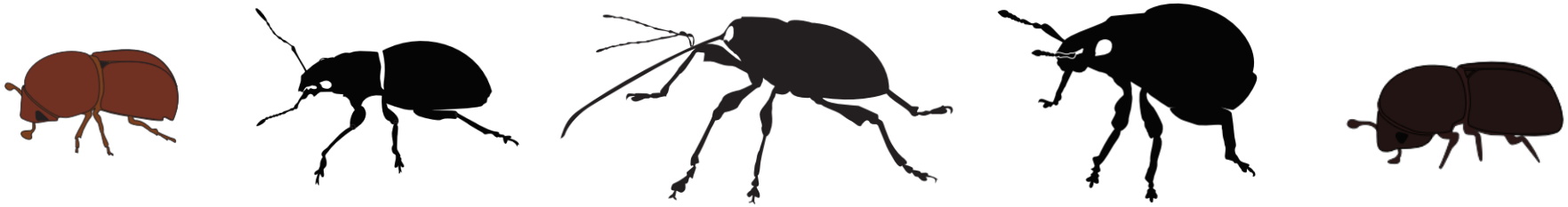
Evaluation of Entomopathogenic Nematodes to Manage Assorted Weevil Pests in Pecan



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Weevils (Curculionidae)

- 50,000+ described species
- Feed on plants of any terrestrial or freshwater habitat
- Can be found feeding on any parts of a plant.
- Several are major pests in agriculture and forestry.

Background

Foliage Feeders

Two-banded Japanese weevil

Nut Feeders

Pecan weevil

Trunk & Root Feeders

Fuller Rose Weevil,

Ambrosia Beetles

(Shapiro et al, 2013, University of Georgia 2017)

What is IPM?

Integrated Pest Management is a science-based approach that combines a variety of techniques. By studying their life cycles and how pests interact with the environment, IPM professionals can manage pests with the most current methods to improve management, lower costs, and reduce risks to people and the environment.

IPM tools include:

- Alter surroundings
- Add beneficial insects/ organisms
- Grow plants that resist pests
- Disrupt development of pest
- Prevention of pest problem developing
- Disrupt insect behaviors
- Use pesticides

1 IDENTIFY/ MONITOR

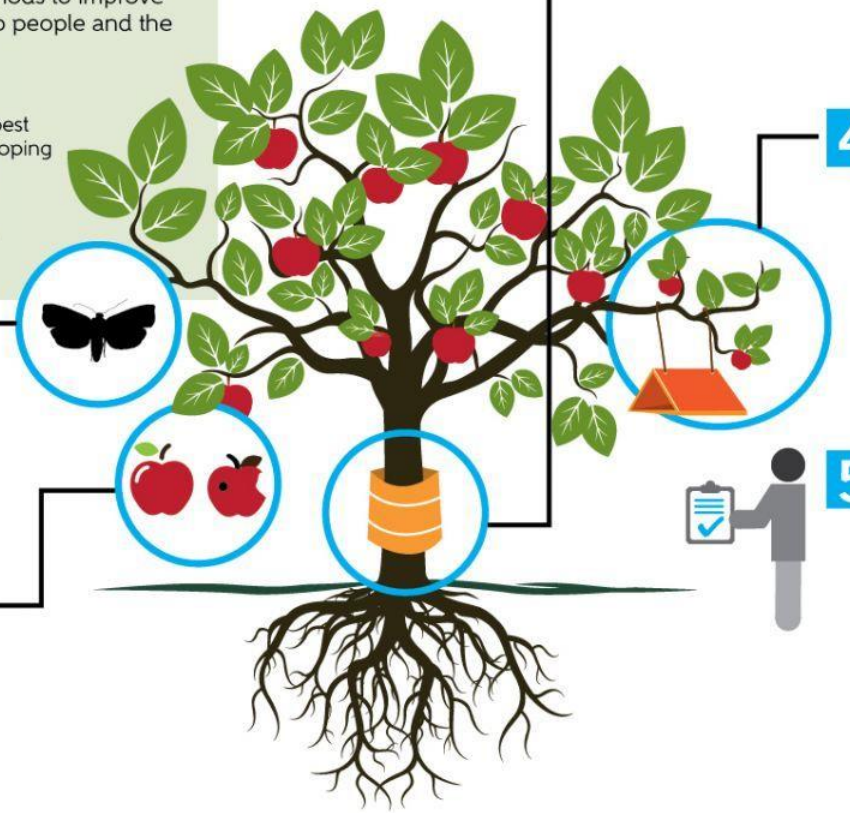
Determine the causal agent and its abundance (contact your local extension agent for help).

2 EVALUATE

The results from monitoring will help to answer the questions: Is the pest causing damage? Do we need to act? As pest numbers increase toward the economic threshold further treatments may be necessary.

3 PREVENT

Some pest problems can be prevented by using resistant plants, planting early, rotating crops, using barriers against climbing pests, sanitation, and sealing cracks in buildings.



4 ACTION

IPM uses multiple tools to reduce pests below an economically damaging level. A careful selection of preventive and curative treatments will reduce reliance on any one tactic and increase likelihood of success.

5 MONITOR

Continue to monitor the pest population. If it remains low or decreases, further treatments may not be necessary, but if it increases and exceeds the action threshold, another IPM tool should be used.

WHERE CAN YOU PRACTICE IPM?

Buildings and Homes:
Inspect, identify pests, keep pests out, clean to deny pests food and water, vacuum, trap, or use low-risk pesticides.

Farms:
Check for pests/pest damage regularly, identify accurately, choose pest-resistant plant varieties, encourage/introduce beneficial insects, time planting to avoid pests, and if needed use low-risk pesticides.

Managed Natural Systems:
Identify the pest and use management options that have minimal risks to pollinators, humans, and pets.

The Entomological Society of America is the largest organization in the world serving the needs of entomologists and other insect scientists. ESA stands as a resource for policymakers and the general public who seek to understand the importance and diversity of earth's most diverse life form—insects. Learn more at www.entsoc.org.

Entomopathogenic Nematodes (EPNS)

- For biocontrol purposes – two genera (*Steinernema & Heterorhabditis*)
- Currently > 115 species (only 21 heterorhabditids)
- >20 producers worldwide.

Symbiotic Bacteria

- Bacteria are the primary killing agents & produce antibiotic defenses to protect against other microbial invaders
- Nematodes also contribute to killing the host, suppress the immune system, and act as vectors for the bacteria (bacteria cannot survive in the soil without the nematodes)
- Specificity: Each nematode associates with one bacterium, but each bacterium can associate with more than one nematode

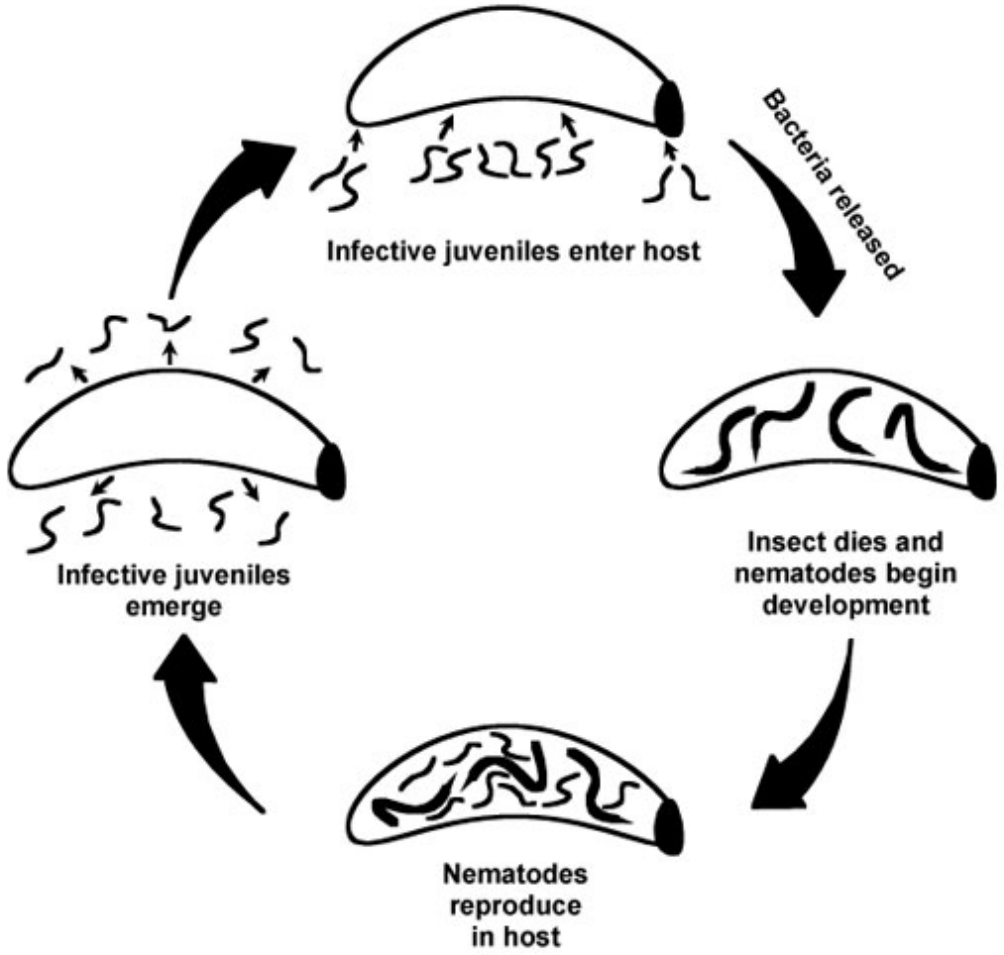


Diagram by Bill Joyner, USDA-ARS

Pest, Common name	Pest, Scientific name	Nemas
Artichoke plume moth	*Platyptilia carduidactyla*	Sc
Banana moth	*Opogona sachari*	Hb, Sc
Banana root borer	*Cosmopolites sordidus*	Sc, Sf, Sg
Black cutworm	*Agrotis ipsilon*	Sc
Black vine weevil	*Otiorhynchus sulcatus*	Hb, Hm
Borers	*Synanthedon* spp.	Hb,Sc, Sf
Codling moth	*Cydia pomonella*	Sc
Corn earworm	*Helicoverpa zea*	Sr
Diamondback moth	*Plutella xylostella*	Sc
Fungus gnats	Diptera: Sciaridae	Sf, Hb
Japanese beetle	*Popillia japonica*	Hb, Sg
Leafminers	*Liriomyza* spp.	Sc
Mole crickets	*Scapteriscus* spp.	Sc, Sr, Ss
Plum curculio	*Conotrachelus nenuphar*	Sr

Shapiro-Ilan & Grewal (2008). Hb=*H. bacteriophora*, Hm= *H. marelata*, Sc=*S. carpocapsae*, Sf=*S. feltiae*, Sg=*S. glaseri*, Sr=*S. riobrave*, Ss=*S. scapterisci*.

Background

- Benefits of using Entomopathogenic Nematodes for weevil management:
  - Easy to rear and maintain.
  - Environmentally friendly form of pest control.
- Drawbacks:
  - Environmentally sensitive (soil moisture, temperature, UV)
  - Can be costly if grower needs to constantly reapply nematodes.
- Approaches
  - Strain improvement & stability
  - Improving mass production
  - Improving formulation
  - Improving application technology
  - Enhanced understanding of biology/ecology

Objective 1

- To compare the effectiveness of two commercially available strains of EPNs to two novel persistent strains (E. Shields, Cornell University) of EPNs on pecan weevils and other weevils in pecans in Oklahoma and Georgia

Commercial	Persistent Strains
SfSn (*Steinernema feltiae*) ScAll (*Steinernema carpocapsae*)	NY04 (*Steinernema feltiae*) NY01 (*Steinernema carpocapsae*)

Background

Foliage Feeders

Two-banded Japanese weevil

Nut Feeders

Pecan weevil

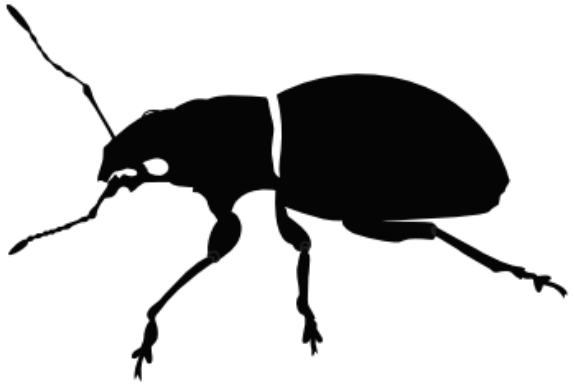
Trunk & Root Feeders

Fuller Rose Weevil

(Shapiro et al, 2013, University of Georgia 2017)

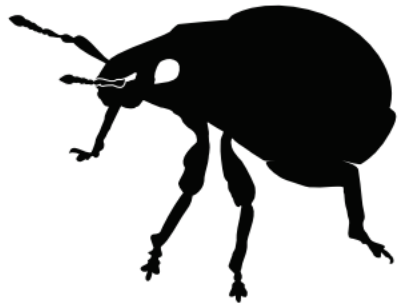
Fuller Rose Weevil

- Originally from South America, now widespread in North America
- Widespread, feed on many different plant species
- Parthenogenetic (All female population)
- Larvae feed on roots
- Adults feed on leaves, shoots, and flowers
- Feeds on pecan but pest potential is unknown.



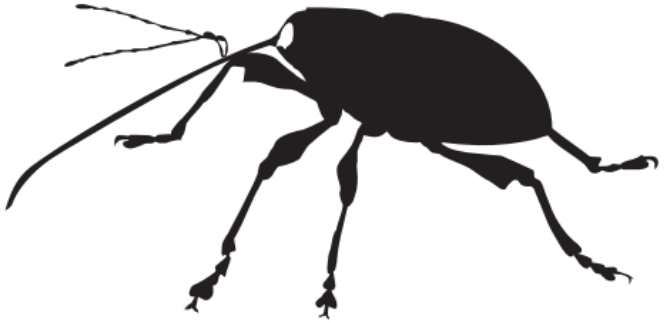
Two-Banded Japanese Weevil

- Widespread on the East Coast down to Florida
- Adults and larvae feed on 100 different host plants.
- Parthenogenetic (All female population)
- Larvae feed on roots
- Adults feed on leaves
- Feeds on pecan but pest potential is unknown.



Pecan Weevil

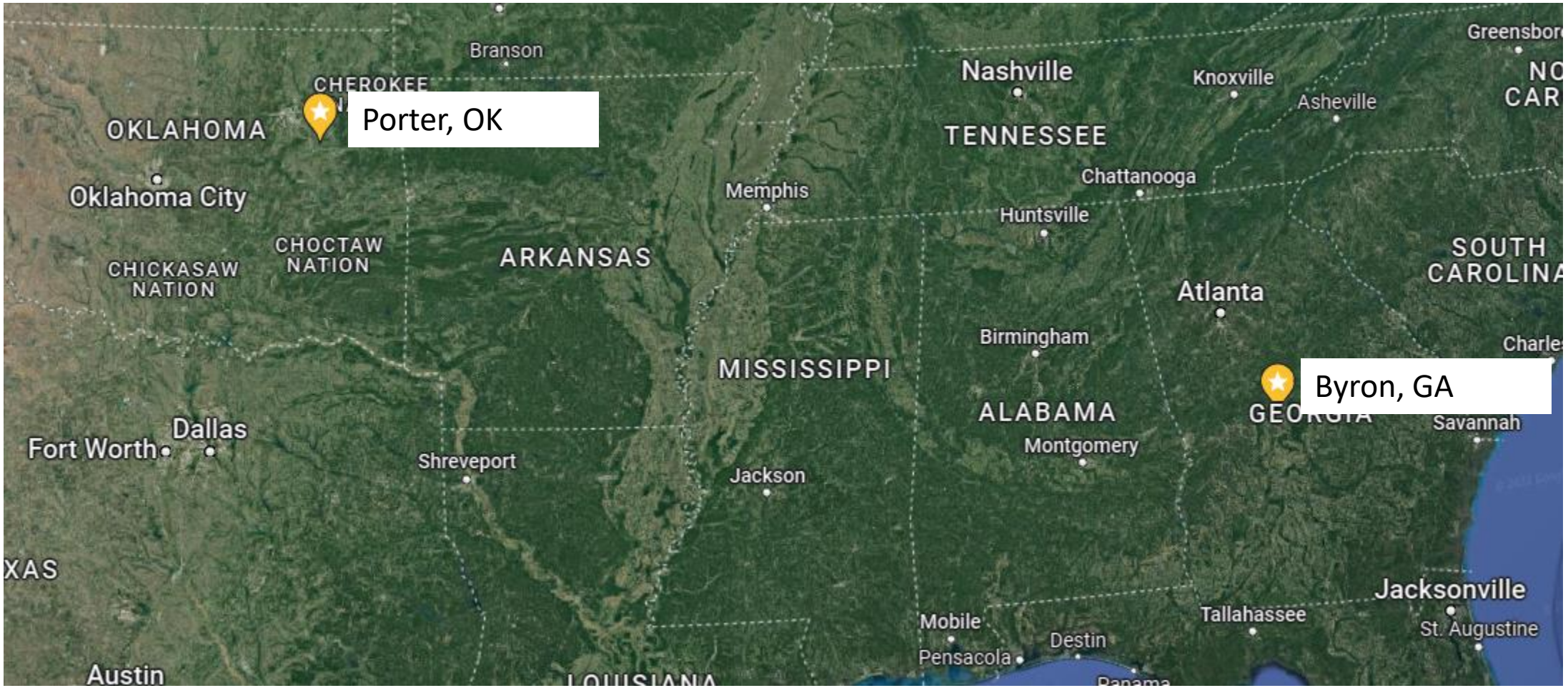
- Emerge from the soil in late summer – early fall (July – September).
- Adults feed on pecan nut kernels prior to shell hardening.
- Females will lay eggs onto the kernel and larvae will feed on the kernel after hatching.
- Key pest of pecan, can damage yield during severe outbreaks.



Background

- Benefits of using Entomopathogenic Nematodes for weevil management:
  - Literature supports virulence on pecan weevil (Nyczepir et al. 1992; Shapiro-Ilan and Gardner 2012; Shapiro-Ilan et al. 2017)
  - Easy to rear and maintain.
  - Environmentally friendly form of pest control when used responsibly.
  - **Potential for lower cost due to lower rate/infrequent application (~$3/acre vs $50/acre) – Persistent vs Commercial strain**
- Drawbacks:
  - Environmentally sensitive (soil moisture, temperature, UV)
  - Can be costly if grower needs to constantly reapply nematodes.

Methods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Byron, GA
Branson
CHEROKEE
OKLAHOMA
Oklahoma City
CHICKASAW NATION
CHOCTAW NATION
ARKANSAS
Memphis
MISSISSIPPI
Nashville
TENNESSEE
Knoxville
Asheville
Chattanooga
Huntsville
Atlanta
Birmingham
ALABAMA
Montgomery
Dallas
Fort Worth
Shreveport
Jackson
Savannah
Jacksonville
Tallahassee
St. Augustine
Mobile
Pensacola
Destin
Austin
SOUTH CAROLINA

Methods (GA)

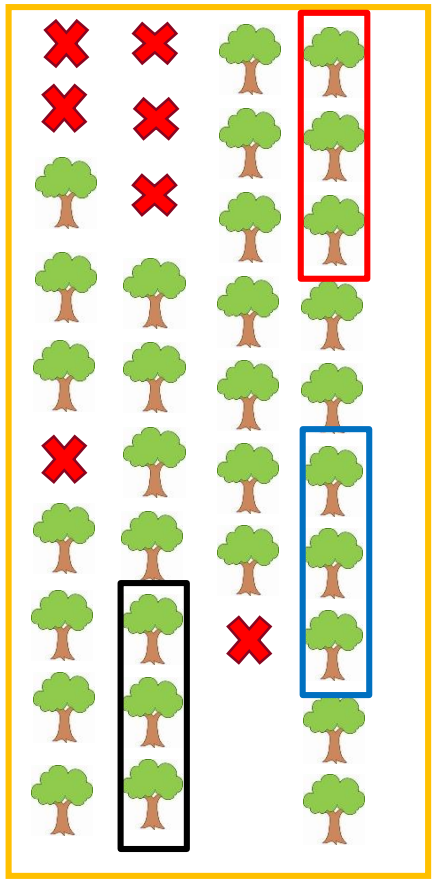
= Tree Present

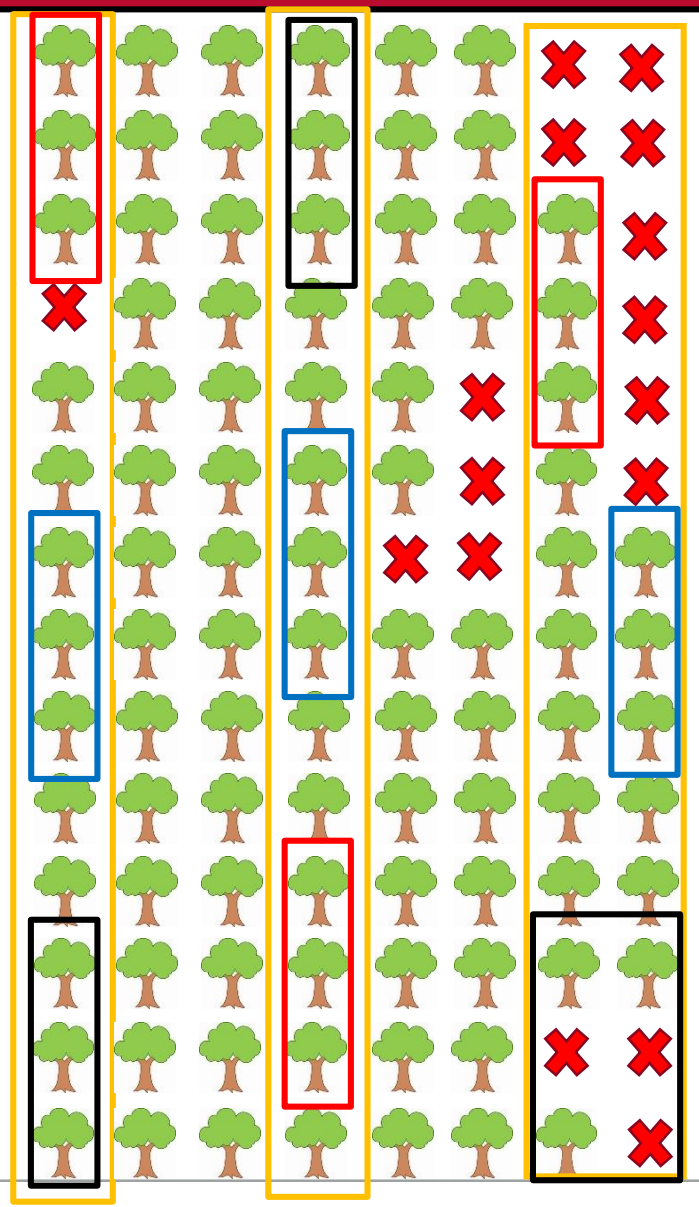
= Tree Absent

= Persistent Strains

= Commercial Strains

= Water Only Control





Methods (OK)

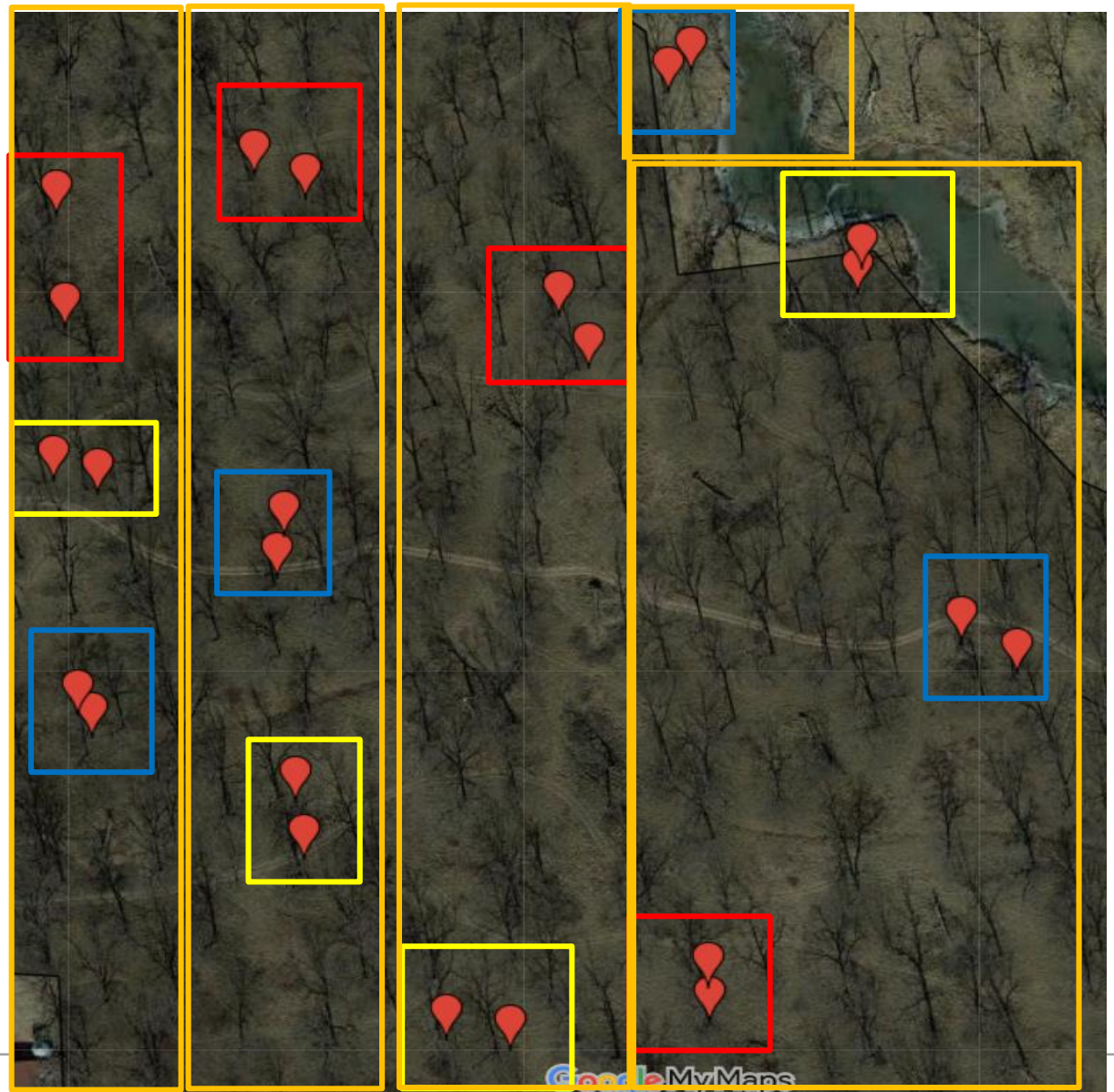
= Tree Present

= Tree Absent

= Persistent Strains

= Commercial Strains

= Water Only Control



Methods

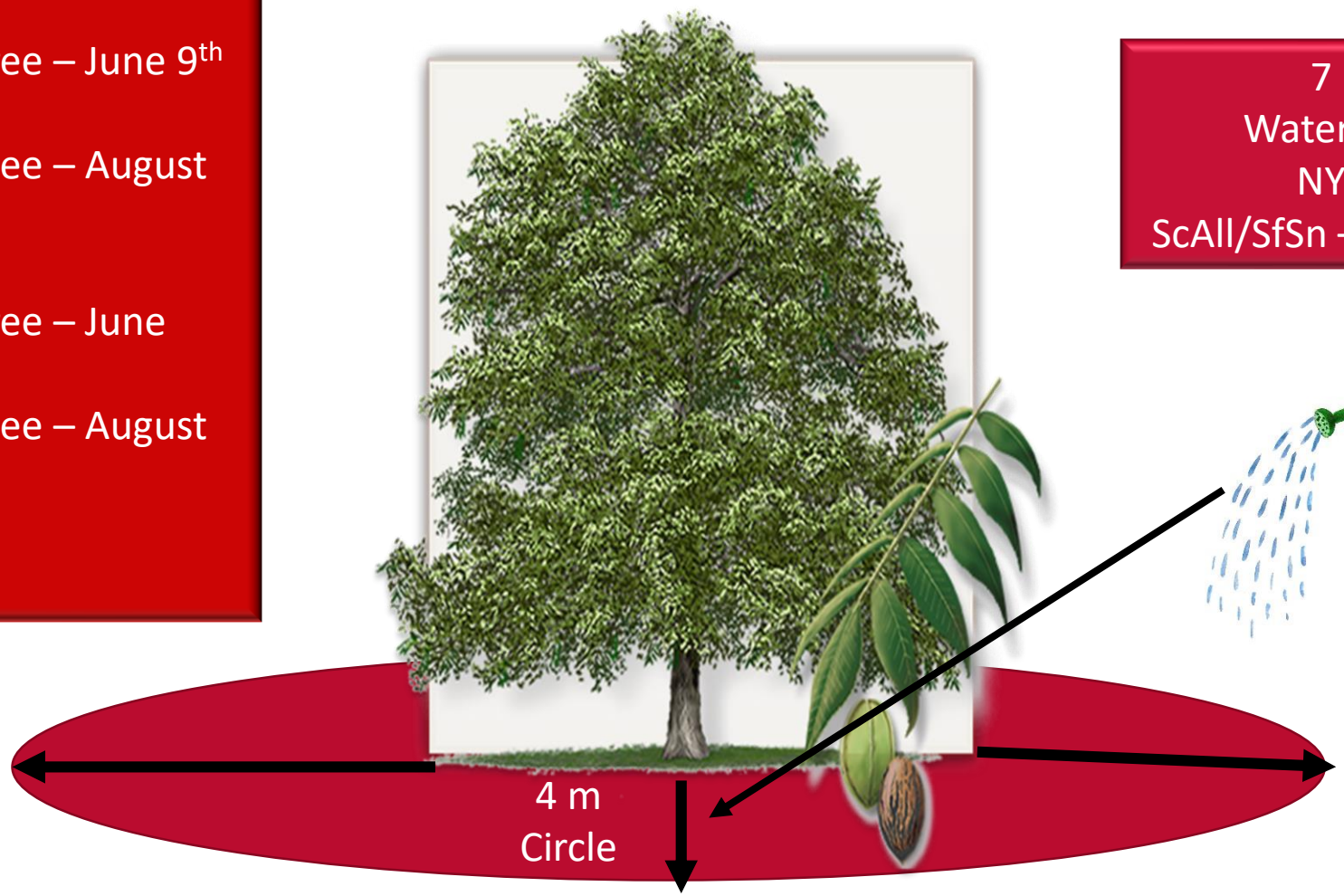
Applications (Low-Rate):

Georgia

- ~125,000 ijs per/tree – June 9th 2022
- ~500,000 ijs per/tree – August 16th 2022

Oklahoma

- ~125,000 ijs per/tree – June 15th 2022
- ~500,000 ijs per/tree – August 25th 2022



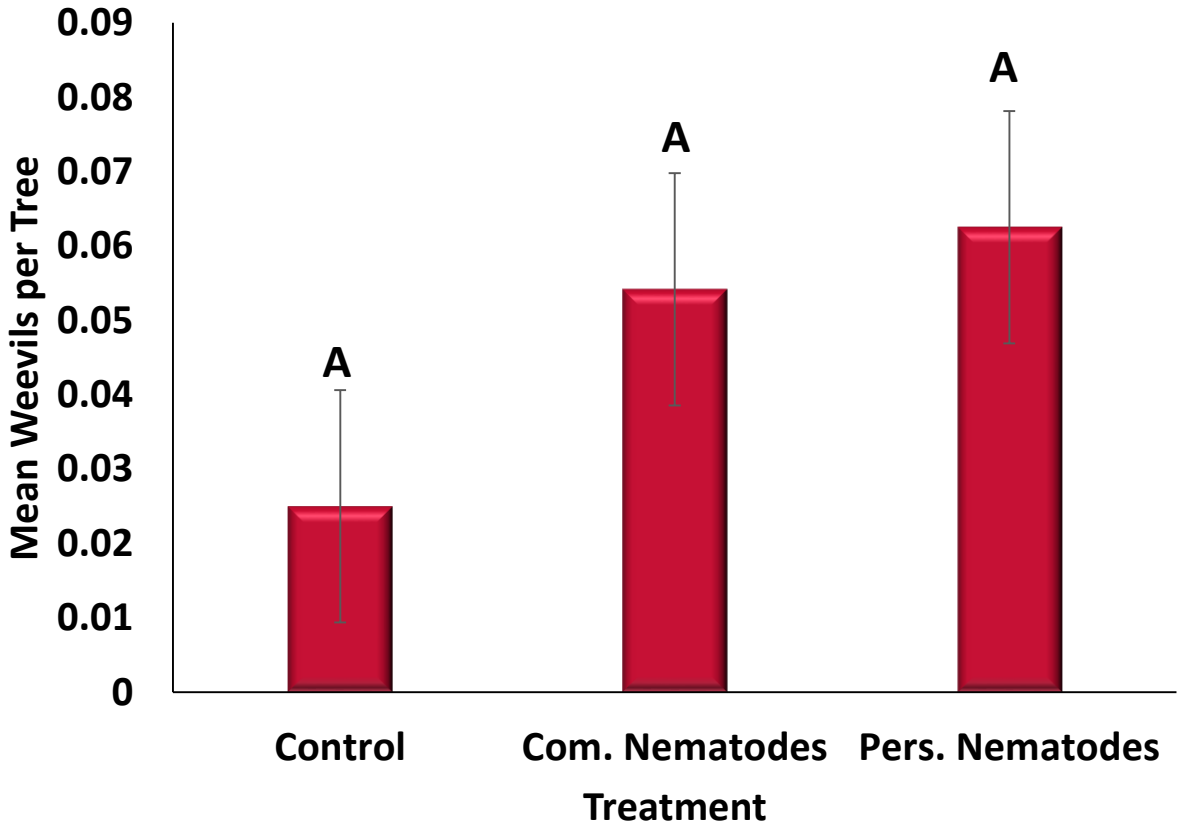
7 liters/water
Water Only – Control
NY – Persistent
ScAll/SfSn – Commercial strains

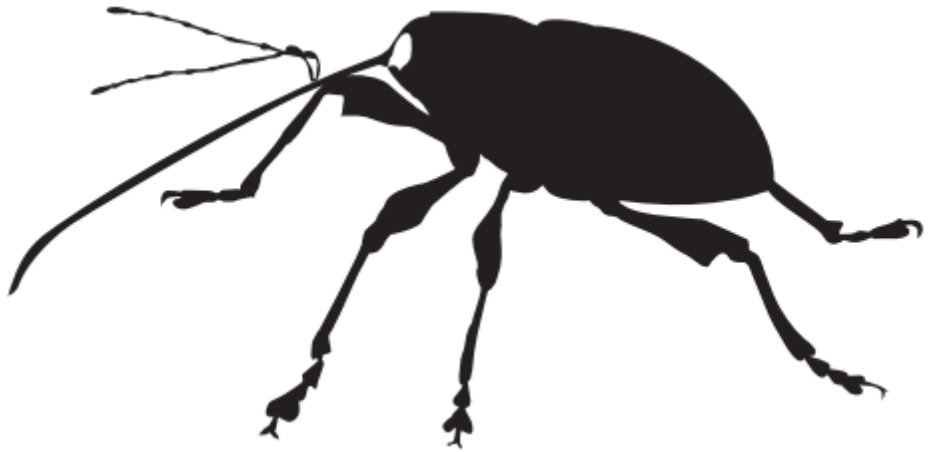
Methods

3 times a week

Results (Georgia)
Pecan Weevil

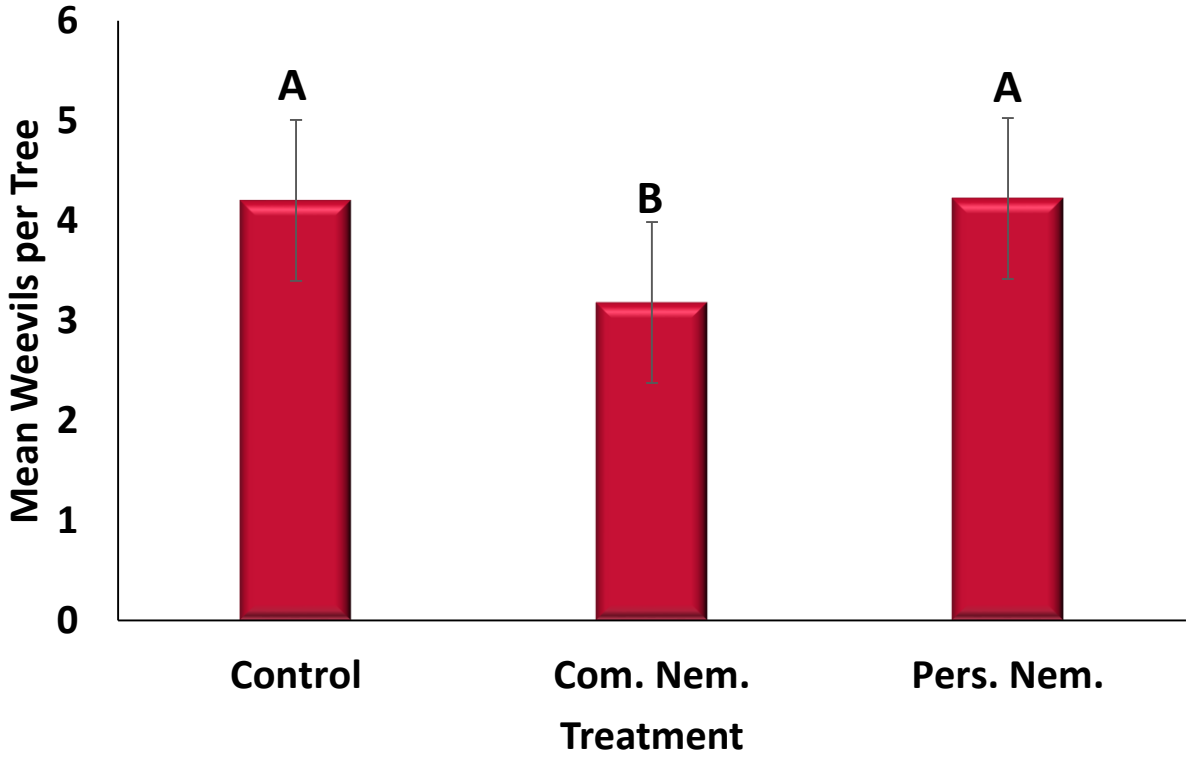
Field Collection

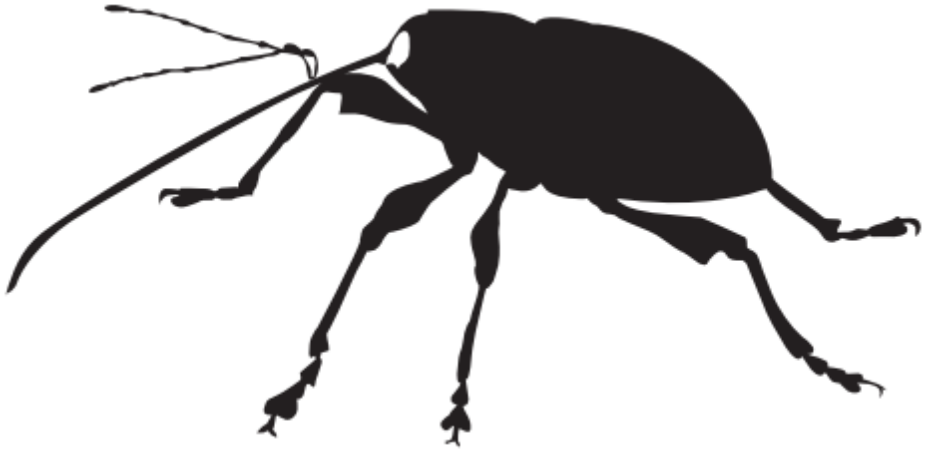




Results (Oklahoma)
Pecan Weevil

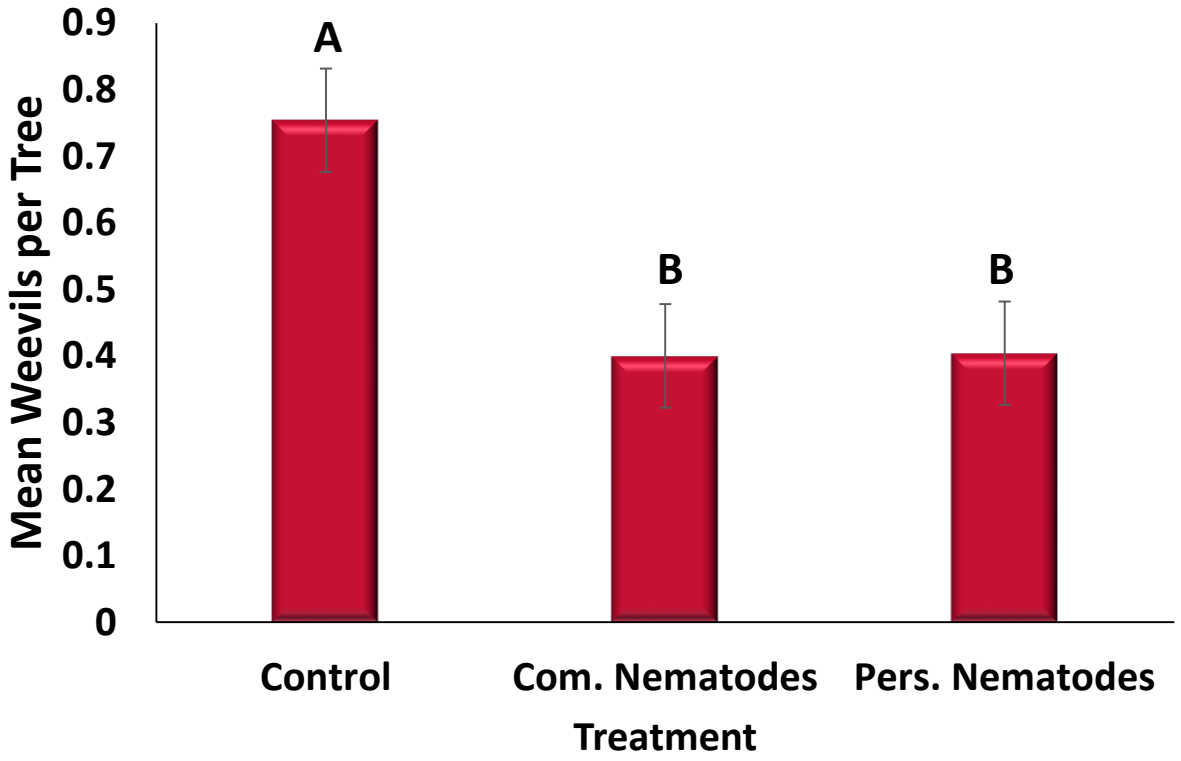
Field Collection

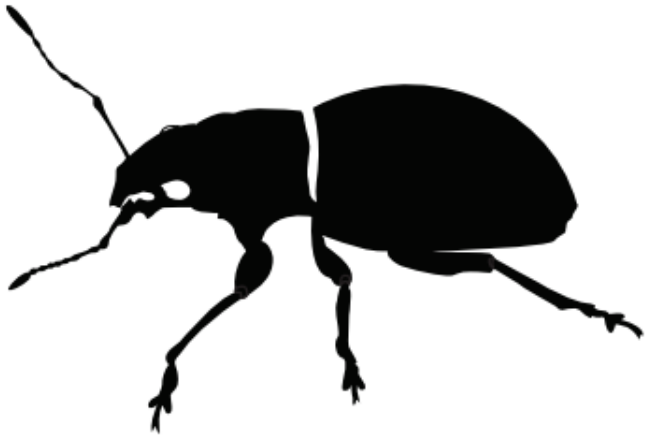




Results (Georgia)
Fuller Rose Beetle

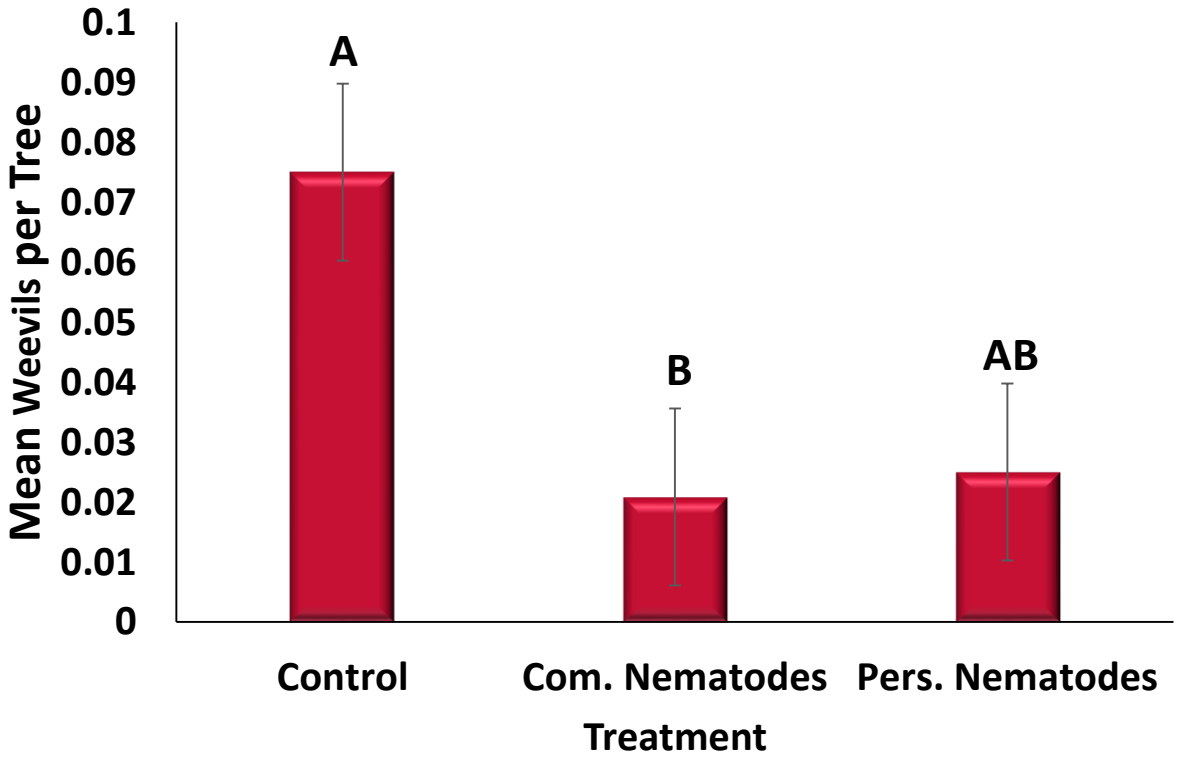
Field Collection

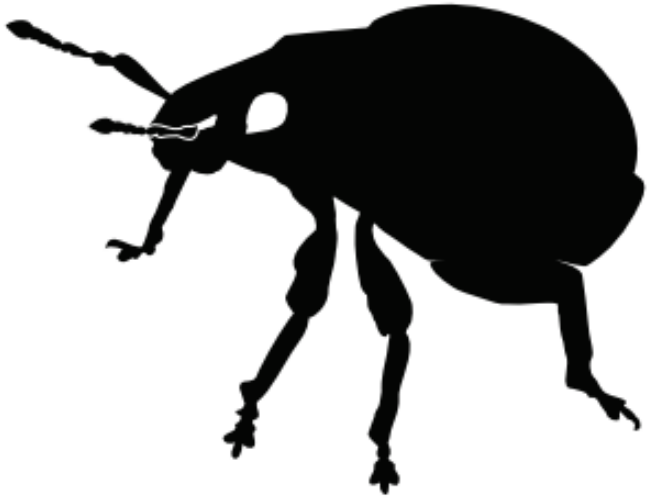




Results (Georgia)
Two-Banded Japanese Weevil

Field Collection





Discussion/Summary

	Georgia		Oklahoma	
	Comm.	Pers.	Comm.	Pers.
Pecan Weevil 	−	−	+	−
Fuller Rose Beetle 	+	+		
Two-Banded Weevil 	+	−		

- Low pecan weevil numbers in Georgia.
- Stronger subterranean control?
- Commercial nematodes may serve as effective tools for non-target weevil management.
- Future? Does the persistent strain strike back?
  - Lab Results?

Background

Foliage Feeders

Nut Feeders

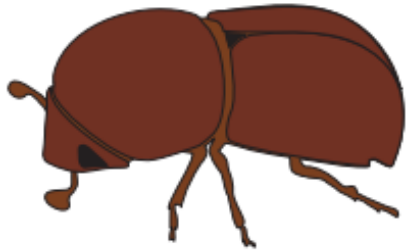
Trunk & Root Feeders

Ambrosia Beetles

(Shapiro et al, 2013, University of Georgia 2017)

2nd Objective

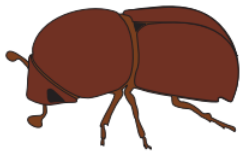
- Evaluate the effects of entomopathogenic nematodes (EPNs) and fungi on two major ambrosia beetle species: Granulate ambrosia beetle and black stem borer.



Ambrosia Beetles

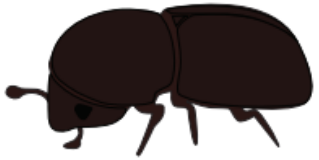
- Subfamily of small wood-boring weevils.
- 3,000+ species
- Often attack dead or stressed trees colonizing the xylem.
- Farm a symbiotic ambrosia fungus that serves as a primary food source for larvae.

Granulate Ambrosia Beetle



- Most common species found in pecan in the southeast.
- Native to tropical and sub-tropical East Asia. Now present in North America, Africa, Papua New Guinea, Central America, and Europe.
- Generalist, often attacks waterlogged or freshly dead wood.
- Pests in agricultural and urban plants as well as stored lumber.

Black Stem Borer



- Replaces granulate ambrosia beetle in northern areas.
- Native to East Asia, especially Japan. Now present in North America and Europe.
- Generalist, often attacks small flood-stressed or irrigated trees.
- Pests in nurseries.

Background

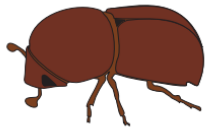
- Benefits of using Entomopathogenic Nematodes for ambrosia beetle management
  - Easy to rear and maintain.
  - Environmentally friendly form of pest control.
- Drawbacks:
  - **Ambrosia beetle susceptibility to EPNs has not been studied yet.****
  - Environmentally sensitive (soil moisture, temperature, UV).
  - Can be costly if grower needs to constantly reapply nematodes.

Methodology

- **1 g Sawdust**
- **2 ml of water**
- **x252 cups per trial**

Methodology

X1



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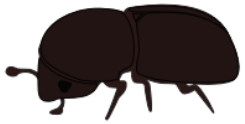

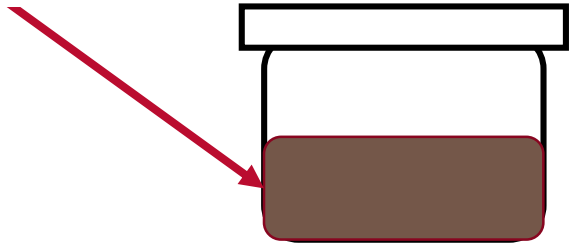

- **1 g Sawdust**
- **2 ml of water**
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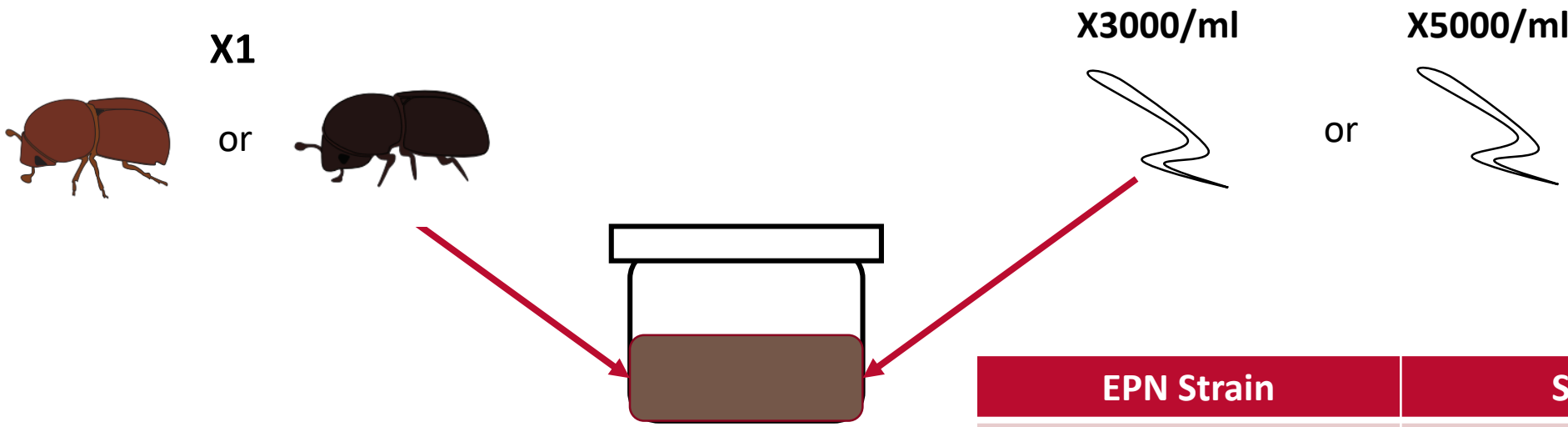
Methodology

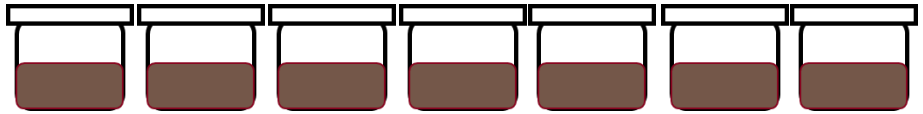


- **1 g Sawdust**
- **2 ml of water**
- **x252 cups per trial**

EPN Strain	Species
ScAll	*Steinernema carpocapsae*
Sr355	*Steinernema riobrave*
HiHom1	*Heterorhabditis indica*
HBVS	*Heterorhabditis bacteriophora*

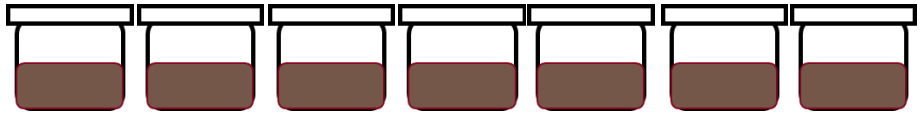
Methodology

Control



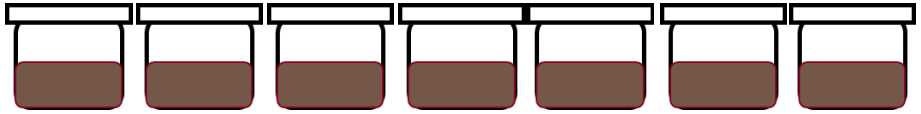
x3000

x5000



S. carpocapsae

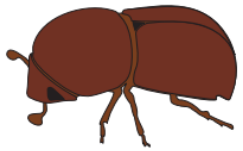
S. riobrave



H. indica

H. bacteriophora

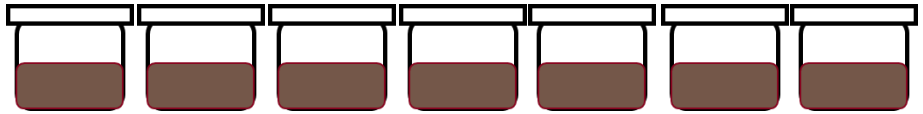
2, 3, 5, 8, 11, 14 Days



X3 Trials

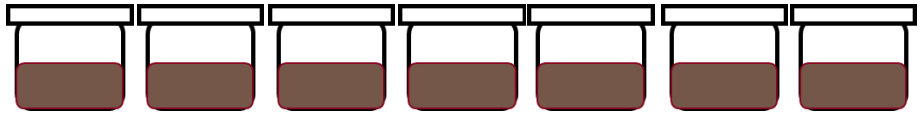
Methodology

Control



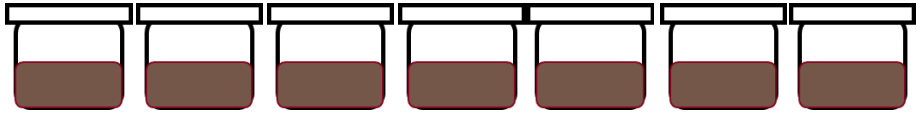
x3000

x5000



S. carpocapsae

S. riobrave



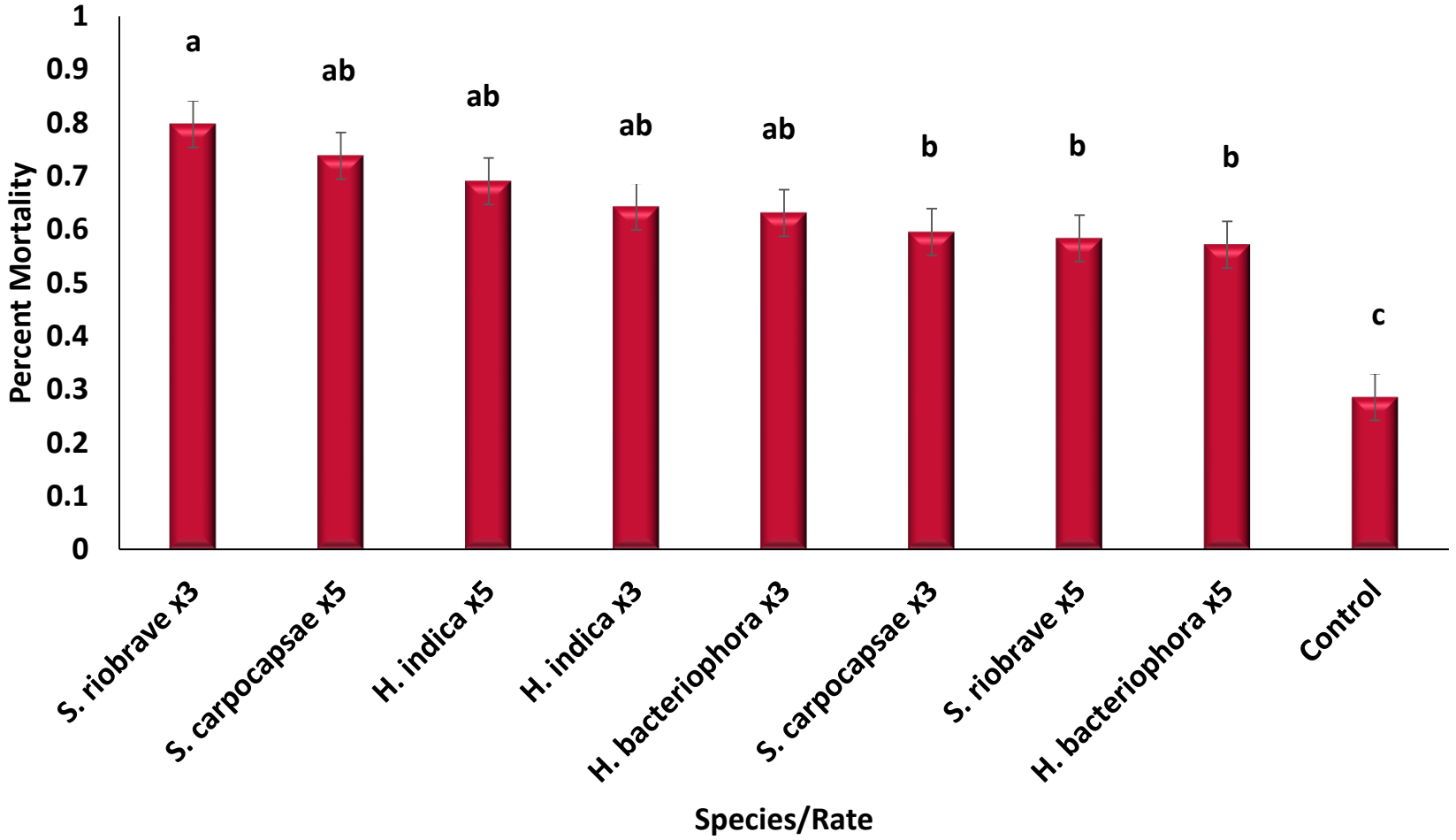
H. indica

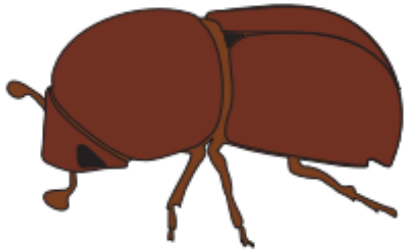
H. bacteriophora

2, 3, 5, 8, 11, 14 Days

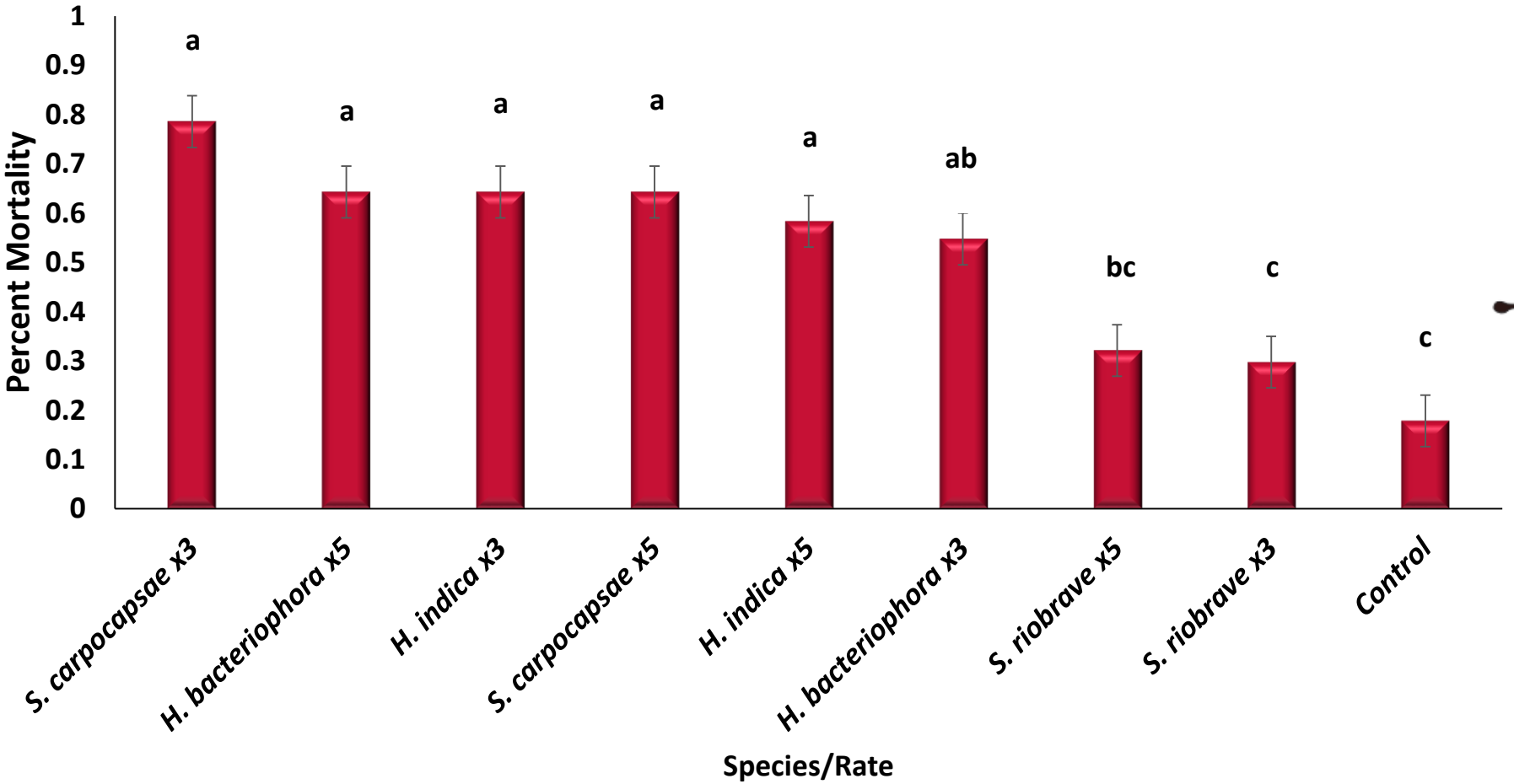
X3 Trials

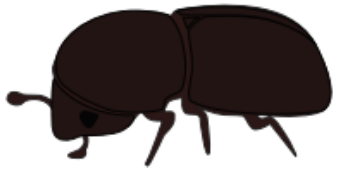
Granulate Ambrosia Beetle
14-Day Mortality





Black Stem Borer
14-Day Mortality



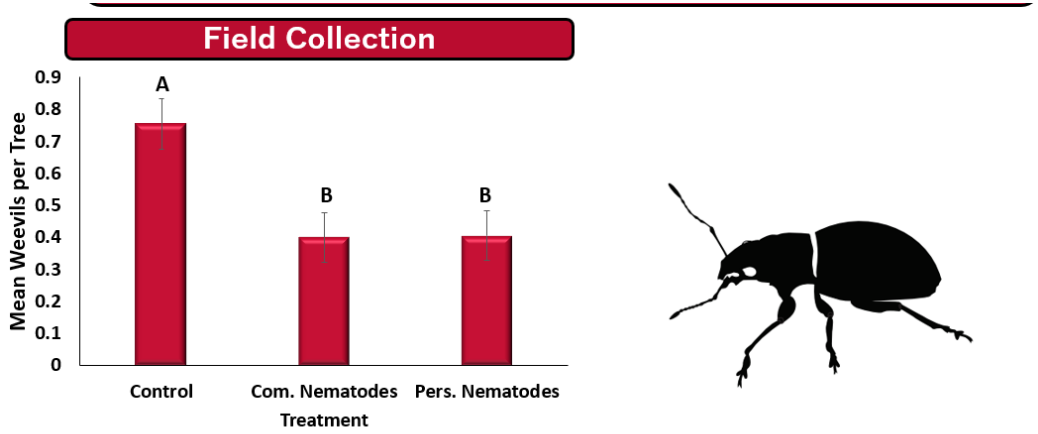


Discussion/Summary

- There is evidence for EPNs as a biological control option for ambrosia beetle in the lab.
- Difference may exist to determine which strains are effective against certain species of ambrosia beetle
    - Granulate AB = *S. carpocapsae,* Black stem borer = *S. riobrave*
- Future?
    - Continue running nematode exposure studies in lab for both adults and larvae of both AB species (may include additional commercial EPNs (SfSN, SgVs) (Current)
    - Assess mobility of EPNs in pecan wood with and without EPN pheromones (Fall/Winter 2022)
    - Effects of EPN metabolite on ambrosia beetle fungus (Winter/Spring 2023)
    - EPN/AB field tests with improved formulations and boosters (pheromones) (Winter/Spring 2023)
    - Effects of endophyte on AB attacks in pecan (Spring 2023)

Take Home Messages

- Commercial nematodes can not only manage target pests but also other insects that may be feeding on pecans orchards.
- Persistent strain potential?



- EPNs have potential as a control options against ambrosia beetle.
- EPNs can be effective tools against a variety of a weevil pests in pecan.

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