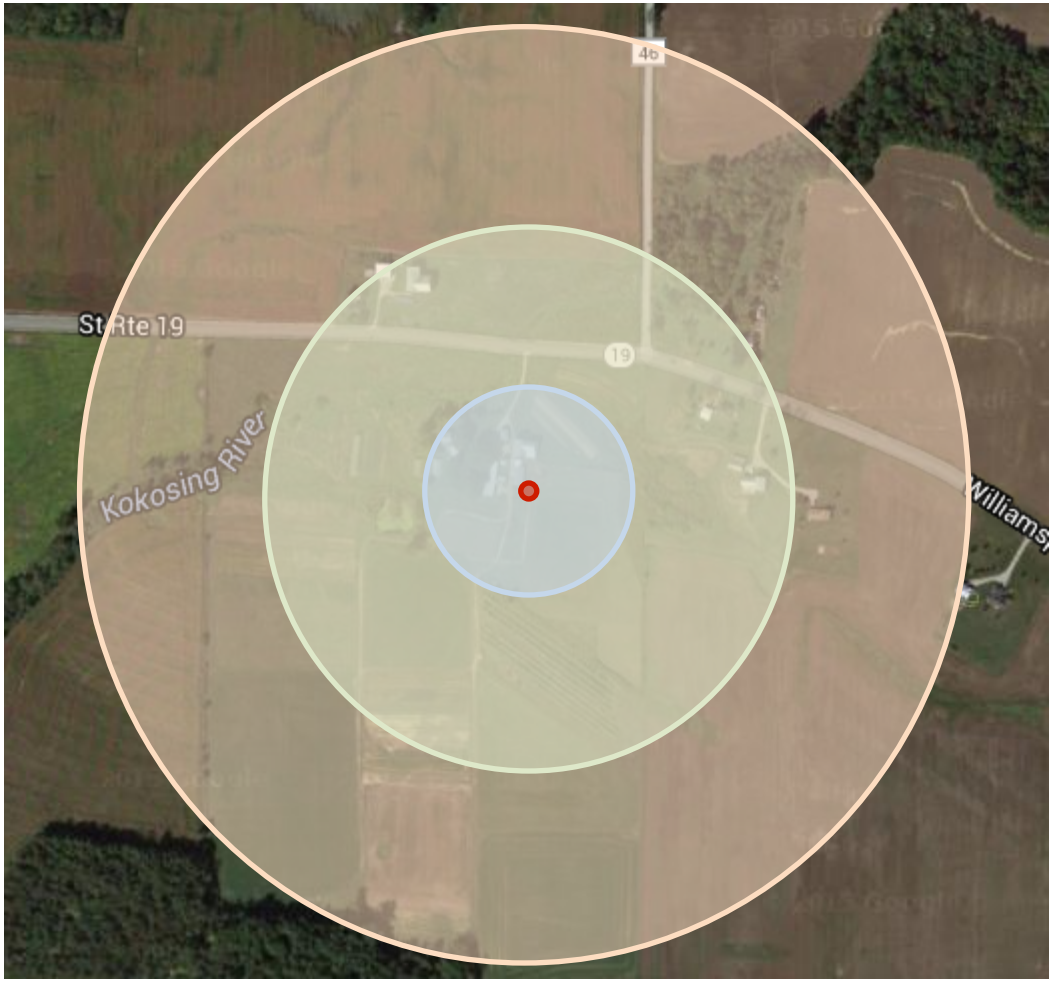
- Does strip tillage result in greater biocontrol?
  - Predator abundance & richness are often greater in strip tillage than in plastic mulch
  - But, biological control was generally greater in plastic mulch
- Which predators consume cucumber beetles?
  - Ants & beetles are common egg predators
  - Wolf spiders & harvestmen consume CB in the field
    - Ground beetles & ants







Implications



Chaplin-Kramer et al. 2011, Tscharntke et al. 2007, Crowder & Jabbour 2014

Thank you!

- Welty Lab
  - Field work
- Ag-Urban Landscape Ecology Lab
- Dr. Andy Michel
- Dr. Susan Jones
  - Lab space

Funding:

USDA United States Department of Agriculture National Institute of Food and Agriculture

Specialty Crop Research Initiative grant number: 2012-51181-20295

The Ohio State University College of Food, Agricultural, and Environmental Sciences

OARDC SEEDS Graduate Student Grant

CERES TRUST

Graduate Research Grant

Questions?

M. Spring