The Continuing Struggle to Manage the Tenlined June Beetle

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Tenlined June Beetle

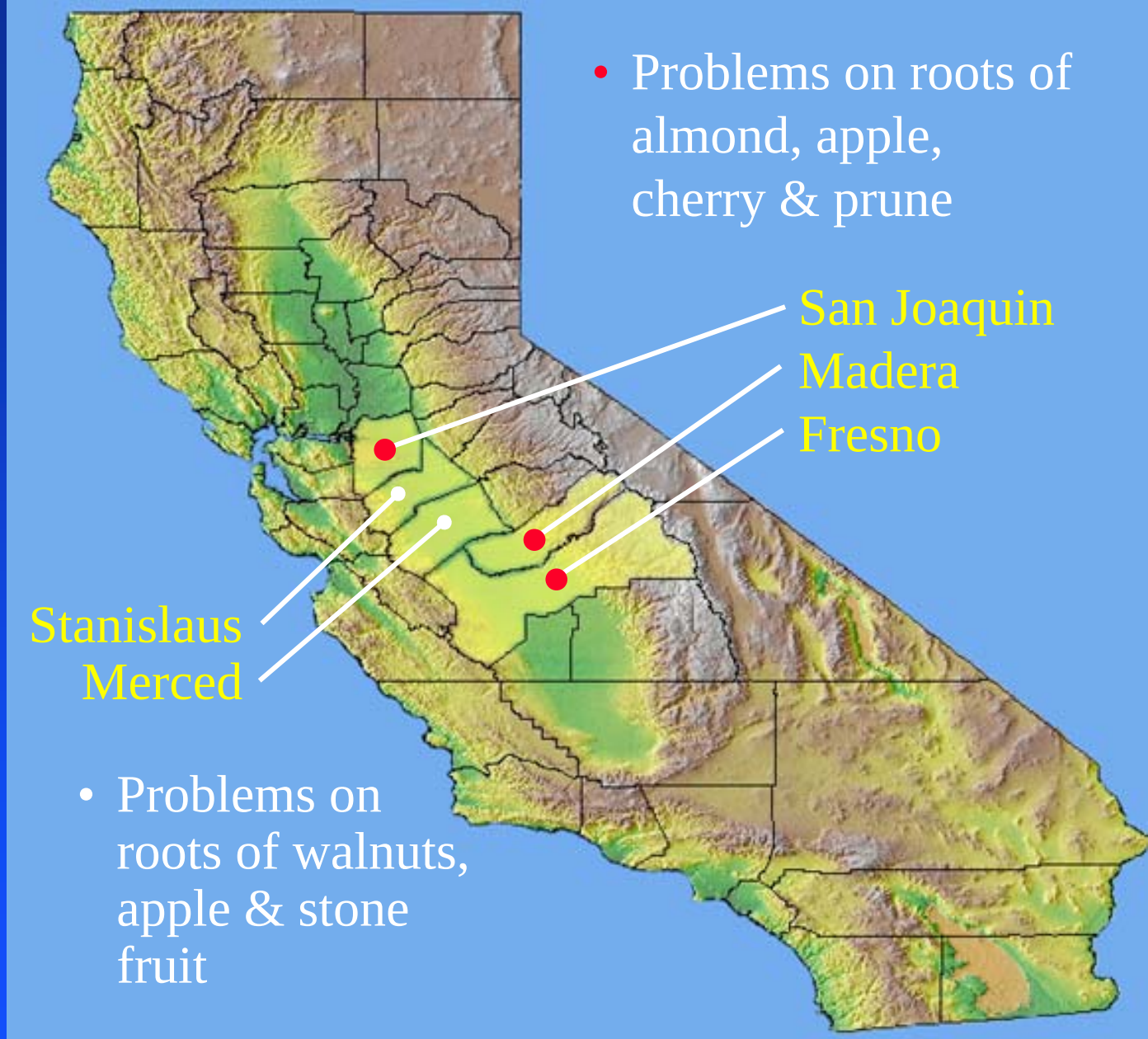
Polyphylla decemlineata or *Polyphylla sobrina?*

Tenlined June Beetle Life Stages

DISTRIBUTION OF THE PROBLEM

Tenlined June beetle grubs are a common problem in sandy soils. This pest is native to California. Grubs feed on tree roots and spend their entire immature life underground.

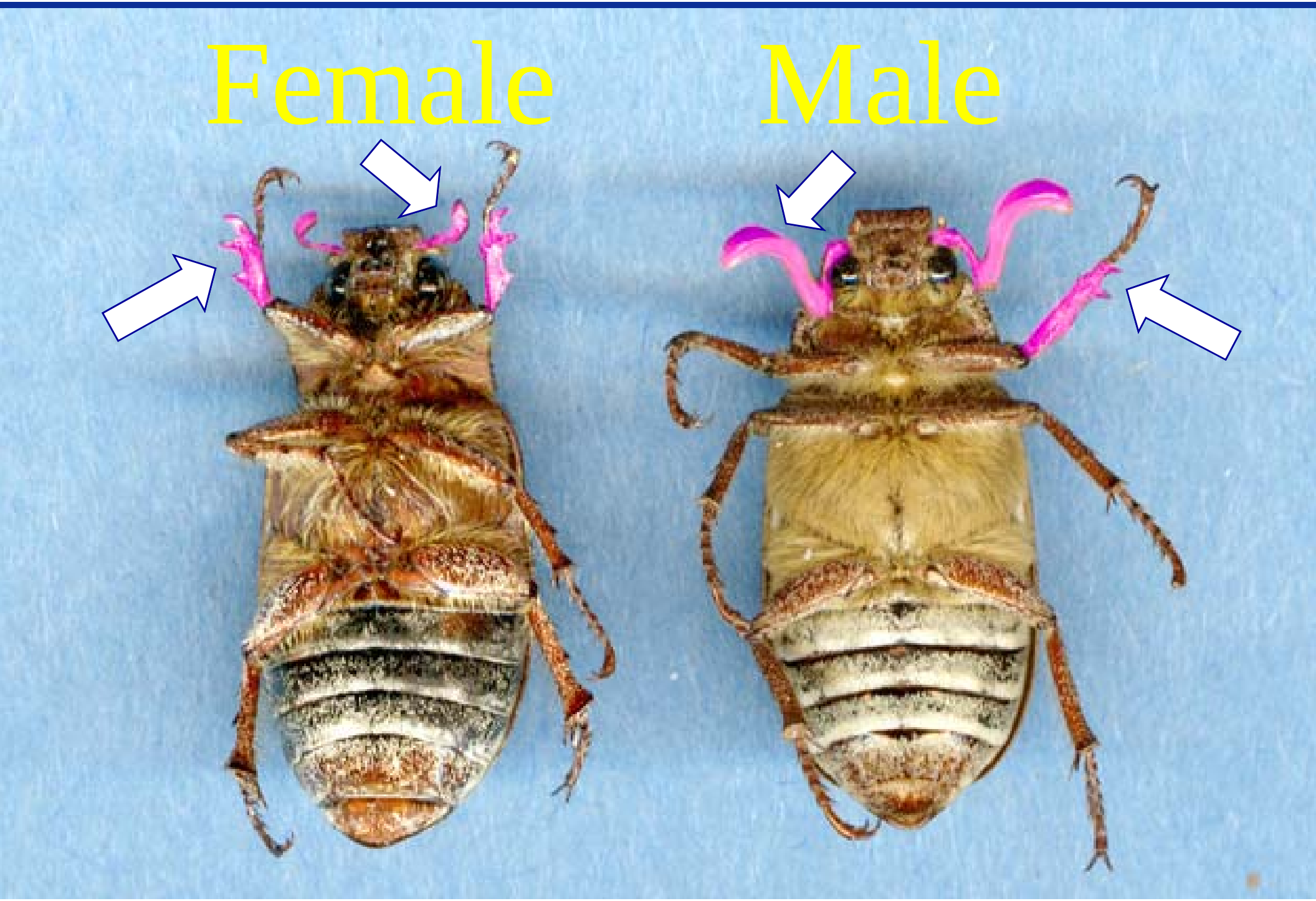
Many of California's agricultural lands are on sandy soils.



Presentation Objectives

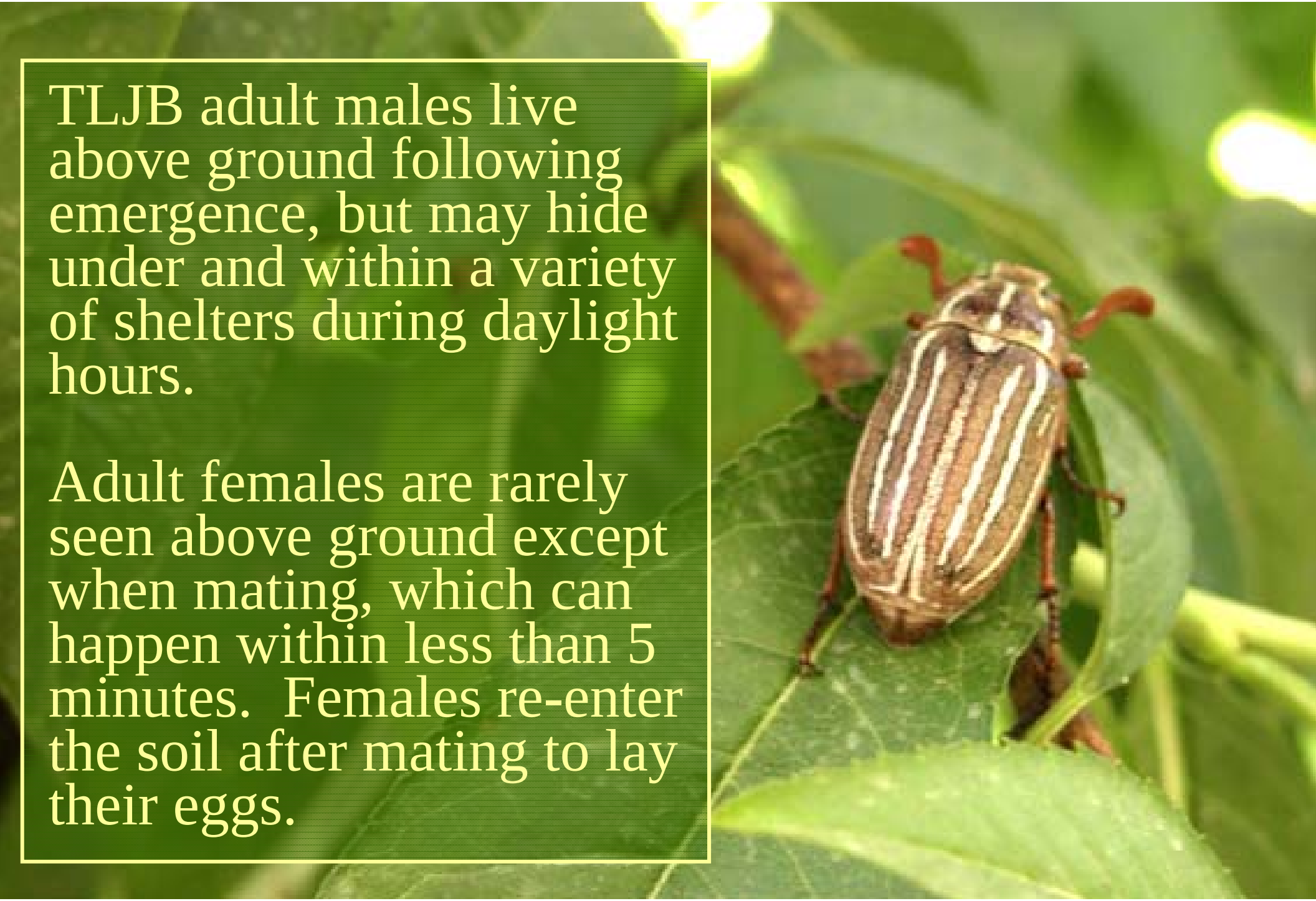
1) Discuss TLJB biology
2) Describe damage to infested trees
3) How to sample for TLJB
4) What are those mites doing on the adults & grubs?
5) What natural enemies exist
6) What pesticides kill the grubs
7) Getting the chemicals to the grubs

Female Male


Female
Male

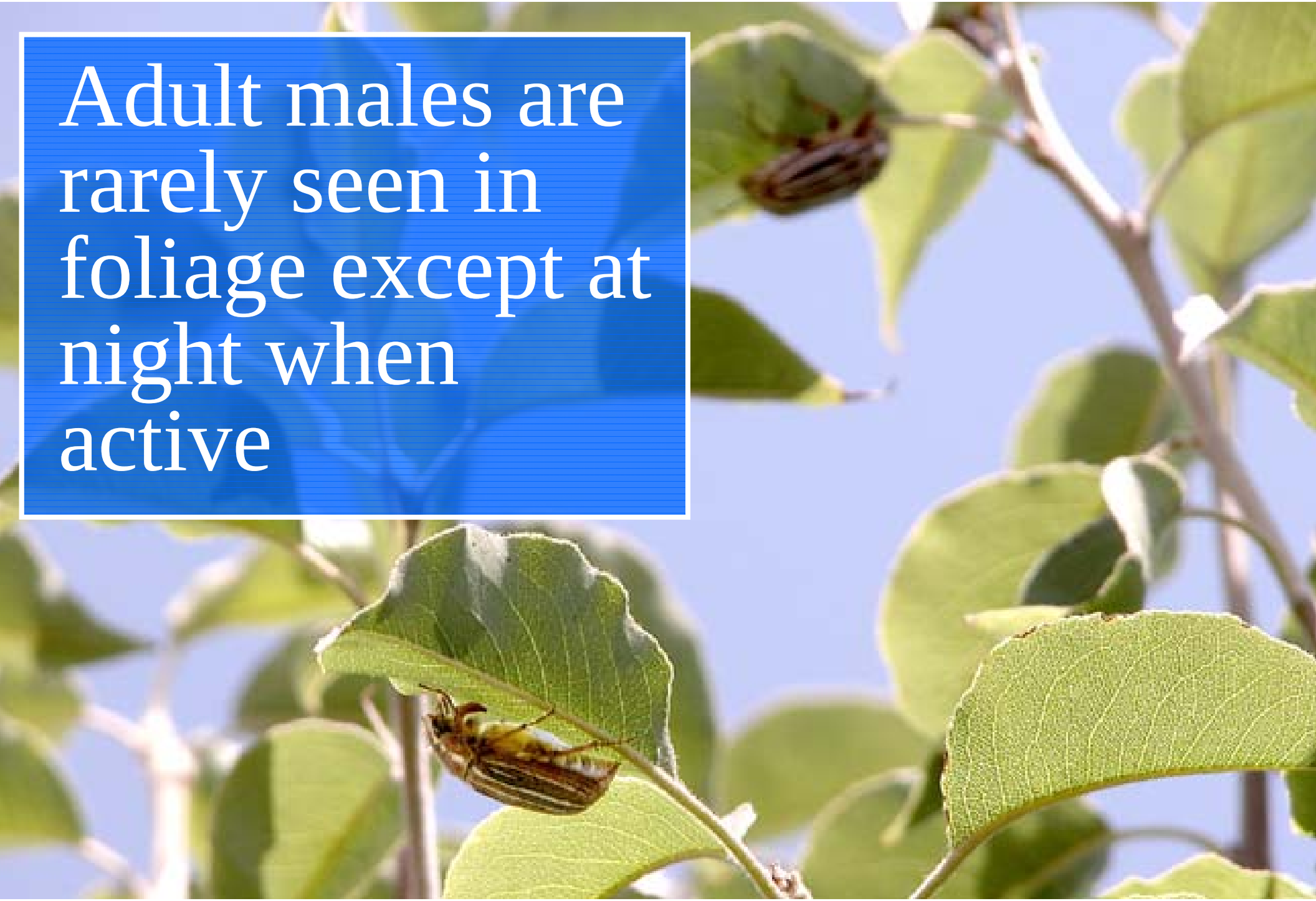
Adults produce an emergence hole when ascending to the soil surface


In areas with high beetle densities,
emergence holes may be quite common
Lack of holes does not
translate to zero beetles



TLJB adult males live above ground following emergence, but may hide under and within a variety of shelters during daylight hours.

Adult females are rarely seen above ground except when mating, which can happen within less than 5 minutes. Females re-enter the soil after mating to lay their eggs.


Adult males are rarely seen in foliage except at night when active

Who Flies?

- Both sexes
- But findings to date indicate that males coming to light traps outnumber females by 99 males to each female trapped.
- Partial control of the males would probably have low impact on TLJB populations unless males mated very few times.


Adult female
Adult male
© Marshall W Johnson

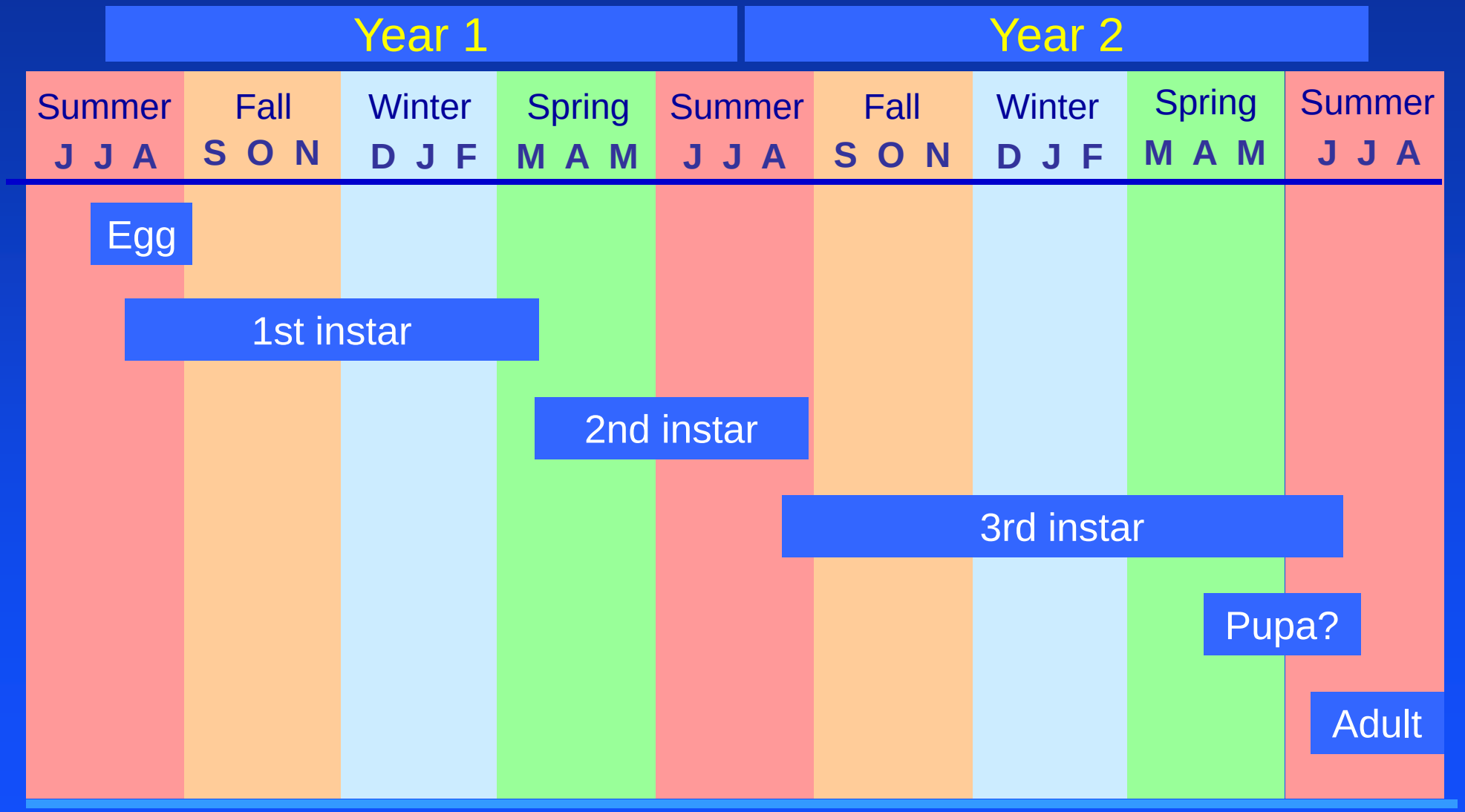

TLJB adults mating
© Marshall W Johnson

Recently laid TLJB eggs

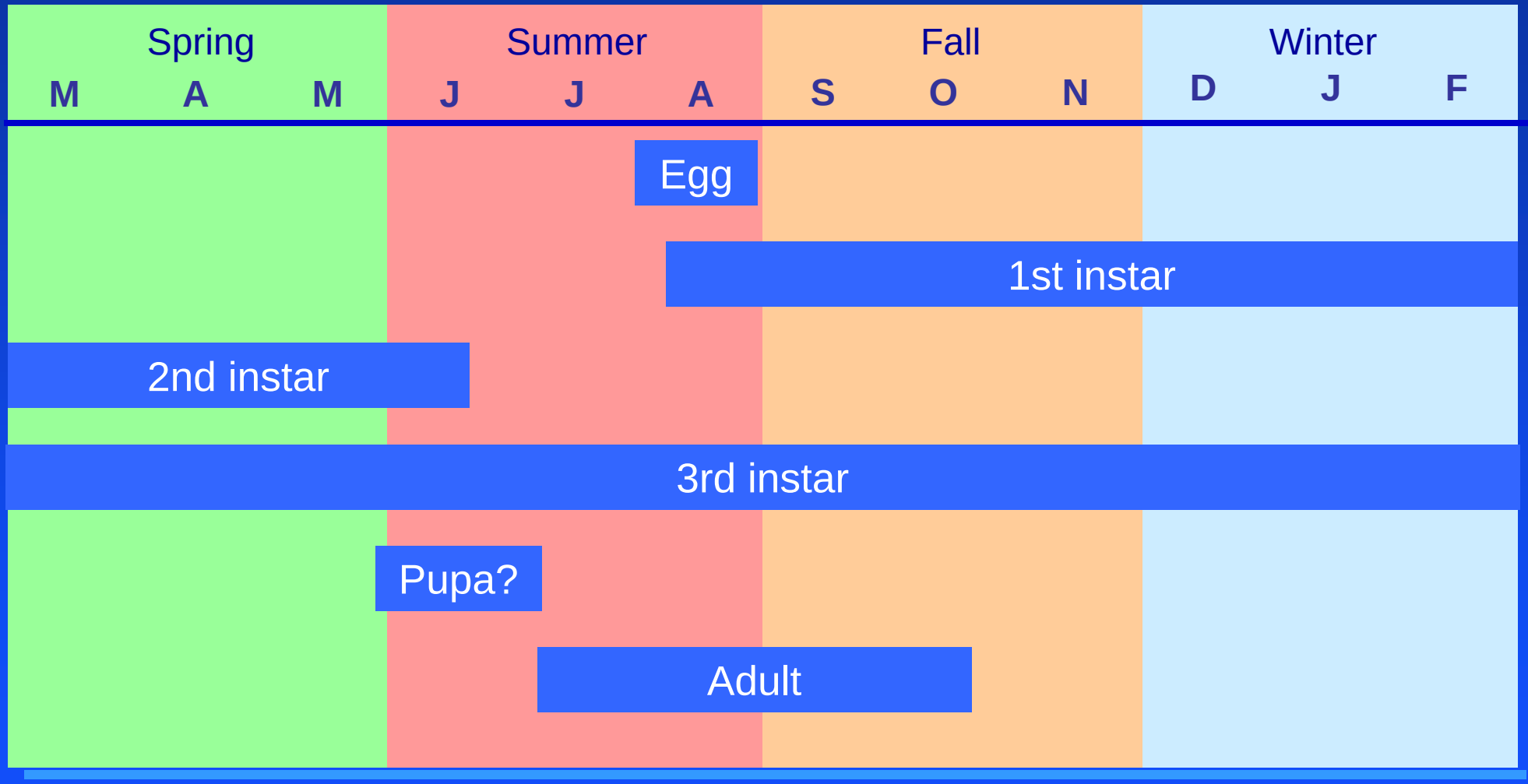
Developing TLJB eggs


Just hatched TLJB 1st instar

TLJB Developmental Cycle



TLJB Seasonal Cycle



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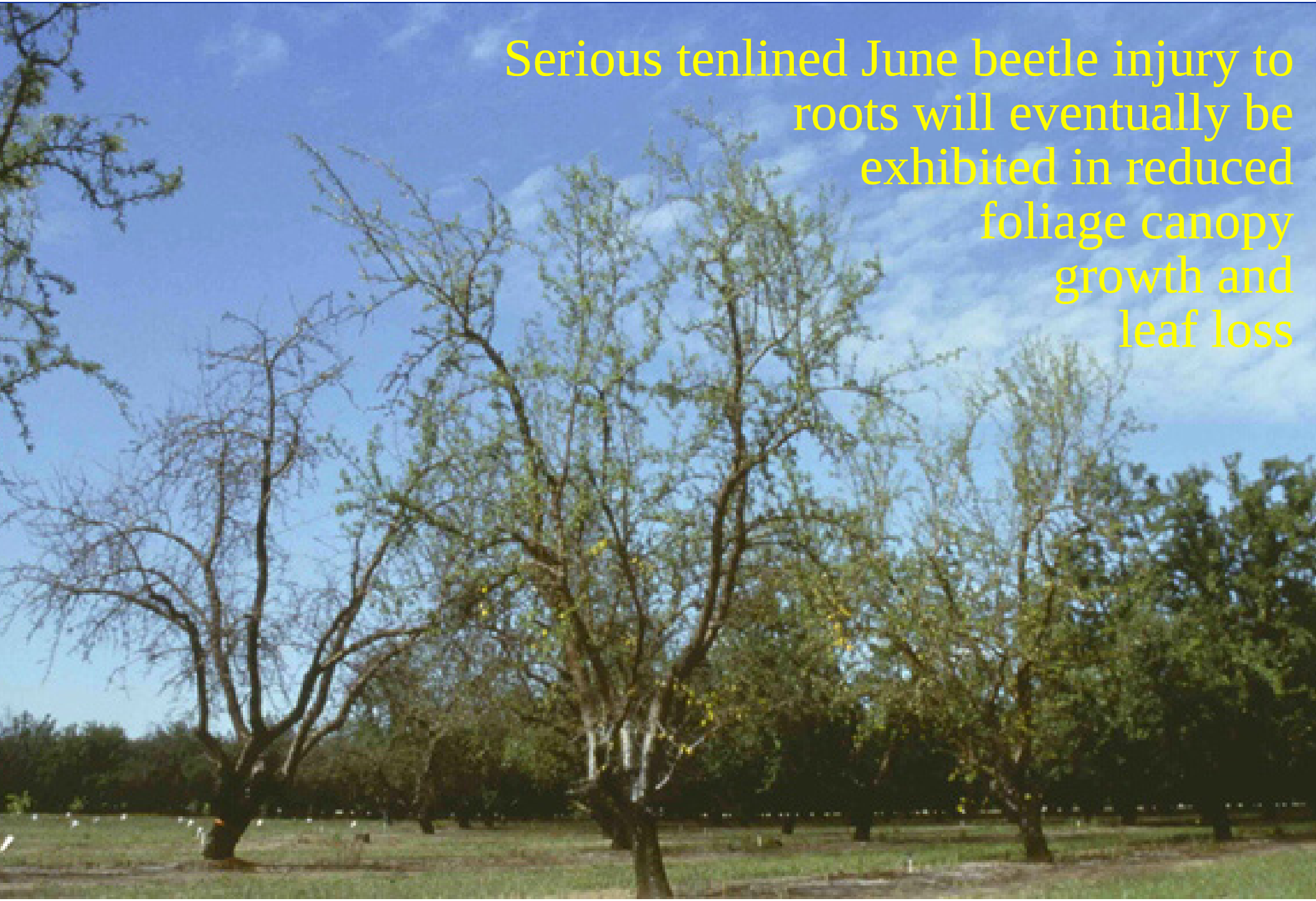
Damage to almond roots

3rd instar mandibles


Injury to roots can be serious. Third instar grubs can be found damaging large roots over 5 feet below the soil surface


Healthy shoot growth


No shoot growth

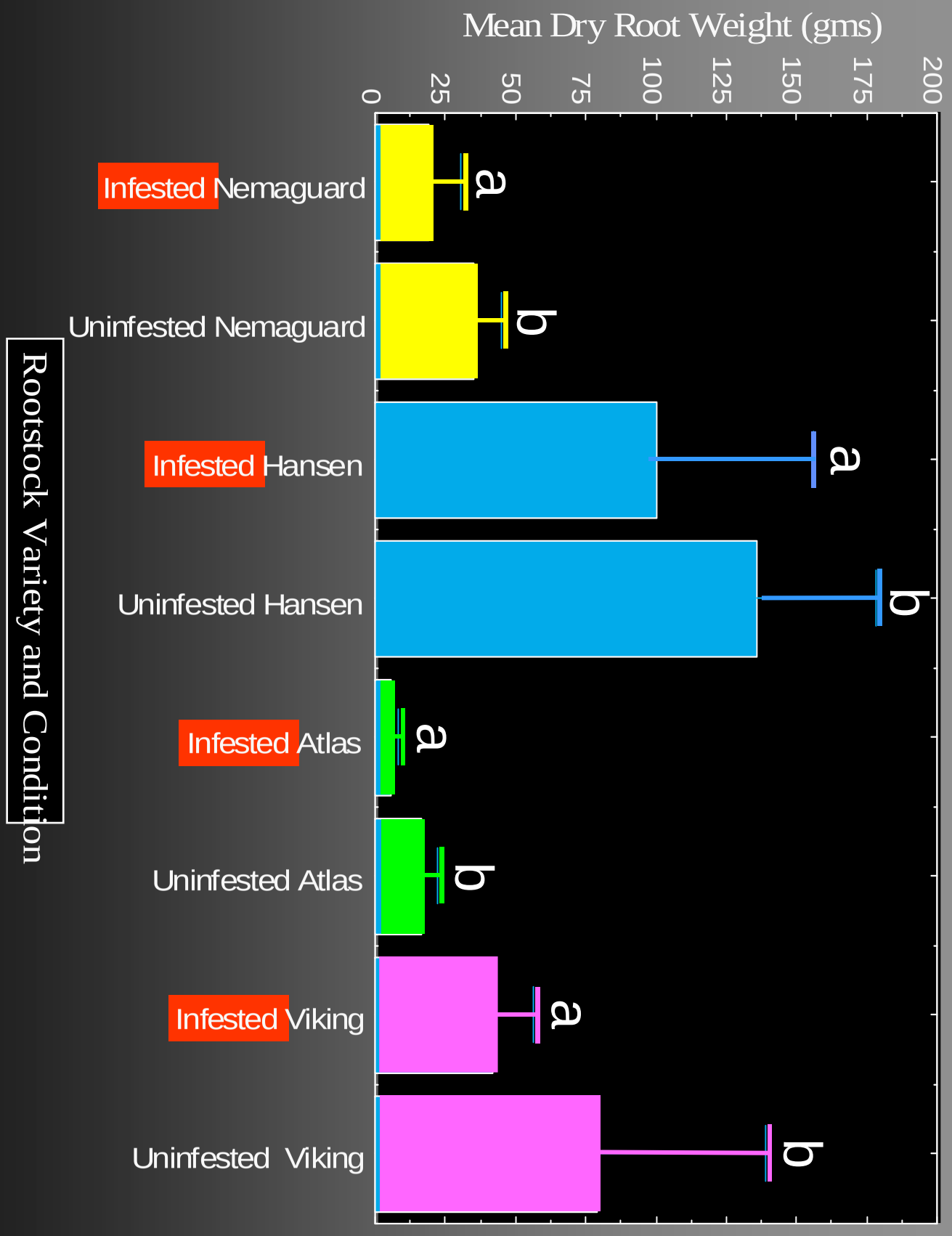

Serious tenlined June beetle injury to roots will eventually be exhibited in reduced foliage canopy growth and leaf loss

Testing Rootstocks

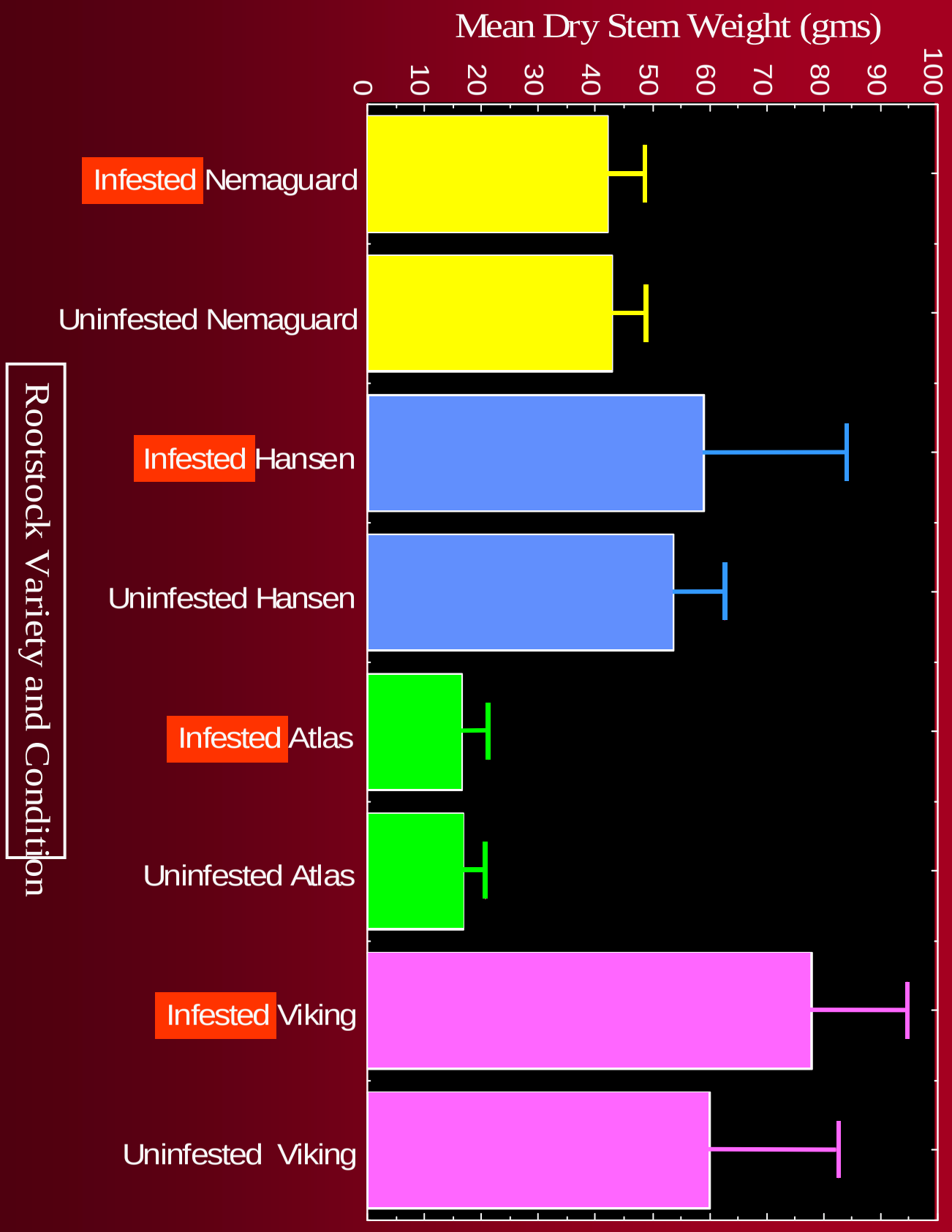
- Casual observations suggested that some rootstocks were not preferred by TLJB grubs or that they are resistant to attack.
- Laboratory studies were attempted to identify potential rootstocks that may resist or avoid TLJB attack.
- The adjacent photo shows Nonpareil scions on Nemaguard, Hansen, Atlas, and Viking rootstocks.
- Twenty 3rd-instar grubs are placed in each test unit and allowed to tunnel and feed for 60 days.
- After the exposure period, damage to the plants was estimated and compared.
- A Nonpareil scion on Nemaguard rootstock was considered the standard.
- No preferred rootstock was found and grub damage to roots was severe.

Viking rootstock before and after 60 days of 20 TLJB grubs feeding

Impact on Roots



Impact on Stems



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Potential Sampling Techniques

Adults

- Soil examination (poor)
- Foliage examination (poor)
- Light traps (good)
- Pheromones or food lures (high potential)

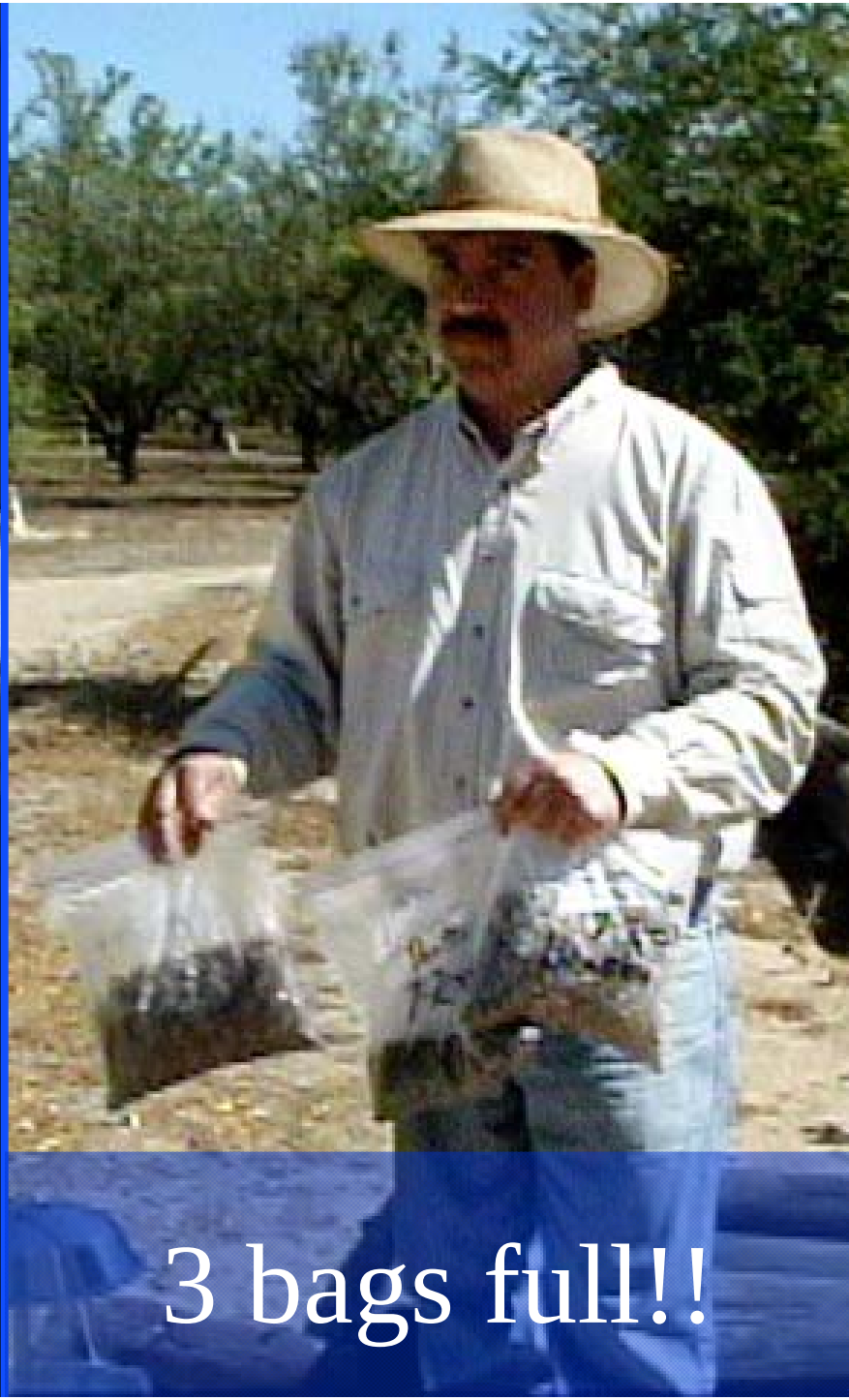
Eggs and Grubs

- Soil examination using sieves

Potential Adult Monitoring Tools

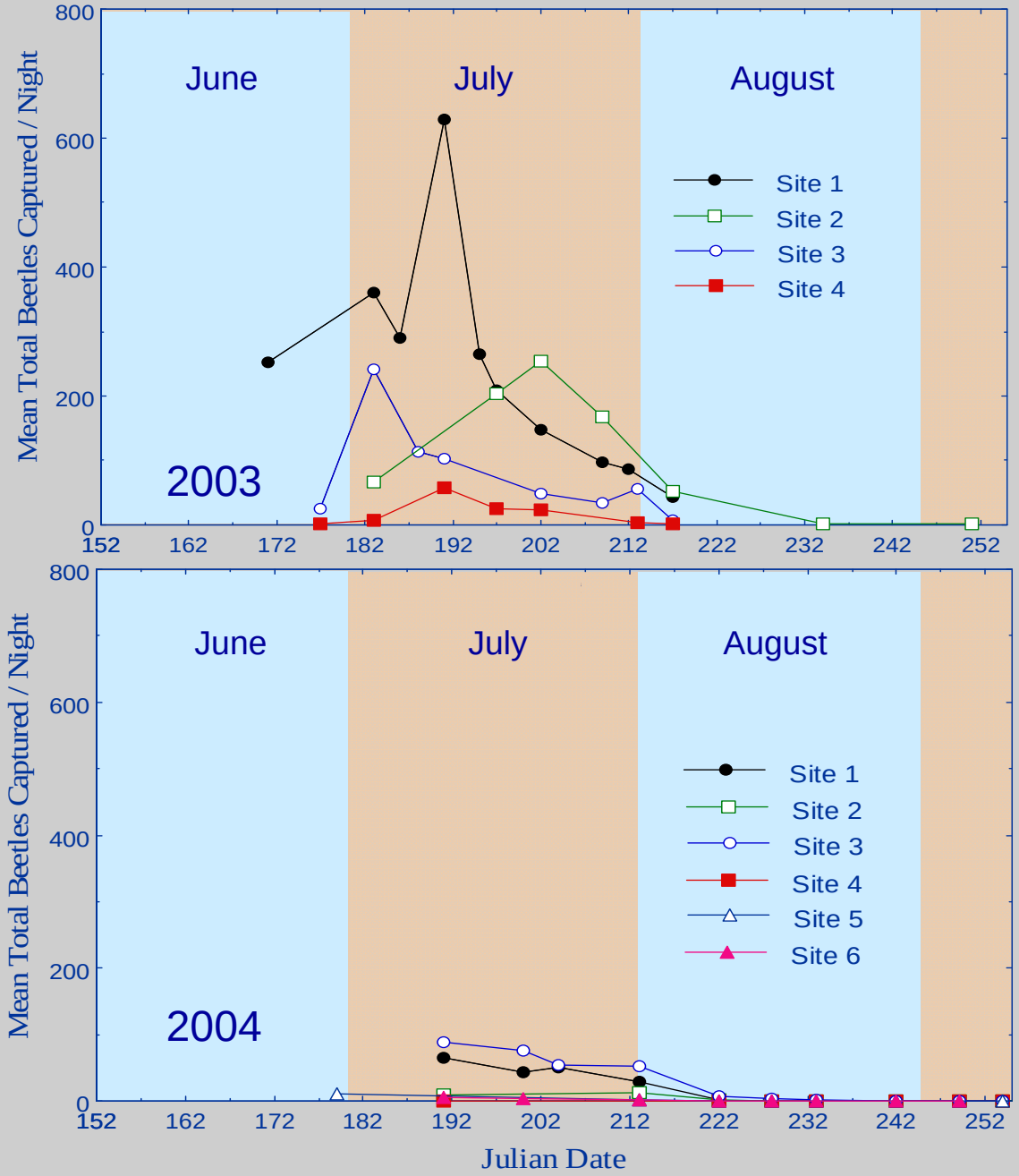
- Light traps — May provide reliable estimate of population size; studies needed to relate numbers of adults caught with local grub infestations

Light traps can bring in the males, but females are highly outnumbered



3 bags full!!

TLJB Adult Counts in Light Traps



Potential Adult Monitoring Tools

- Light traps — May provide reliable estimate of population size; studies needed to relate numbers of adults caught with local grub infestations
- Male attractant pheromone — Walter Leal reports that a pheromone is produced by females. It is an unusual compound produced in minute quantities. Its complete composition and structure are known.
- Synthetic pheromones and lures presently available —W. Leal continues to work on producing the TLJB pheromone, but availability is far off.

Dr. Walter Leal
with pheromone trap

Potential Sampling Techniques

Adults

- Soil examination (poor)
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Eggs and Grubs

- Soil examination using sieves


Sampling for grubs is time & energy consuming.
More standardized methods are needed so comparisons can be made for research purposes.


TLJB grubs are found feeding along the roots
Soil sampling needs to include areas with roots

Pulling out
the roots.

Checking
the crown
for grubs.

New sampling method

New sampling method

Campsomeris pilipes (Hymenoptera: Scoliidae)

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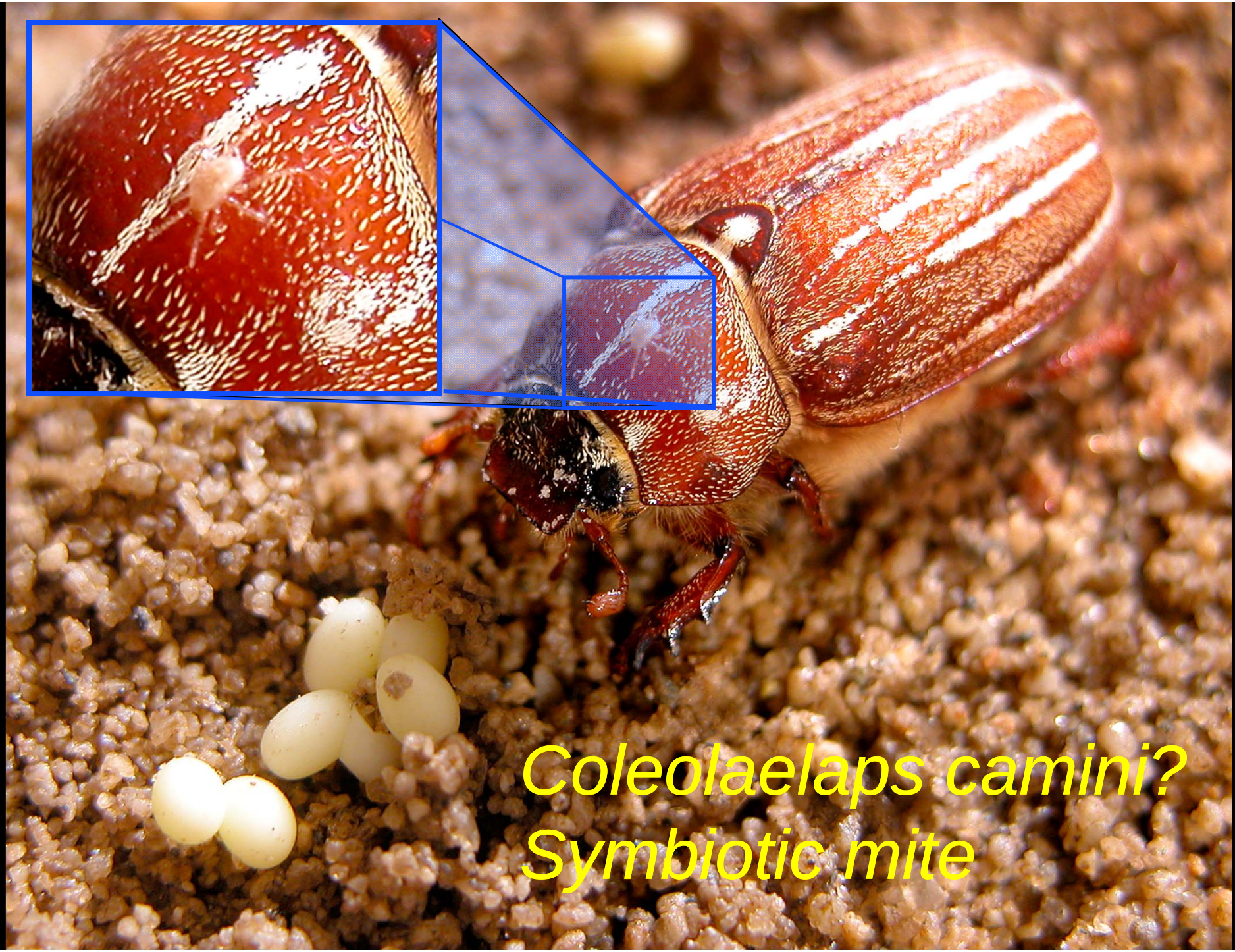
Coleolaelaps camini?
Symbiotic mite

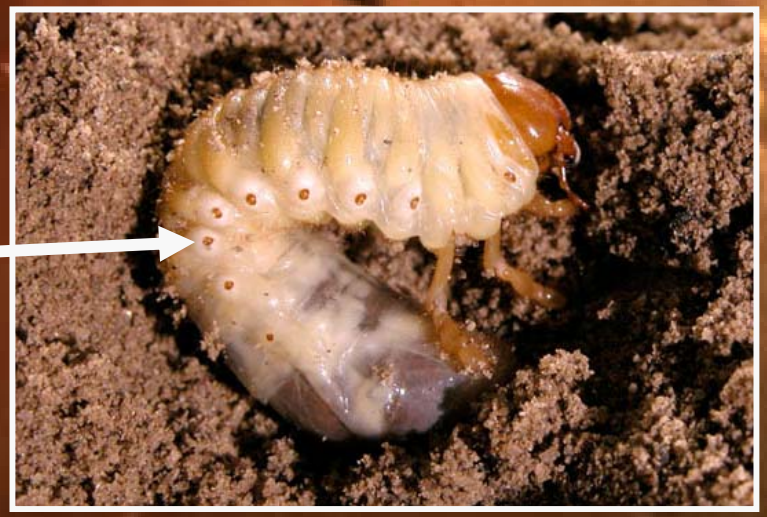

Coleolaelaps camini?
Symbiotic mite

Coleolaelaps camini?
Symbiotic mite

Mite

Mite eggs

Grub spiracle



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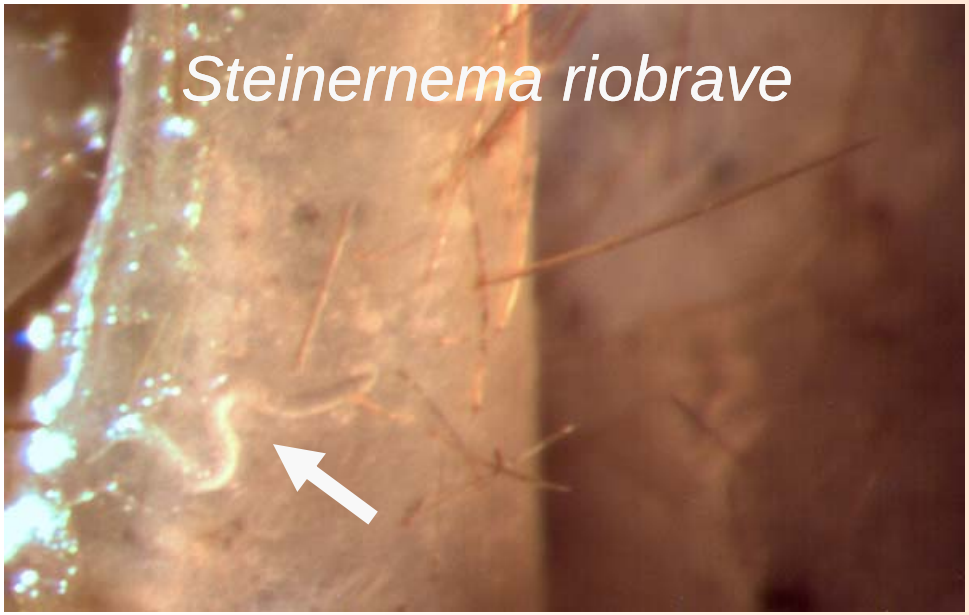
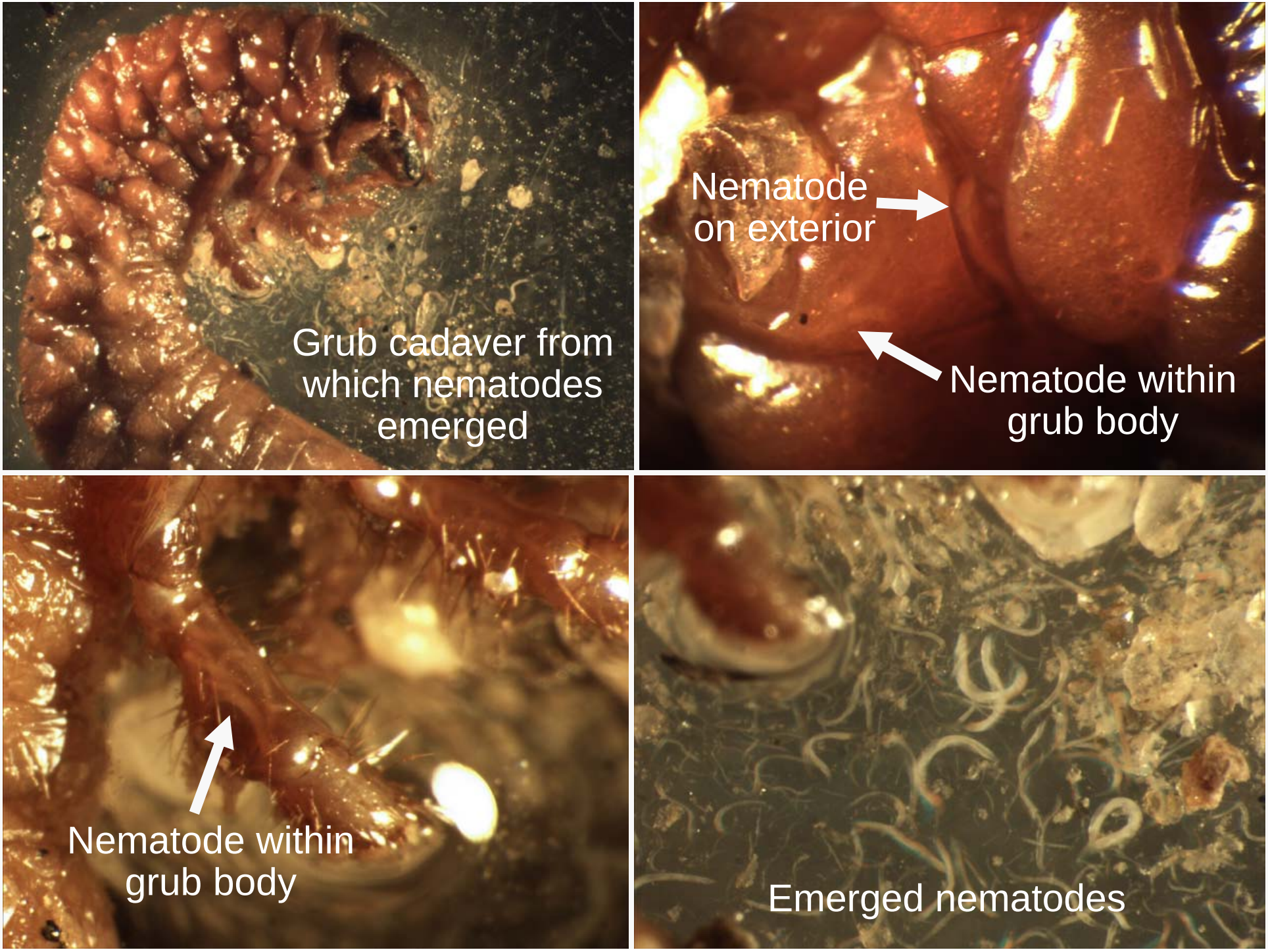
Campsomeris pilipes (Saussure)
Hymenoptera: Scoliidae
Biological Control by Parasitoid ?

Biological Control by Parasitoid

- *Campsomeris pilipes* female adults seek out and lay individual eggs on the TLJB grub
- The egg hatches and the emerging immature feeds on the TLJB grub.
- Time from egg to adult is probably about 4 to 8 weeks
- Unfortunately, although common in the SJV, this natural enemy has not effectively controlled the TLJB during outbreaks

Insect Parasitic Nematodes




Grub cadaver from which nematodes emerged
Nematode on exterior
Nematode within grub body
Nematode within grub body
Emerged nematodes

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CHEMICAL CONTROLS FOR TENLINED JUNE BEETLE SUPPRESSION

Desirable traits:

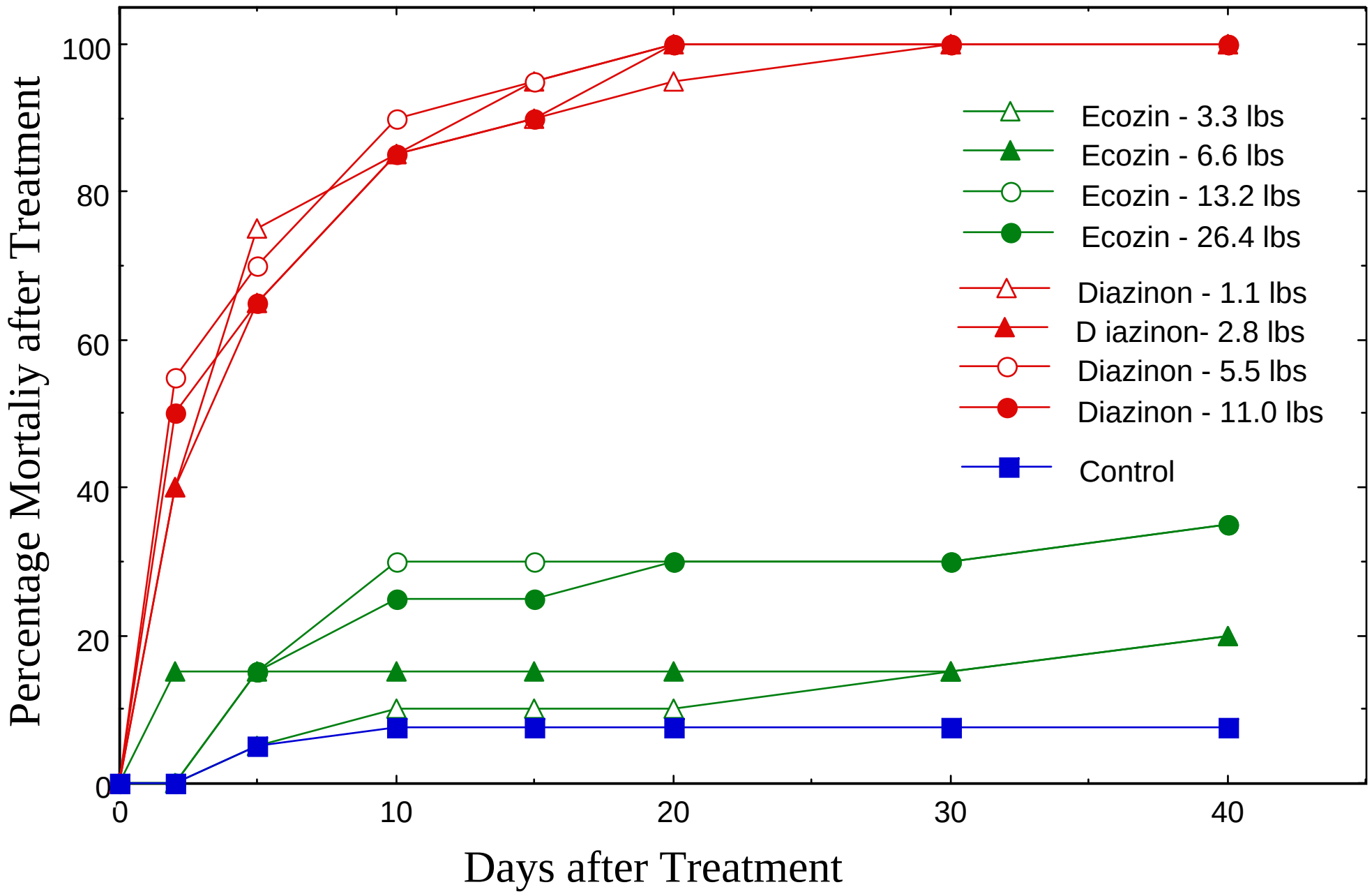
- toxic to egg, grub, and adult stages
- amenable to application via irrigation systems
- high water solubility
- high mobility in soil

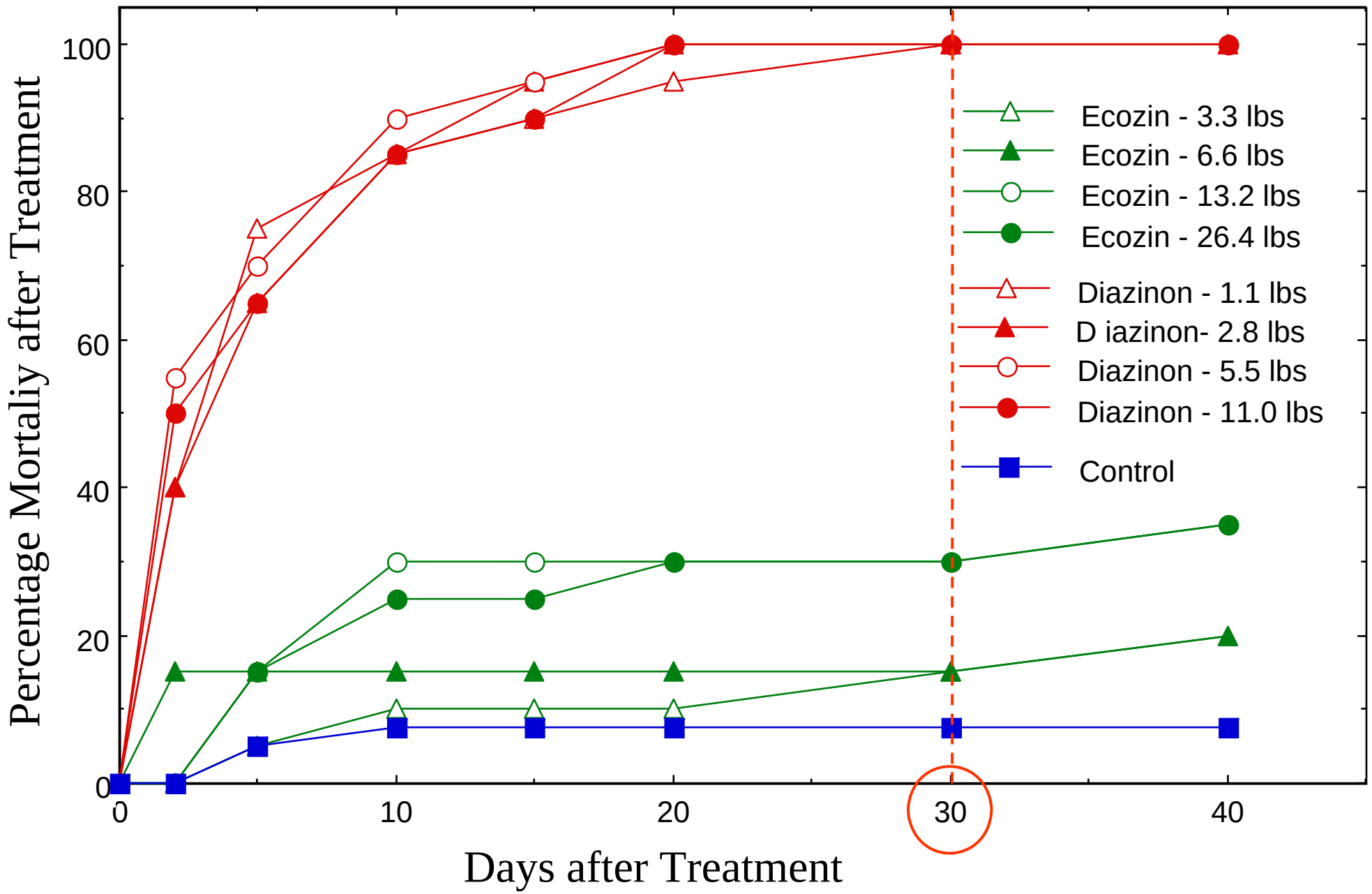
Insecticides for TLJB control / Methods

- Two insecticides initially tested: Diazinon 50 W and Ecozin 3% EC
- These compounds are registered for use in California fruit orchards.
- The active compound in Ecozin 3% EC is the organic pesticide azadirachtin (an insect growth regulator). No recommended rate is provided for ground application, although 10 oz/acre is recommended for foliar application
- Diazinon may be applied at 1 to 1.5 lbs per 100 gallons of water at 300 to 400 gallons per acre
- Diazinon 50 W has an VOC Emission Potential below 5. However, Ecozin 3% EC is has an EP value of 75.
- Four concentrations of the two insecticides were tested
- One pound of dried, sandy soil was placed into each 700 ml container
- 50 ml of diluted insecticide solution was added to each soil container, and the solution was mixed through the soil
- A 3rd instar grub and a carrot piece were added to each soil container, and carrots were changed when evidence of grub feeding appeared or the carrot rotted
- Grub mortality was checked at 2 days post treatment and afterwards at 5 day intervals until the study was terminated

RESULTS: Insecticides

- Diazinon 50 W killed the TLJB grubs at all concentrations tested (1.1 to 11.0 lbs AI / acre); however, death was not quick and took as much as 20 days for all grubs to die at the highest treatment rate
- Although Diazinon treated grubs did not die quickly, they all quickly ceased feeding
- At the lowest treatment rate (1.1 lbs AI / acre), it took 30 days for all treated individuals to die
- Ecozin 3% EC was less effective than the Diazinon treatment, and only 35% of the treated individuals died at the higher treatment concentrations (13.2 & 26.4 lbs AI / acre)
- Some of the Ecozin treated individuals that did not immediately die, ceased to feed post-treatment, but later started again if they did not die
- At 40 days post-treatment, all surviving grubs in the Ecozin test began feeding again
- Only 7.5 percent of the Control grubs died, and all suriving grubs were feeding at 40 days post-treatment


Percentage Mortaliy after Treatment
100
80
60
40
20
0
0
10
20
30
40
Days after Treatment
Ecozin - 3.3 lbs
Ecozin - 6.6 lbs
Ecozin - 13.2 lbs
Ecozin - 26.4 lbs
Diazinon - 1.1 lbs
D iazinon- 2.8 lbs
Diazinon - 5.5 lbs
Diazinon - 11.0 lbs
Control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Days after Treatment
Ecozin - 3.3 lbs
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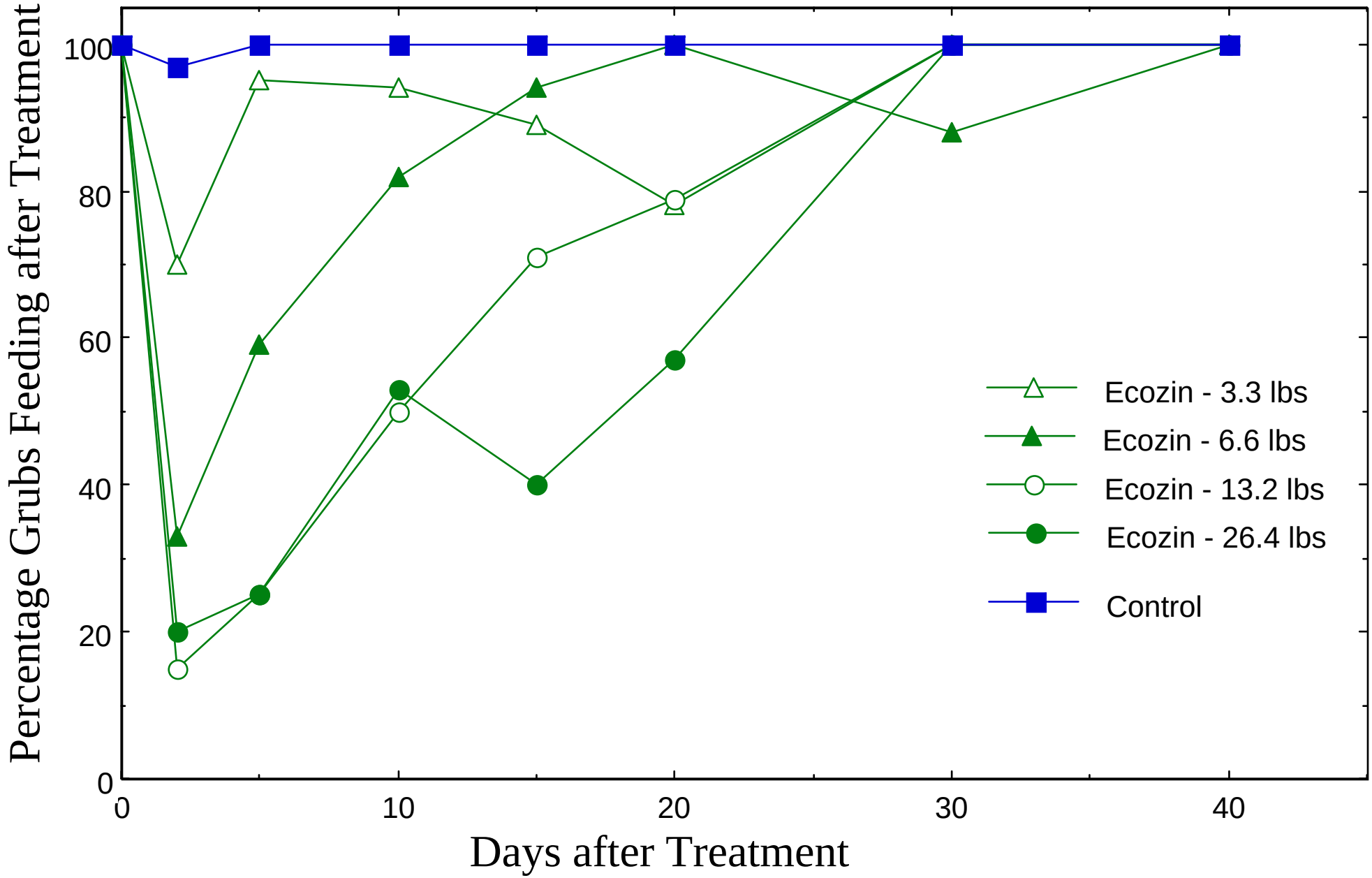
Ecozin - 26.4 lbs
Diazinon - 1.1 lbs
D iazinon- 2.8 lbs
Diazinon - 5.5 lbs
Diazinon - 11.0 lbs
Control


Diazinon treated
Untreated

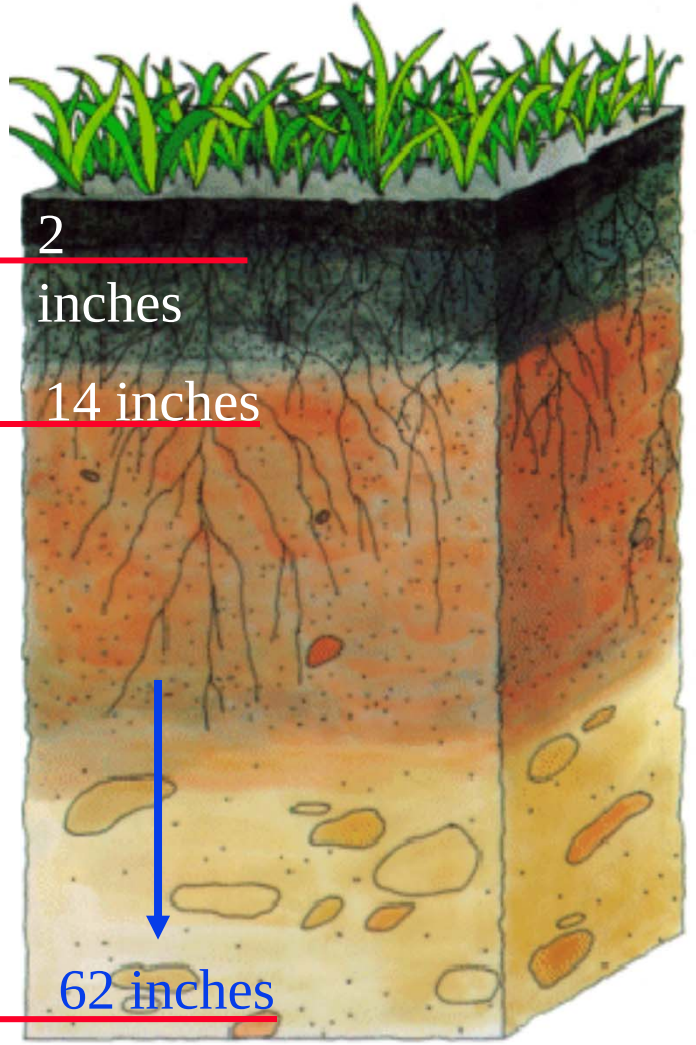

Percentage Grubs Feeding after Treatment
100
80
60
40
20
0
0
10
20
30
40
Days after Treatment
Ecozin - 3.3 lbs
Ecozin - 6.6 lbs
Ecozin - 13.2 lbs
Ecozin - 26.4 lbs
Control

Challenges to Managing TLJB

Most grubs found within this level where the almond roots are

Toxic materials or pathogens must penetrate more than 14 inches or more to kill all TLJB grubs. **1 inch of water is needed to deliver toxins one foot deep.**

Large grubs may be this far down



Moving Diazinon through the soil / Methods

- Diazinon 50 W was tested at an equivalent rate of 5 lbs AI per acre
- Two amounts of Diazinon solution were tested: 250 ml and 500 ml into the column
- Four soil depths were tested: 0 – 2 inches; 2 – 4 inches; 4 – 6 inches; and 8 – 10 inches
- Soil columns were made of 15 cm diameter PVC irrigation pipes that were cut into various lengths (7.5, 12.5, and 22.5 cm = ca. 3 inches; 5 inches; and 9 inches)
- Sandy soil (ca. 90% sand) was used
- Prior to treatment, the water in the soil was brought to field saturation capacity
- The insecticide was added very slowly to the column to ensure that the solution penetrated the soil rather than ran down the interior wall of the column
- The insecticide was allowed to penetrate the soil column for 24 hours, and was then disassembled to allow collection of samples of ca. 1 lb of treated soil from different column depths
- With respect to each soil depth, the collected soil was mixed and then set up in a test container to which a 3rd instar TLJB grub was added with a carrot piece
- Grub mortality was checked starting at 2 days post treatment and at 5 day intervals afterwards.

Soil Column

Because of the difficulty in locating grubs in the soil and the number of tests needed to determine effective insecticidal compounds and parasitic nematodes as well as methods to facilitate penetration of the soil strata, laboratory methods were developed as an initial step in TLJB investigations instead of going straight to the field.

RESULTS: Moving Diazinon through the soil

- As of Day 5 of the test, 100% TLJB mortality was recorded in the 0 – 2 inch strata that received 250 ml of solution with less than 60% mortality below 2 inches. Insects in the 0 – 2 inch strata stopped feeding. Feeding was considerably reduced below the 2 inch strata and by Day 5 only 67% of the grubs continued to feed at 8 – 10 inches.
- As of Day 2, grubs held in the columns receiving the greater amount of solution (500 ml), had stopped feeding in all column strata. However, in the strata below 4 inches, about 7 to 10% of the grubs began to feed again.
- As of Day 5, strata that received the 500 ml solution had grub mortality from 78 to 100% above 6 inches and at 8 – 10 inches mortality was 70%.
- These tests indicate that the Diazinon will penetrate the soil and that water is important to moving the chemical. The addition of wetting agents to help the chemical move through the soil will be investigated.

Moving Imidacloprid through the soil / Methods

- Imidacloprid (Admire® 2, 21% a.i.) was tested at a concentration of 0.5 ml Admire in 1000 ml water (= ratio of 1 part Admire to 2000 parts water) and it killed TLJB grubs. Next, two amounts of imidacloprid solution were used: 250 ml and 500 ml in a soil column
- Four soil depths were tested: 0 – 2 inches; 2 – 4 inches; 4 – 6 inches; and 8 – 10 inches
- Soil columns were made of 15 cm diameter PVC irrigation pipes that were cut into various lengths (7.5, 12.5, and 22.5 cm = ca. 3 inches; 5 inches; and 9 inches)
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- With respect to each soil depth, the collected soil was mixed and then set up in a test container to which a 3rd instar TLJB grub was added with a carrot piece
- Grub mortality was checked starting at 2 days post treatment and at 5 day intervals afterwards.

Percentage mortality of TLJB grubs exposed to treated soil with Imidacloprid in soil column tests

Solution (ml)	Soil depth (inches)	N	% Mortality of grubs post-treatment (weeks)						
			1	2	3	4	5	6	>10
0 (CK)		10	0.0	0.0	0.0	0.0	0.0	0.0	0.0
250	0-2	6	33.3	50.0	66.7	100.0	100.0	100.0	100.0
250	2-4	12	25.0	25.0	41.7	41.7	41.7	41.7	83.3
250	4-6	12	0.0	0.0	0.0	0.0	0.0	8.3	91.7
250	6-10	12	0.0	0.0	0.0	0.0	0.0	0.0	83.3
500	0-2	6	16.7	50.0	66.7	100.0	100.0	100.0	100.0
500	2-4	12	8.3	75.0	91.7	100.0	100.0	100.0	100.0
500	4-6	12	0.0	41.7	100.0	100.0	100.0	100.0	100.0
500	6-10	12	0.0	16.7	16.7	16.7	16.7	33.3	91.7

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0 (CK)		10	0.0	0.0	0.0	0.0	0.0	0.0	0.0
250	0-2	6	33.3	50.0	66.7	100.0	100.0	100.0	100.0
250	2-4	12	25.0	25.0	41.7	41.7	41.7	41.7	83.3
250	4-6	12	0.0	0.0	0.0	0.0	0.0	8.3	91.7
250	6-10	12	0.0	0.0	0.0	0.0	0.0	0.0	83.3
500	0-2	6	16.7	50.0	66.7	100.0	100.0	100.0	100.0
500	2-4	12	8.3	75.0	91.7	100.0	100.0	100.0	100.0
500	4-6	12	0.0	41.7	100.0	100.0	100.0	100.0	100.0
500	6-10	12	0.0	16.7	16.7	16.7	16.7	33.3	91.7

Percentage feeding of TLJB grubs exposed to treated soil with Imidacloprid in soil column tests

Solution (ml)	Soil depth (inches)	N	% Feeding of grubs post-treatment (weeks)						
			1	2	3	4	5	6	>10
0 (CK)		10	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
250	0-2	6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
250	2-4	12	0.0	8.3	16.7	16.7	16.7	16.7	16.7
250	4-6	12	0.0	25.0	25.0	25.0	41.7	41.7	8.3
250	6-10	12	25.0	41.7	83.3	66.7	25.0	41.7	16.7
500	0-2	6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
500	2-4	12	0.0	0.0	0.0	0.0	0.0	0.0	0.0
500	4-6	12	0.0	0.0	0.0	0.0	0.0	0.0	0.0
500	6-10	12	0.0	0.0	0.0	0.0	0.0	0.0	0.0

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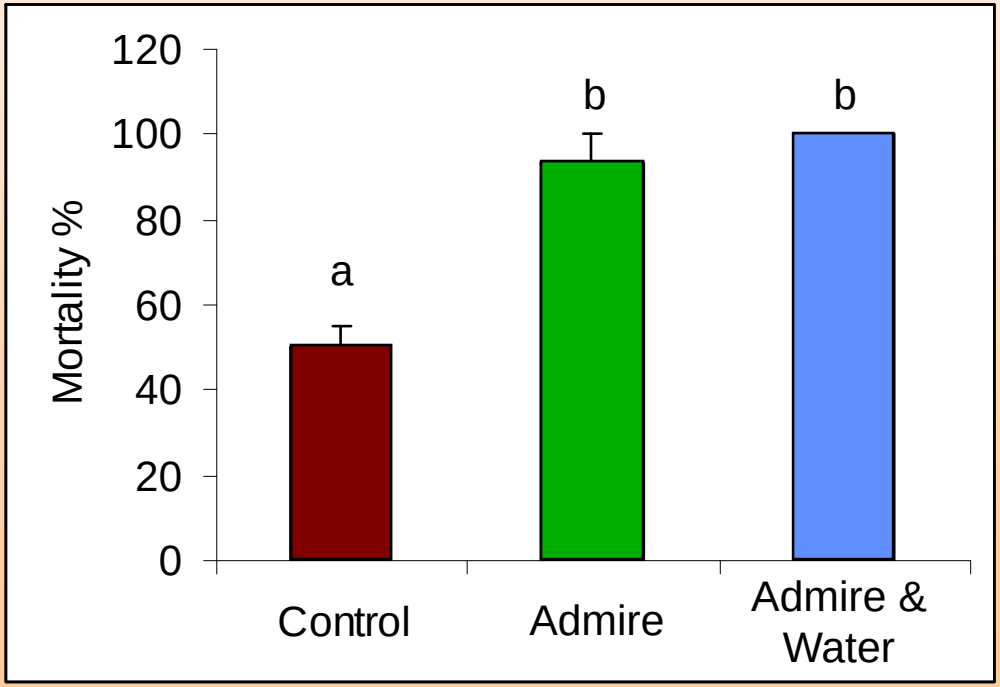
250	0-2	6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
250	2-4	12	0.0	8.3	16.7	16.7	16.7	16.7	16.7
250	4-6	12	0.0	25.0	25.0	25.0	41.7	41.7	8.3
250	6-10	12	25.0	41.7	83.3	66.7	25.0	41.7	16.7
500	0-2	6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
500	2-4	12	0.0	0.0	0.0	0.0	0.0	0.0	0.0
500	4-6	12	0.0	0.0	0.0	0.0	0.0	0.0	0.0
500	6-10	12	0.0	0.0	0.0	0.0	0.0	0.0	0.0

More on Imidacloprid / Methods & Results

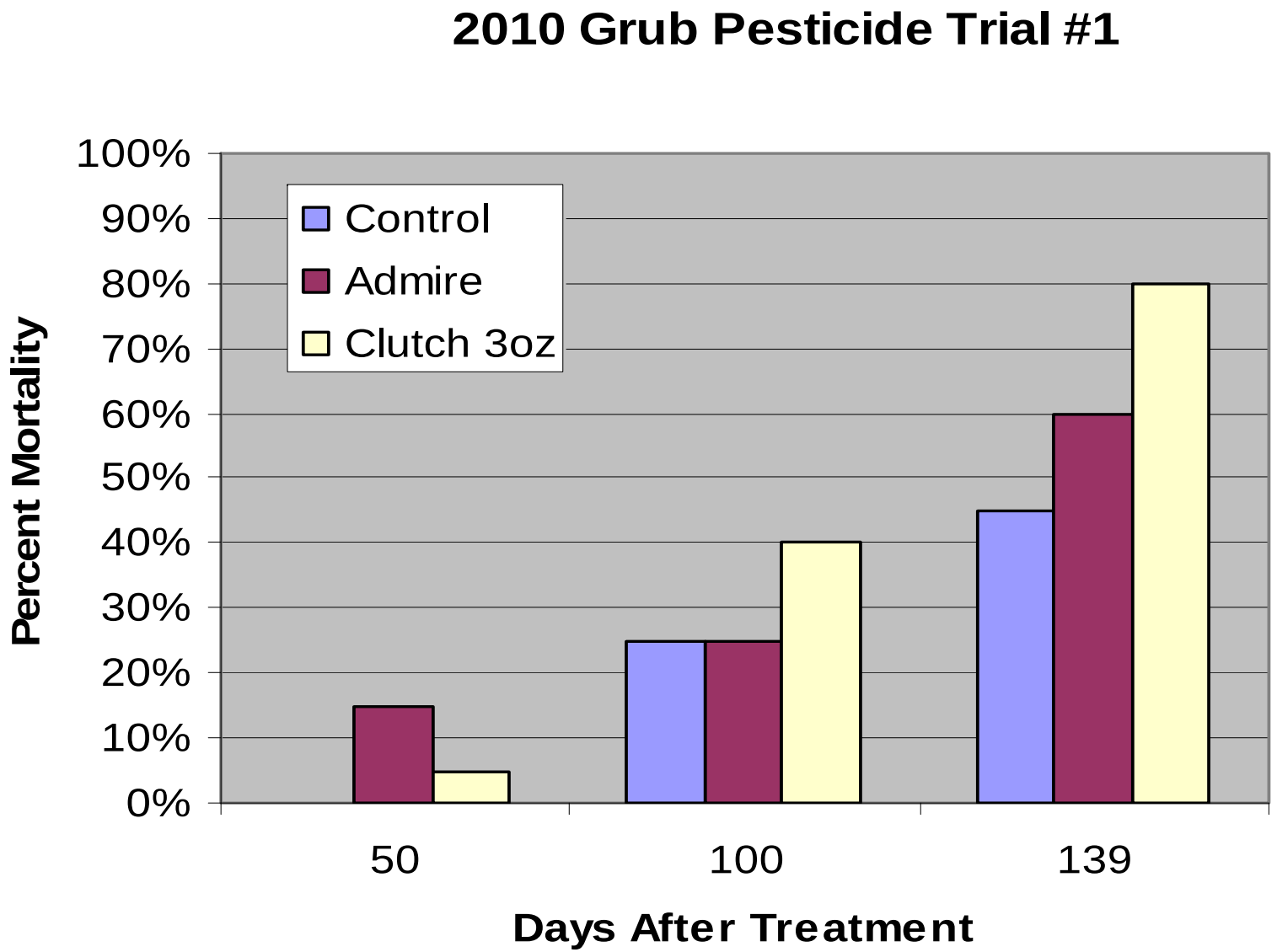
- Another test using imidacloprid (Admire® 2, 21% a.i.) was conducted to determine if adding additional water following the initial imidacloprid treatment would be beneficial.
- Two treatments were established using peach plants in pots (9.8 inch diam. X 11.8 inch height) with infestations of 2nd and 3rd instar TLJB grubs.. A concentration 0.65 ml imidacloprid in 1000 ml water was applied at 100 ml of solution per potted plant. One group of plants was only treated with the imidacloprid solution. Another group received the same amount of imidacloprid, but that was followed with one-half inch of water after 24 hours. A check consisted of potted plants with TLJB grubs and 100 ml of water.
- Mortality was checked after 6 weeks.
- Treatments of the soil with imidacloprid caused significantly higher mortality of the grubs ($F = 24.3$, $P < 0.001$). However, the second treatment with one half inch of water being added after the imidacloprid treatment was not significantly different. HOWEVER, in the treatment receiving the post treatment water, all grubs died as compared to the first treatment where only a mean of about 95% of the grubs died.

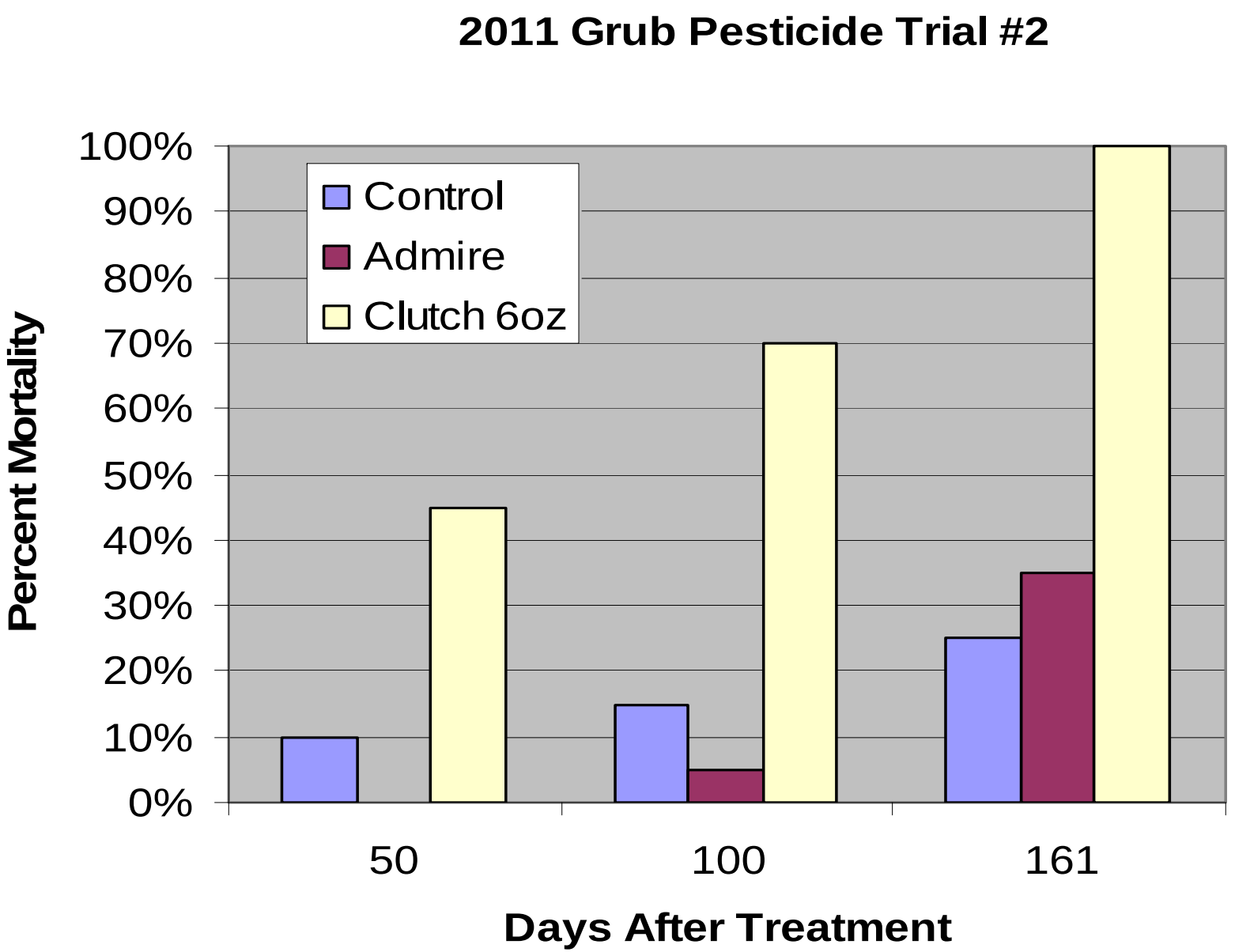


Other Products Tested

- Movento™ (Spirotetramat) w/ Dyne-amic
  Did not kill or retard grubs from feeding
- Venom™ (dinotefuran) / 6 oz
  Did not kill grubs, but 100% ceased feeding.
  However, many survived the test.
- Clutch™ or Belay™ (clothianidin) / 3.2 and 6 oz
  Shows promise. See following graphs.
- Admire 2™ (imidacloprid) / 32 oz

  Only using a ratio of 0.19 parts Admire
  to 2000 parts water (actual field rate)
  See following graphs


2010 Grub Pesticide Trial #1
Percent Mortality
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Control
Admire
Clutch 3oz
50
100
139
Days After Treatment


2011 Grub Pesticide Trial #2
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Control
Admire
Clutch 6oz
Percent Mortality
50
100
161
Days After Treatment

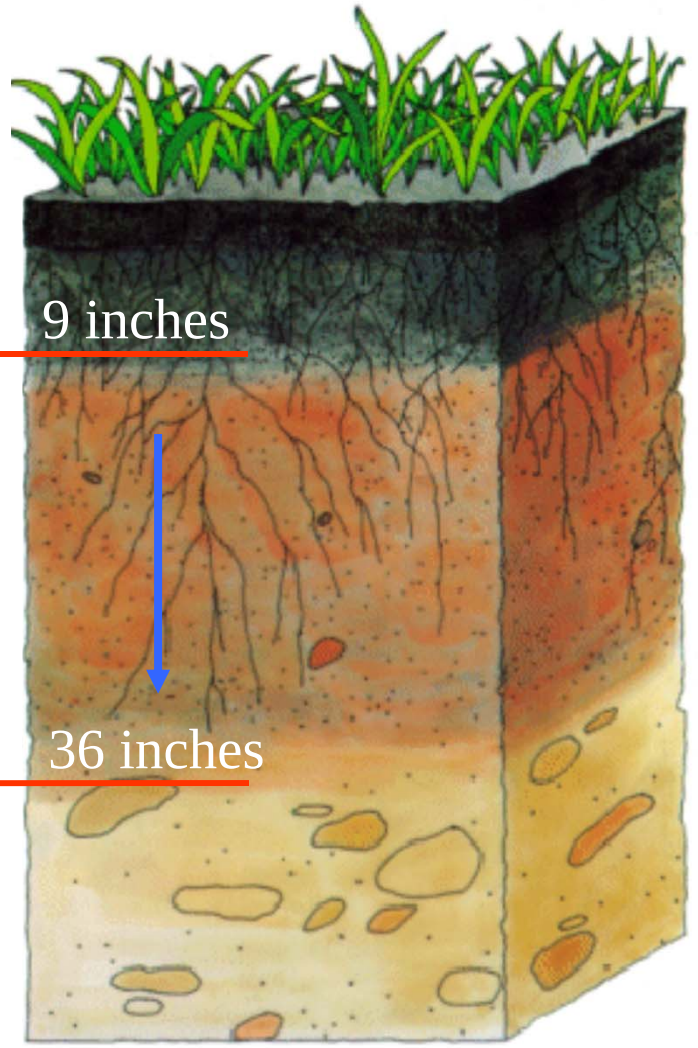
Presentation Objectives

1) Discuss TLJB biology
2) Describe damage to infested trees
3) How to sample for TLJB
4) What are those mites doing on the adults & grubs?
5) What natural enemies exist
6) What pesticides kill the grubs
7) Getting the chemicals to the grubs

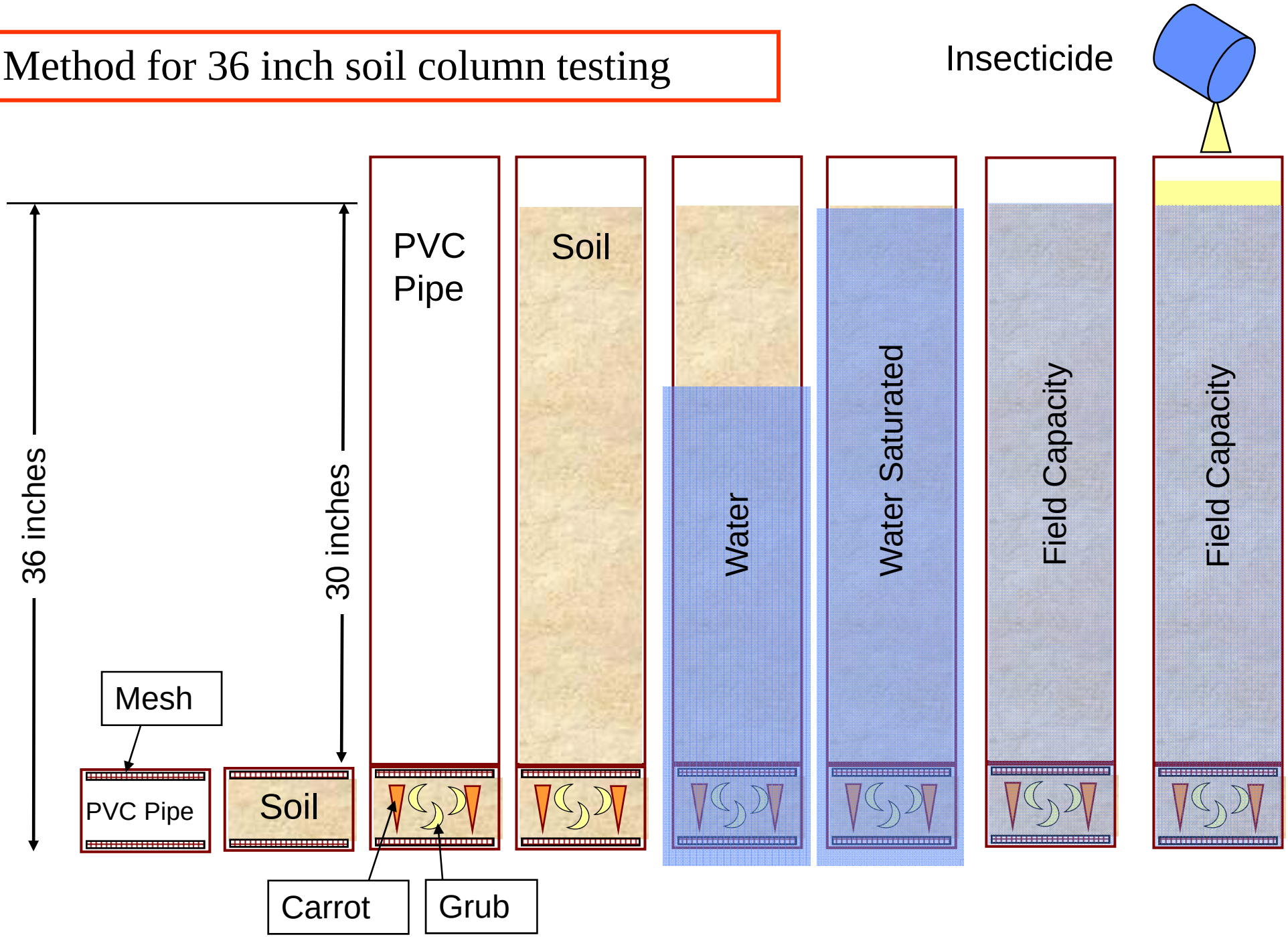
Challenges to Managing TLJB

In the lab, we have killed TLJB grubs to this depth in soil columns

We are targeting suppression at 36 inches below the soil surface. This will require additional irrigation to move the insecticide down.

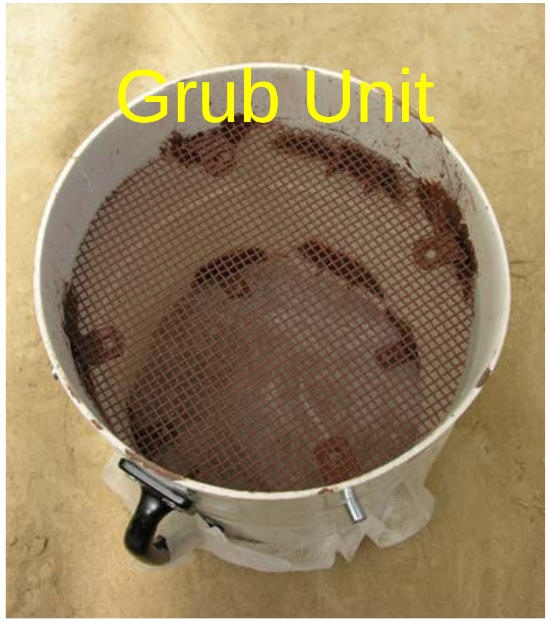


Method for 36 inch soil column testing



Soil Column

Grub Unit

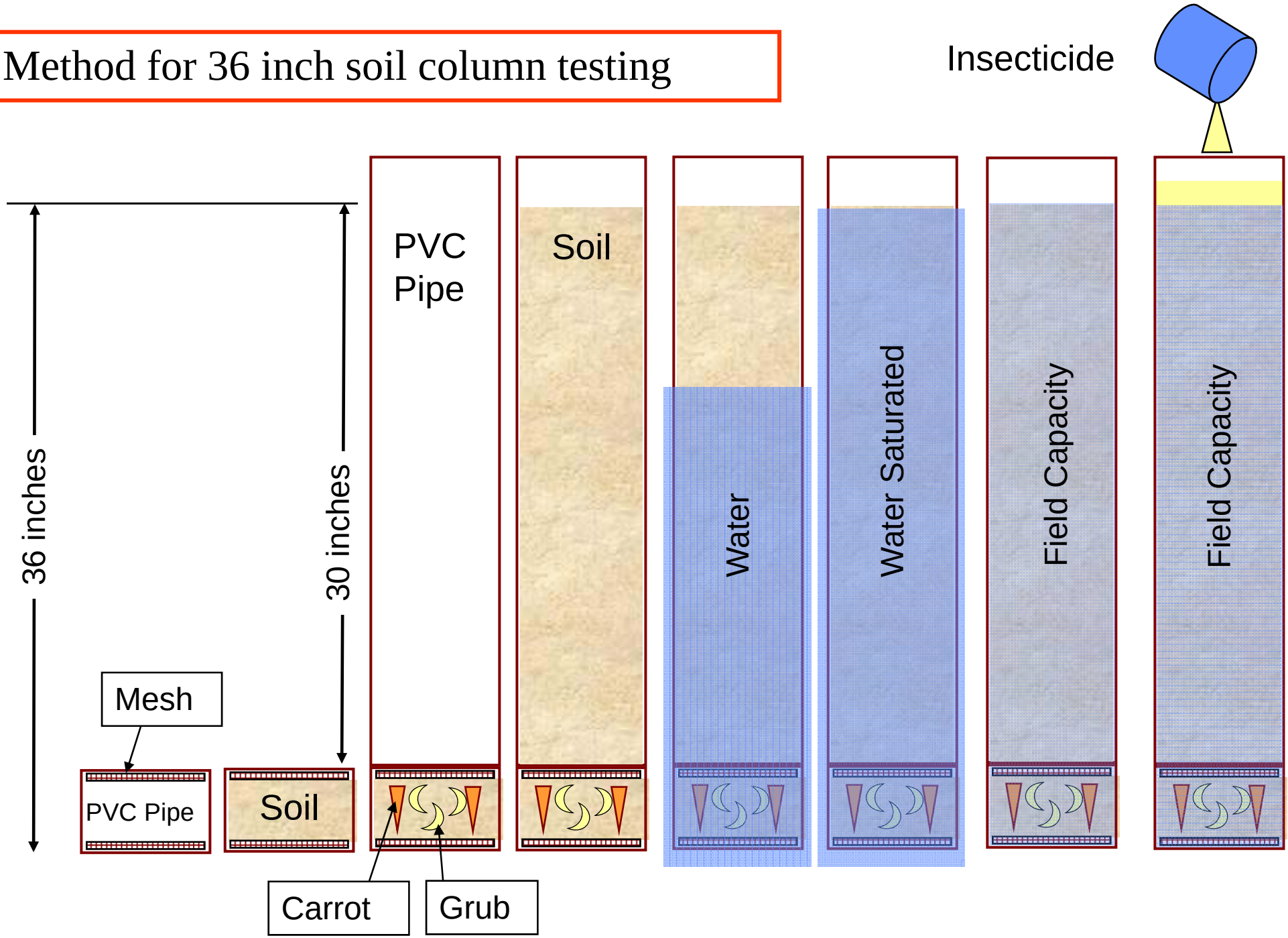


6-inch diameter and 36 inch long soil columns were designed and built, but would did not uniformly drain when water was poured through them unless pure sand was used as filler.

Column Preparation

Drip Unit

Method for 36 inch soil column testing



What happened in the column trials?

First attempt: 99% of grubs died (including controls) from drowning (in water for about 25 days). Columns did not drain.

Second attempt: Columns did not drain properly. No grub mortality in control, but little mortality in chemical treatments.

Third attempt: Columns did not drain properly. Some grubs died in control and chemical treatments because of drowning. Difference in control and chemical treatments was not significant.

WHAT'S NEXT?

- Have initiated studies to reduce rearing period for TLJB grubs in culture
- If the TLJB can be reared in culture in one year, then we will focus efforts on 1st and 2nd instars, which are less deep in the soil
- Will attempt use of sand columns with sandbox sand (very pure)
- Follow up on the association between the grubs and mites

Summary

- TLJB has proven itself to be a very difficult species to investigate for many reasons
- Insecticides are available that will kill TLJB grubs, but the challenge is delivering enough chemical to the grubs to kill them
- Tested entomopathogenic nematodes were not highly effective in killing 3rd instar grubs, but this was somewhat influenced by the presence of symbiotic mites associated with the grubs.
- The most effective approach may be to focus on killing the 1st and 2nd instars that are found within the top 10 inches of the soil strata
- More information is needed on the impacts of soil moisture on grub populations

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