

Spiders as Biocontrol

Eric Yip & Codey Mathis
The Pennsylvania State University

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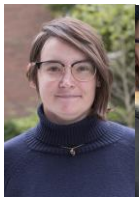
The Ohio State University Extension

PennState

OHIO STATE

Who are we?



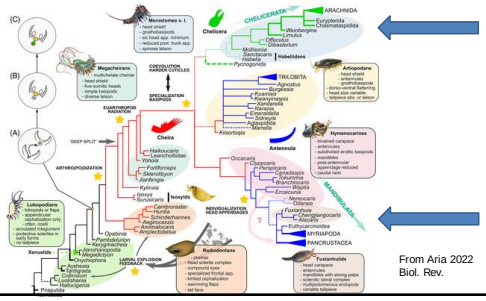

Codey Mathis, PhD Candidate in the Skvarla Lab
Pollinator Conservation & Management – Bees, Wasps, Syrphid flies

Dr. Eric Yip, Assistant Research Professor
Previously: Group living & Sexual Selection in Spiders. Now: Plant-based effects on sexual selection in goldenrod gall flies

- What is a spider?
- Spider biology
- Are spiders good biocontrol and why?
- Are spiders dangerous?
- Spiders of Ohio

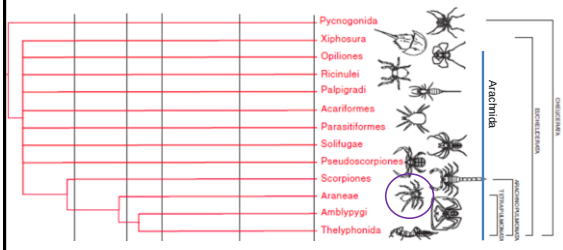
What is a spider?

- Spiders are arthropods (phylum)



From Aria 2022 Biol. Rev.

Spiders are chelicerates



Spiders are arachnids

- Arachnids have chelicerae
- 8 legs + 2 palps
- 2 (more or less) body parts

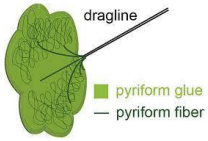




What is a spider?

- Have venom in fangs
- Abdominal silk glands and spinnerets



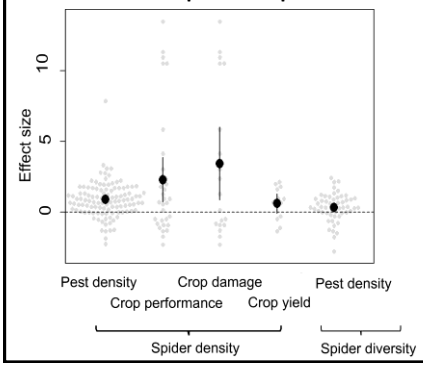


  - Eye number is variable (and can be used to ID)

Question:

Are Spiders Good Biocontrol Agents?

Yes! Spiders protect crops



Michalko et al. 2019

Types of Biocontrol

1. Classical
2. Augmentation
3. Conservation

Types of Biocontrol

Cactoblastis cactorum

1. Classical
   1. **Ease of manipulation** (storage, shipping, mass rearing, release, integration)
   2. **Climatic/habitat suitability**
   3. **Host/prey specificity**
   4. **Searching ability**
   5. **Relatively high reproductive capacity**
   6. **Mobility**
   7. **Phenological synchrony**
   8. **Aggregation behavior** -

Types of Biocontrol

1. Classical
2. Augmentation
   - Inundation: large numbers
   - Inoculation: multiple generations

First, the Good News!

- **All* spiders are predators**

**Bagheera kiplingi* only known vegetarian spider (Meehan et al. 2009 Current Biology)

First, the Good News!

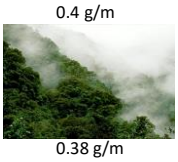
- All* spiders are predators
- **Can be very abundant**

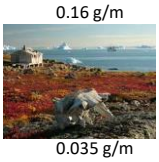
How many spiders are there?

- 132 per m^2 (Turnbull 1973, Ann. Rev. Entomol.)
- 150 per m^2 (Nyffeler 2000, Bull. Brit. Arachnol. Soc.)
- 25 million tons (Nyffeler and Birkhoffer 2017)

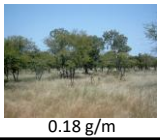

0.4 g/m

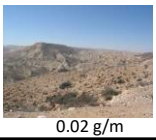

0.16 g/m


0.38 g/m


0.035 g/m


0.017 g/m


0.18 g/m


0.02 g/m

From Nyffeler and Birkhofer 2017

First, the Good News!

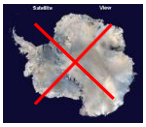
- All* spiders are predators
- Can be very abundant (130+ spiders/m^2)
- **Eat a lot of insects, though estimates vary**
  - Insects consumed by spiders
    100 – 47,500 Kg/hectare/year (Foelix 2011)

How much do spiders eat?

- 132 per m^2 (Turnbull 1973, Ann. Rev. Entomol.)
- 150 per m^2 (Nyffeler 2000, Bull. Brit. Arachnol. Soc.)
- 25 million tons (Nyffeler and Birkhoffer 2017)
  - 460-720 million tons of insects/yr (based on metabolism)
  - 400-800 million tons of insects/yr (based on field obs.)

First, the Good News!

- All* spiders are predators
- Can be very abundant (130+ spiders/m^2)
- Eat a lot of insects, though estimates vary
- **Live in nearly all terrestrial habitats**



First, the Good News!

- All* spiders are predators
- Can be very abundant (130+ spiders/m^2)
- Eat a lot of insects, though estimates vary
- Live in nearly all terrestrial habitats
- **Good dispersers**

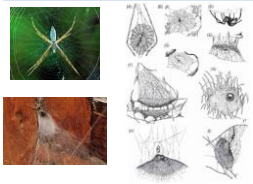
1832
October: 31st
A beautiful day: but the wind has been steadily against us. — In the evening all the ropes were coated & fringed with Gossamer web. — I caught some of the Aeronaut spiders, which must have come at least **60 miles**. --Charles Darwin

First, the Good News!

- All* spiders are predators
- Can be very abundant (130+ spiders/m^2)
- Eat a lot of insects, though estimates vary
- Live in nearly all terrestrial habitats
- Good dispersers
- **Hunt both day and night using different modes of predation**

Modes of Predation

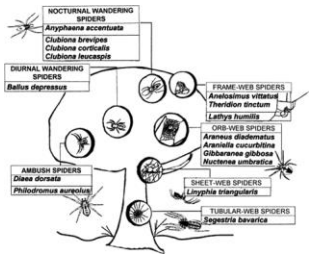
Webs



Cursorial

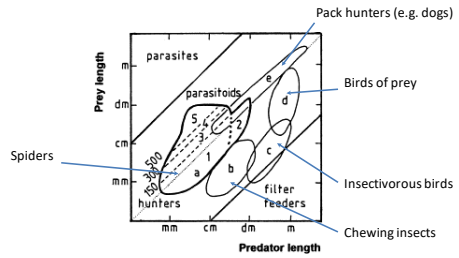
- Orb weavers: target flying insects
- Cursorial spiders: target crawling insects
- Sheet web weavers: target crawling and flying
- **Poor predators of pests underground or in plant tissue**

Location, Location, Location…



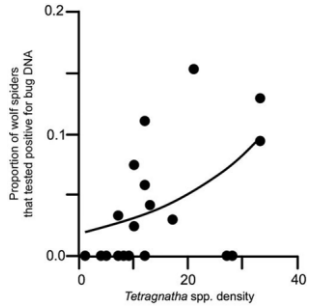
Marc et al. 1999 Agric. Ecosyst. Environ.

Size Specificity



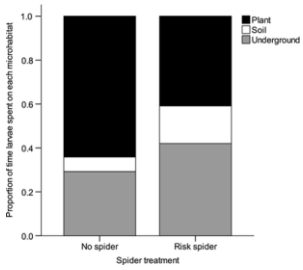
Marc et al. 1999 Agric. Ecosyst. Environ.

Niche complementarity



Wolf spiders and *Tretragnatha* vs. mirid bugs in organic rice paddies (Takada et al., 2013, J. Arachnol)

Non-consumptive effects

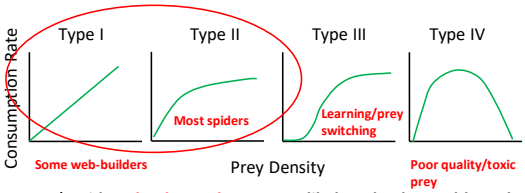


But boll damage increased with spiders, suggesting larvae ate more quickly (Rendon et al., 2016, Entomol. Exp. Applicat.)

Helicoverpa armigera in response to *Tasmanicosa leuckartii*

Functional responses

Functional Responses:



Most* spiders, by themselves, are unlikely to lead to stable cycles

* Some may learn/switch prey items, leading to Type III (Maloney et al. 2003)

Spiders' numerical response

- Can spider numbers track prey number?
  - Reproduction
  - Migration

Long Generation Times
r VS **k**

- **Spiders can have very high fecundity:**

  1500 -2500 eggs per sac in *Cupiennius* (Melchers 1963)




Long Generation Times
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- Spiders can have very high fecundity:

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- But most spiders have an annual life cycle with **only 1 generation/yr**

  7 days between generations in aphids (Hales et al. 1997 Eur. J. Entomol.)

Long Generation Times
r VS **k**

- Spiders can have very high fecundity:
  1500 -2500 eggs per sac in *Cupiennius* (Melchers 1963)
- But most spiders have an annual life cycle with only 1 generation/yr
- **Can't track pest populations within a season**

Spiders' numerical response

- Can spider numbers track prey number?
  - Reproduction
  - Migration



Little control over ballooning direction or landing

Birkhofer et al., 2018, Agriculture Ecosystems and Environment

Most Spiders are Generalists

- Some exceptions:


Mastophora spp.


Evarcha culicivora

- May target beneficial insects

- Intraguild predation

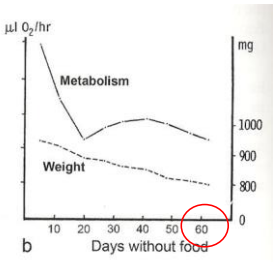
Hard to Build Up High Densities

- Some predators are commercially available


- Not an option for most spiders
- Social spiders…??

Slow Metabolism

- Spiders can survive for months without food



Metabolism and weight over time in *Lycosa lenta* (Anderson 1974)

Slow Metabolism

- Spiders can survive for months without food
- But might not be all bad….
  - Superfluous killing
  - Spiders can kill 50x more prey than they eat
    (Riechert and Lockley 1984, Annu. Rev. Entomol.)
  - Spider can regulate their metabolism and ride out periods of low pest density

Local extinction-reinvasion paradigm

Removal of Spiders Increases Crop Damage

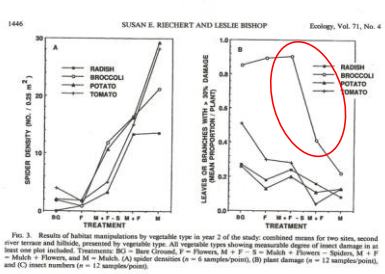


FIG. 3. Results of habitat manipulations by vegetable type in year 2 of the study: combined means for two sites, second river terrace and hillside, presented by vegetable type. All vegetable types showing measurable degree of insect damage in at least one plot included. Treatments: BG = Bare Ground, F = Flowers, M + F − S = Mulch + Flowers − Spiders, M + F = Mulch + Flowers, and M = Mulch. (A) spider densities (n = 6 samples/point), (B) plant damage (n = 12 samples/point), and (C) insect numbers (n = 12 samples/point).

BG = bare ground; F = flowers; M+F-S = mulch + flowers w/o spiders; M+F = mulch + flowers; M = mulch

Types of Biocontrol

1. Classical
   - ✖ **1. Ease of manipulation** (storage, shipping, mass rearing, release, integration)
   - **2. Climatic/habitat suitability**
   - ✖ **3. Host/prey specificity**
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~~1. Classical~~

~~2. Augmentation~~

3. Conservation

How to Conserve Spiders

- Use mulch for protection & humidity
- Provide (or not remove) sites for web attachments or retreats – crates, tall plants, hay, stakes
  - Bales of hay used in Chinese rice fields for 2000 years

- Leave plants & untilled areas for overwinter refuge
- Grow flowers
- **Achieve niche complementarity!**
- Minimize pesticides or spray during midday

Are spiders dangerous (to humans)?

Medically Important Spiders

Range of recluse (genus Loxosceles) spiders in the United States

Brown Recluse - *Loxosceles reclusa*

Symptoms of bite: mild reddening to large necrotic ulcers; in rare cases (<1%) destroys red blood cells, causes intra-vascular coagulation, renal failure, and death in 12-30 hrs (mostly in children)

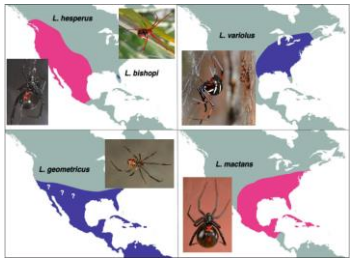
Most systemic effects chills/sweating and malaise

Medically Important Spiders

Widows - *Latrodectus* spp.

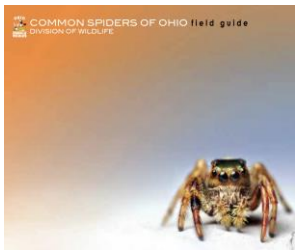
Causes release of neurotransmitters and prevents resorption

Symptoms of bite: pain (local, radiating, or specific to back, chest, and abdomen), sweating, and less commonly fever, hypertension, paralysis, cardiac effects, renal failure



Spiders of Ohio

Ohio Spider Survey Project
Dr. Richard Bradley - OSU



Mission: Enhance the understanding of Ohio Spiders

Promote public education

Conduct surveys & create database

Develop materials for the public

ID-ing spiders: coloration


Lycosidae


Agelenopsis


Pisaurina


Tibellus (Philodromidae)


Cupiennius salei


Zora hespera (Miturgidae)

ID-ing spiders: webs

Orb-weavers

Tetragnathidae
Long-jawed orb-weavers

Araneidae Orb-weavers

Uloboridae Cribellate orb-weavers

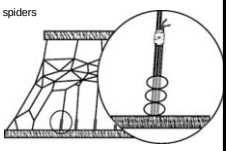
Sheet web weavers

Linyphiidae Lace and doily spiders

Agelenidae Grass spiders or funnel webs

Cobweb weavers

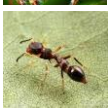
Theridiidae or comb-footed spiders



Pholcidae Daddy-long-legs or cellar spiders

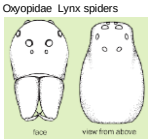
ID-ing spiders: eyes!

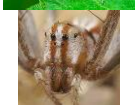
Salticidae Jumping spiders



Lycosidae Wolf spiders

Oxyopidae Lynx spiders





Gestalt appearance: Thomiside

- "Crab" spiders
- Often found on flowers
- Sexual size dimorphism
- Some can change color

Hard to ID sac spiders

- Miturgidae, Clubionidae, Gnaphosidae, Liocranidae, Corinnidae, Eutichuridae, Trachelidae
- "Sac" or "ground" spiders
- Similar morphology: 8 eyes in two rows, 2 claws, stout spinnerets

Thank you!

Questions?