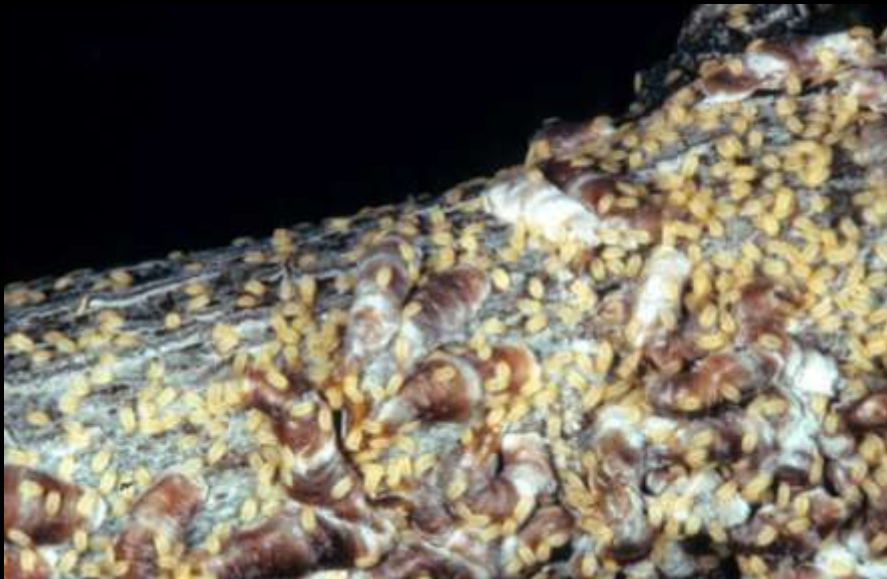


# Quality Time with Scale Insects (and Spider Mites?)

Whitney Cranshaw  
Colorado State University



63<sup>rd</sup> Annual Shade Tree Conference  
Topeka, KS      January 10, 2018

# Scale Insects

**Order: Hemiptera**

**Families: Diaspididae  
(armored scales), Coccidae  
(soft scales), Eriococcidae  
(Felt scales), others**



# Scale Insect Basics

- Scale insects feed on plant fluids using 'piercing-sucking' mouthparts
  - Insect order Hemiptera
  - Related insects include mealybugs, aphids and whiteflies



Willow aphids



Longtailed mealybug

# Scale Insect Basics

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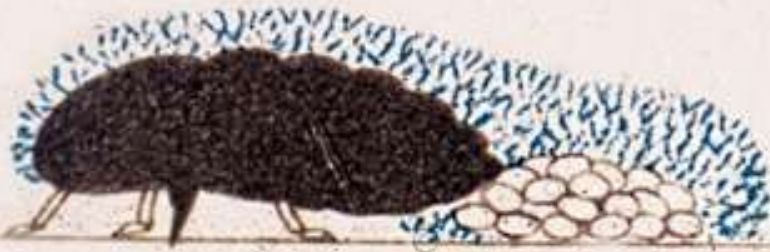
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# There are two general types of scale insects:

**'Soft' Scales**



**Armored Scales**



Pine needle scale



Oystershell scale



## Armored Scales Family Diaspididae

San Jose scale



Obscure scale





Oak lecanium



European elm scale



## Soft Scales

## Families Coccidae, Eriococcidae

Pine tortoise scale



Cottony maple scale



# There are two general types of scale insects:

**'Soft' Scales**



**Armored Scales**



# Armored Scales



- Covering completely encloses, but is not attached to, the body
- Covering made up primarily of proteins and some waxes
- Two primary body forms (elongate, circular)

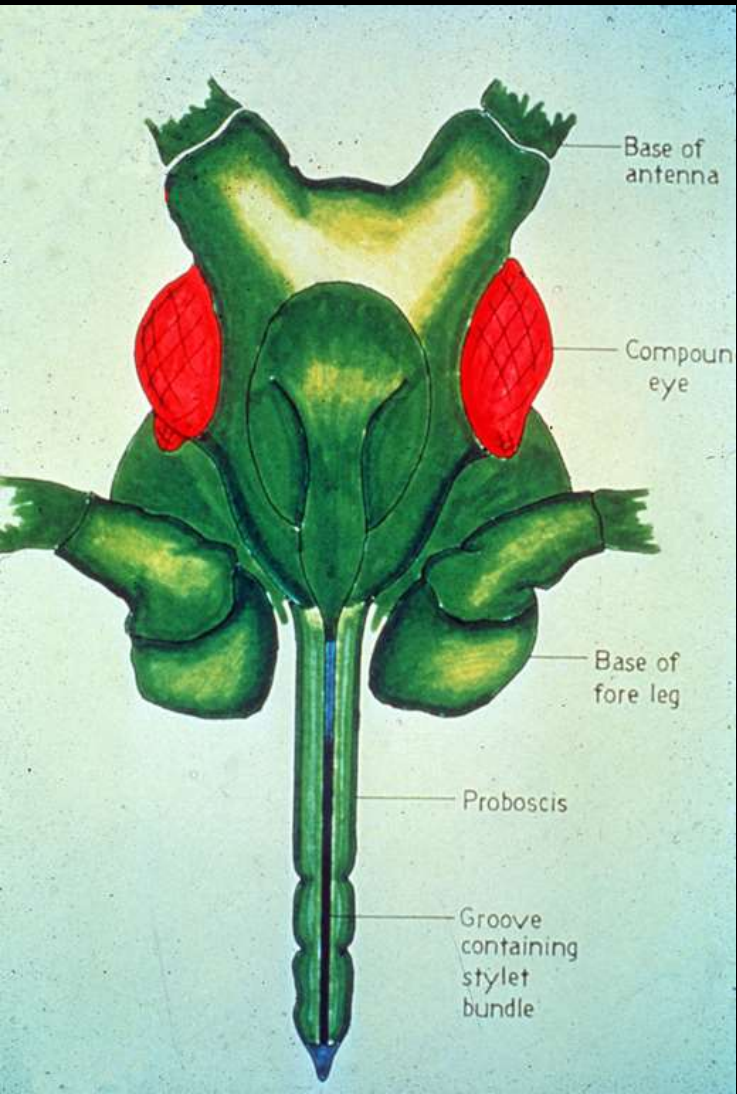
# Soft Scales



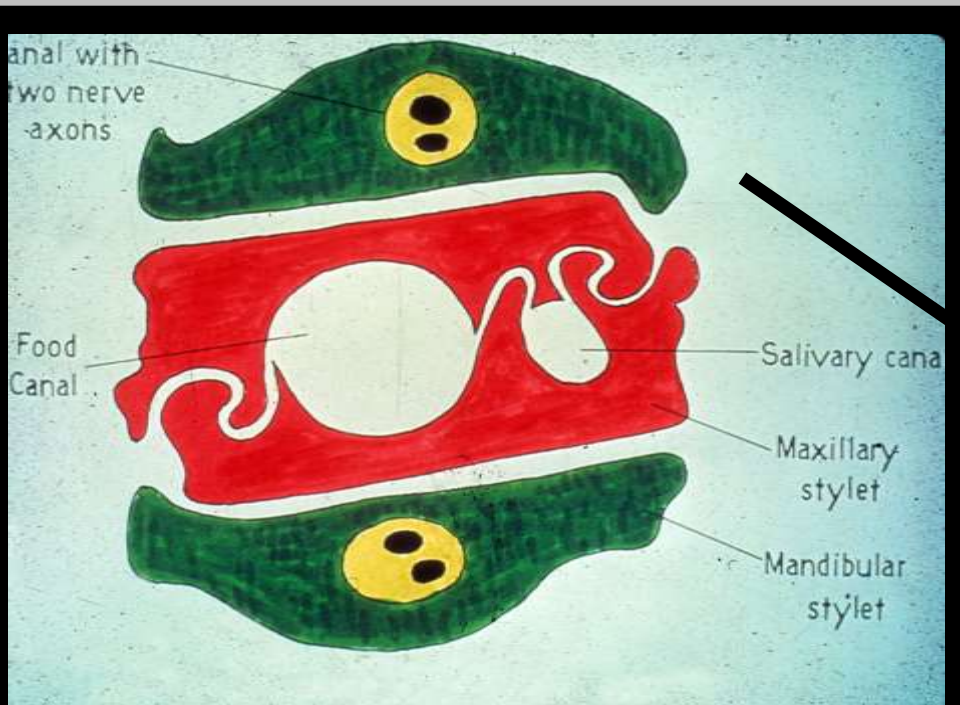
- Covering is attached to body; underside is not covered
- Covering made up of waxes
- Body forms tend to be elongate-oval, more rounded at maturity



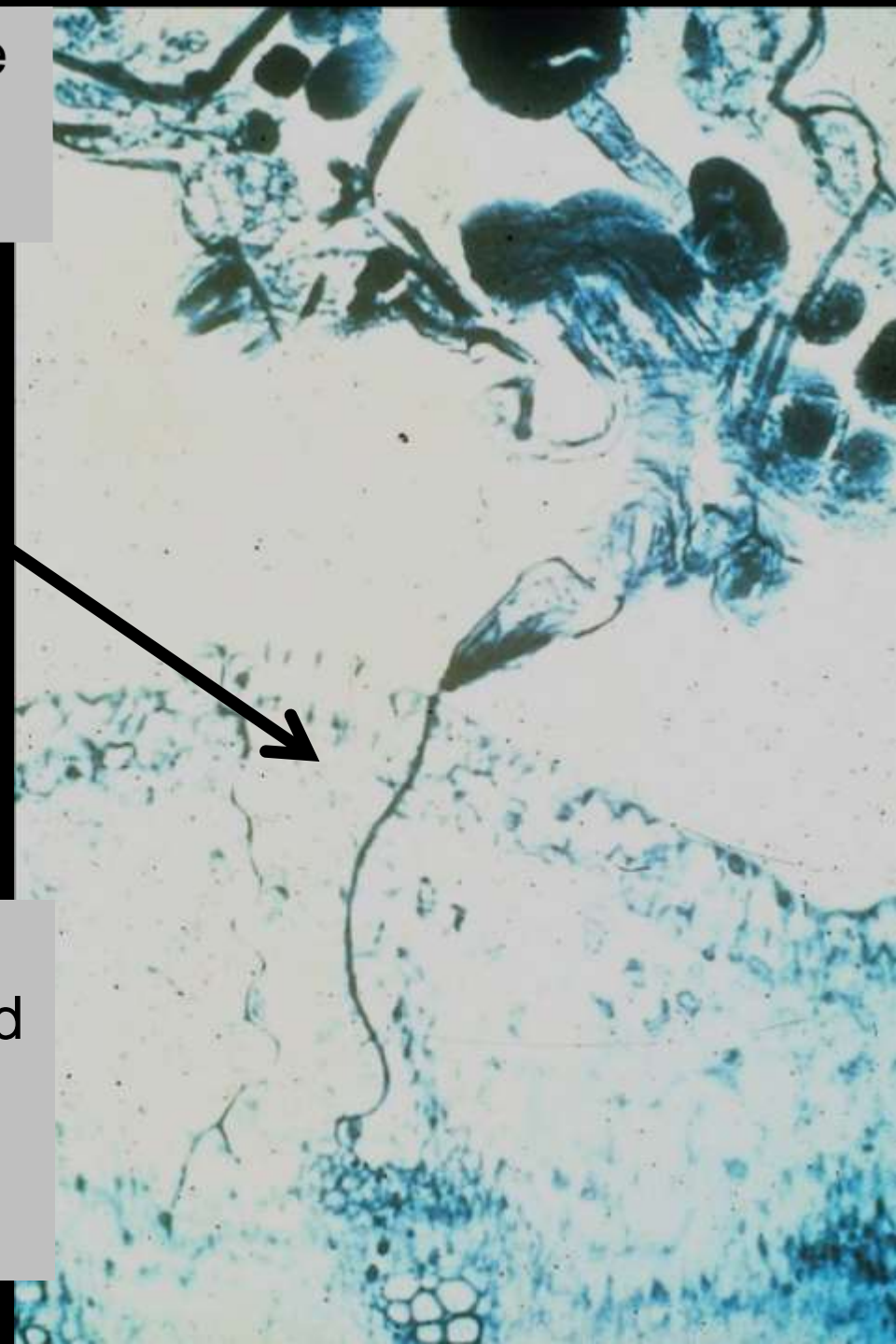
# Piercing-sucking mouthparts



The mandibles are on the outside of the stylet bundle. They are used to penetrate the plant.

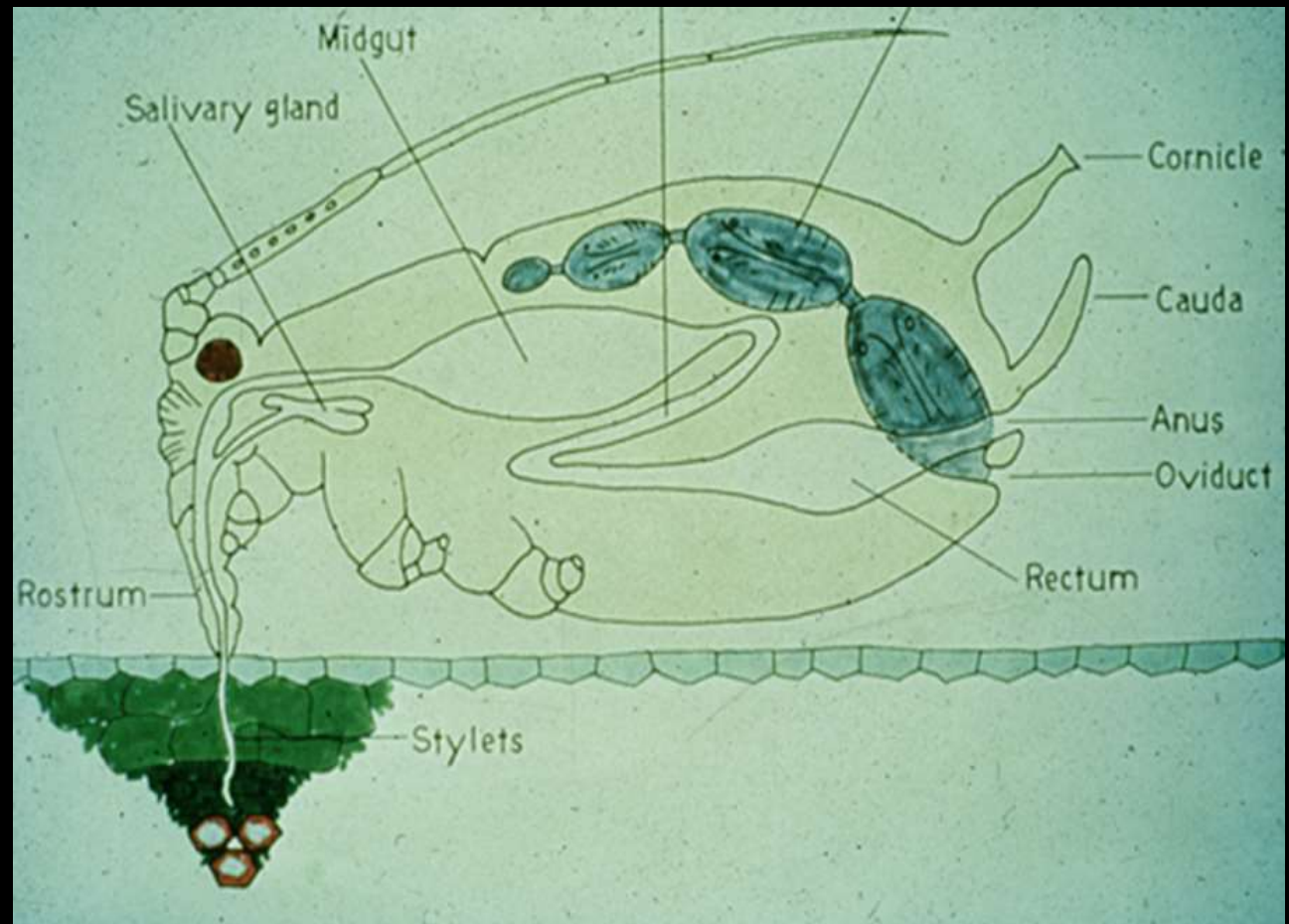


The maxillae are on the inside of the stylet bundle. They are paired and interlock. A food canal and parallel salivary canal are formed by the paired maxillae.



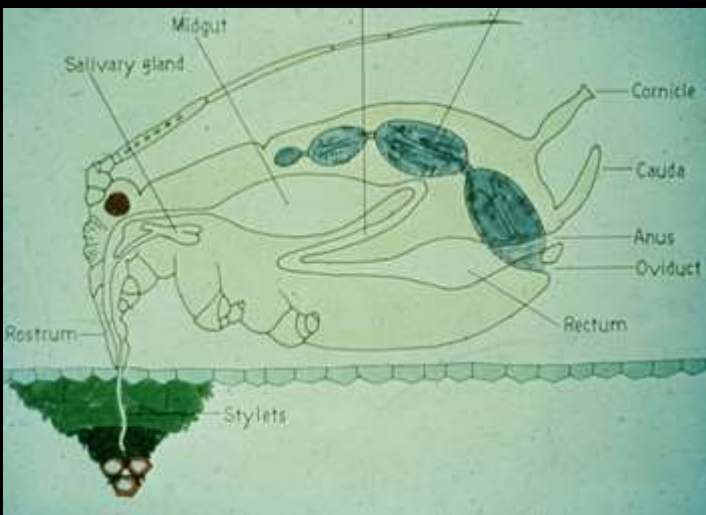
# Scale Insect Feeding

- **Soft scales feed on the fluids of the phloem**



# Scale Insect Feeding

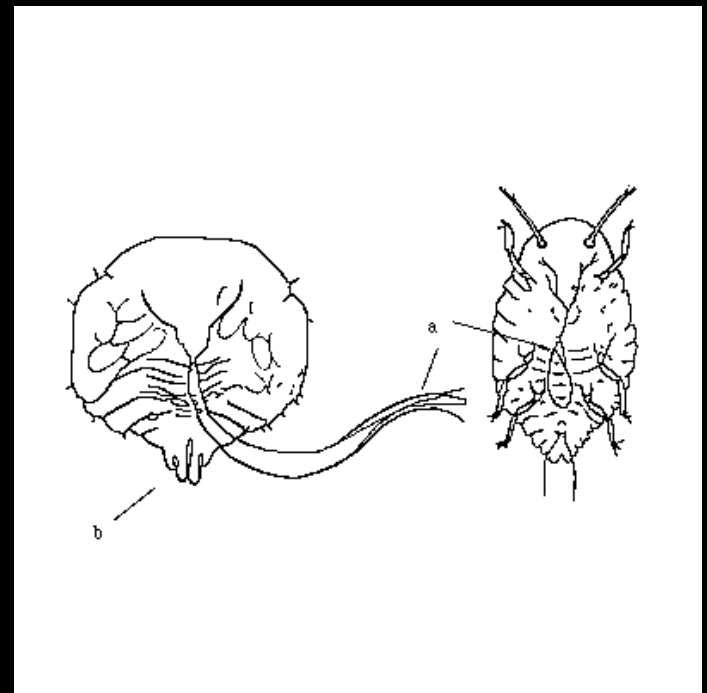
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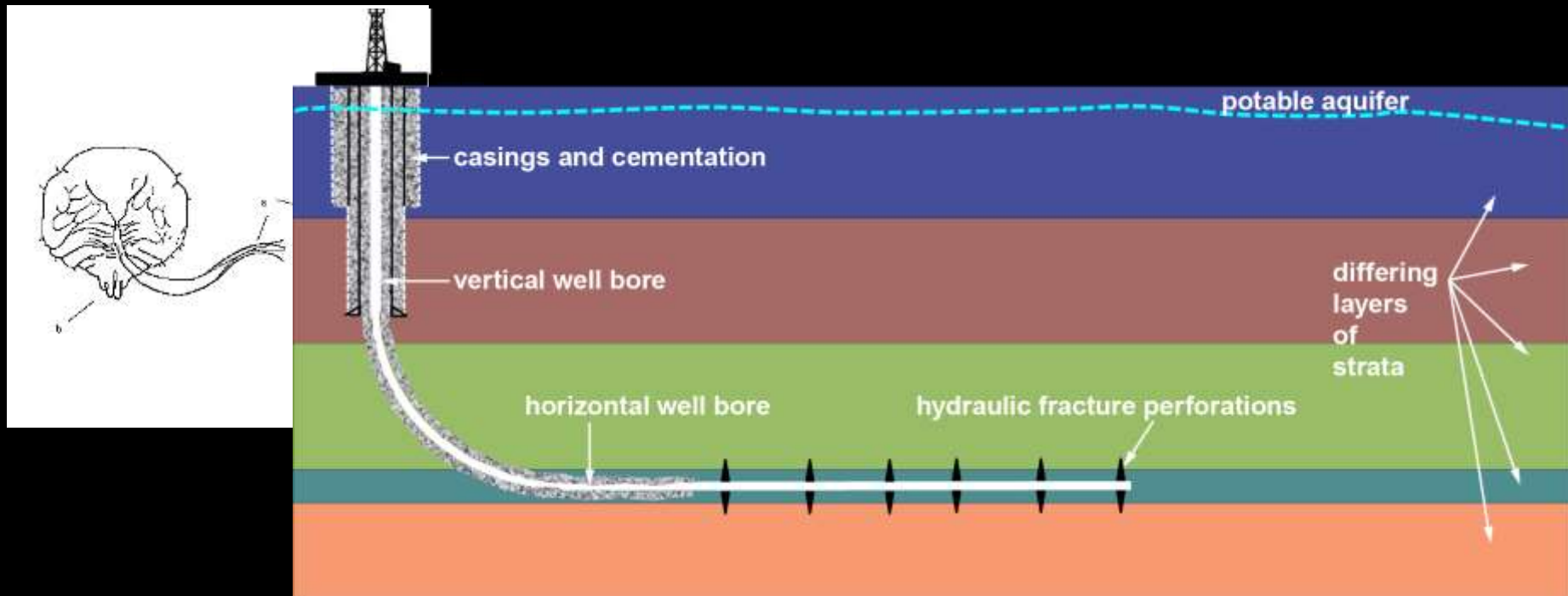
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- Soft scales feed on the fluids of the phloem
- Armored scales feed on cell contents, often in cambium



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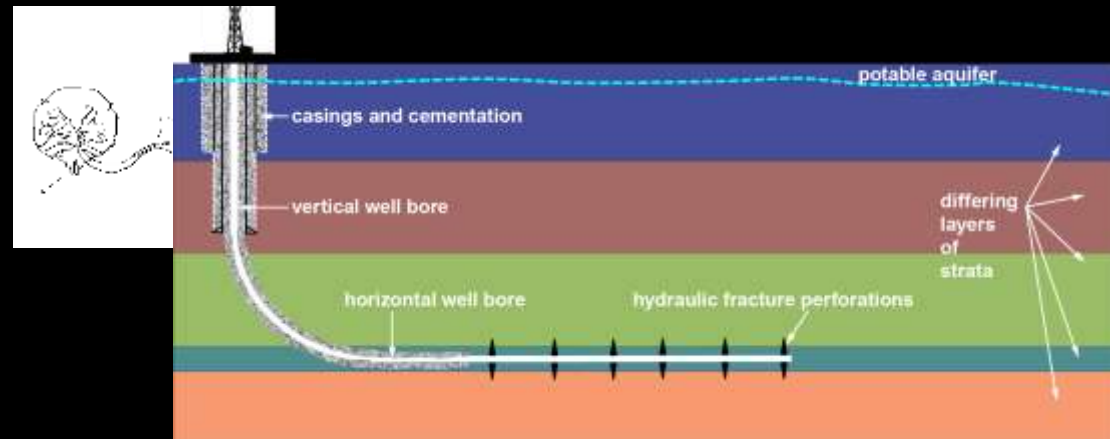


# Scale Insect Feeding

- Soft scales feed on the fluids of the phloem
- Armored scales feed on cell contents, often in cambium



*No honeydew!*



# Males?



Some scale insects rarely or never produce males

If they do the **males** are much smaller than the **females**.

# Males?

Cocoons of  
males scales



Winged adult male



Maturing  
female scales

Pine needle scale



Oystershell scale



## Armored Scales Family Diaspididae

San Jose scale



Obscure scale



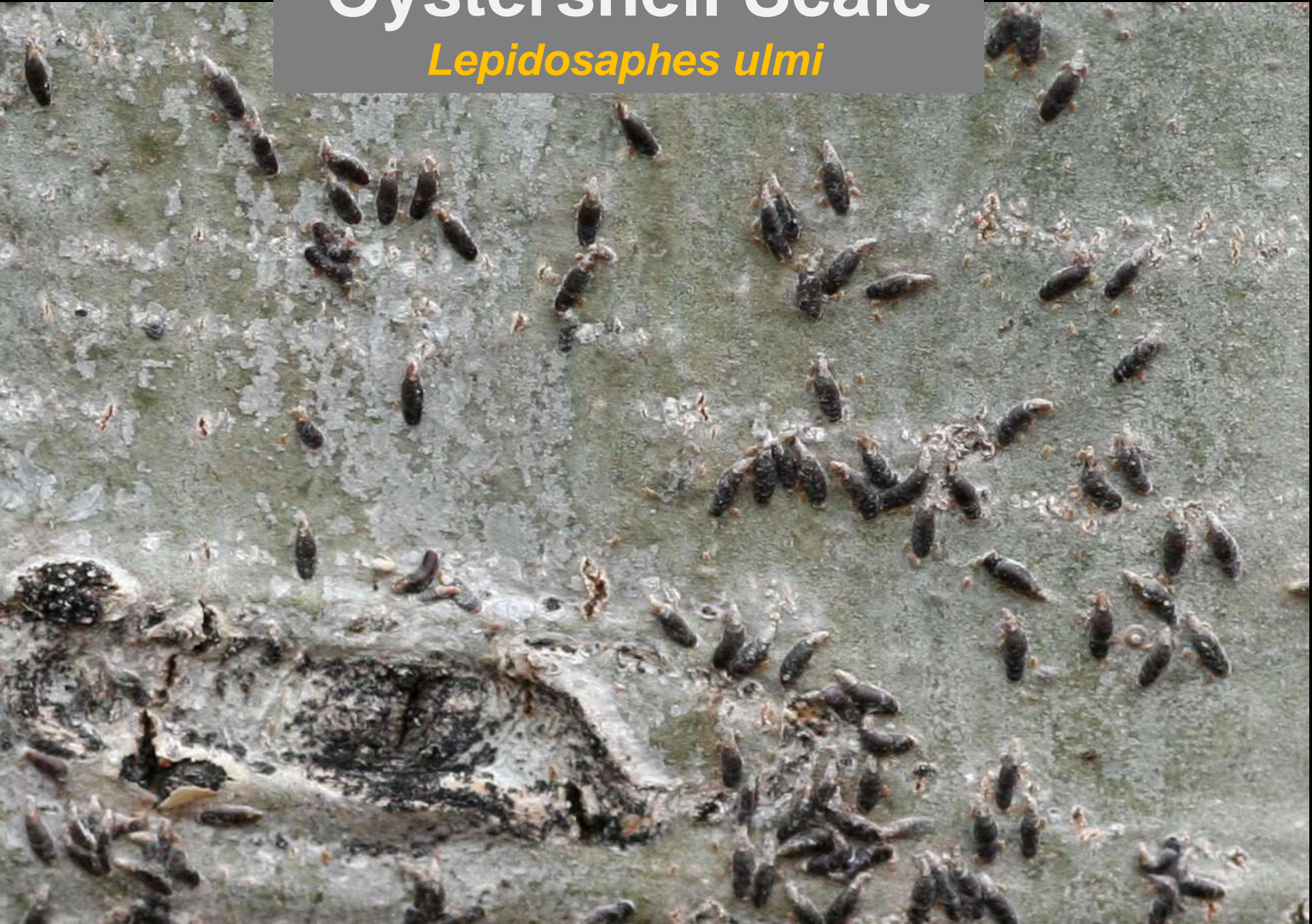
# Some Important Armored (Hard) Scales in Kansas

- Oystershell scale
- Pine needle scale
- Euonymus scale
- Obscure scale



# Oystershell Scale

*Lepidosaphes ulmi*







**Oystershell scale can develop thick colonies on the bark of susceptible hosts**



**Bark cracking is a common symptom of current or previous oystershell scale infestation of aspen**



**Oystershell scale infested trees. Note bark cracking.**





**Oystershell scale flipped over to exposure lower surface. Some eggs are visible at right where the 'test' has torn.**



**Oystershell scale eggs  
(left) and recently  
hatched eggs,  
producing the  
“crawler” stage**

**Eggs, under the cover  
of the mother, are the  
overwintering stage.**



**The crawler stage usually occurs in late May and early June. It lasts for about a week.**

**It is the only mobile stage of the oystershell scale – and all other armored scales.**





**Within about a week the crawlers have either 'settled' or died. They remain in place where they settled for the rest of their life.**



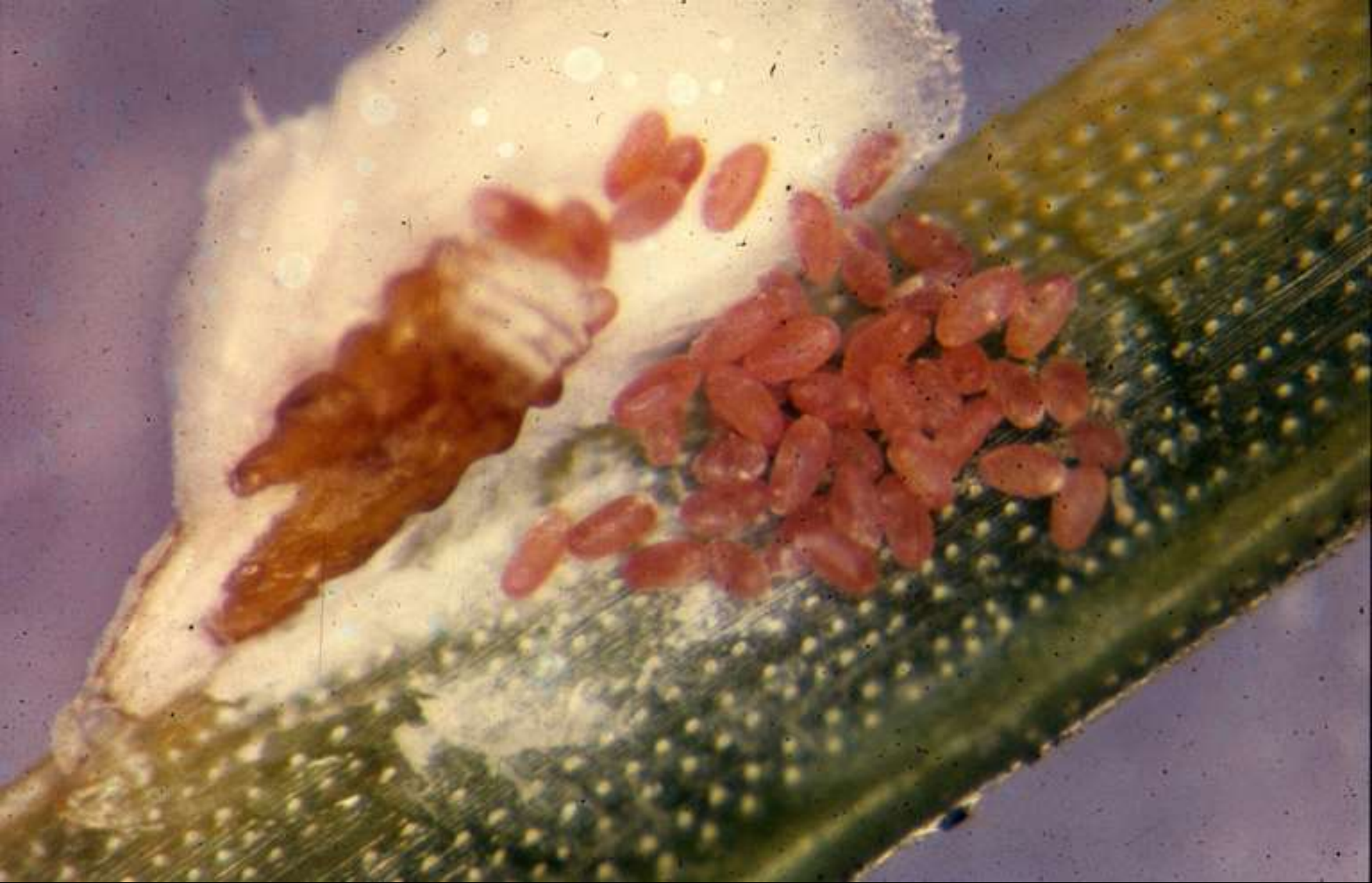


# Pine Needle Scale

Hosts: Pines, spruce







**Mother scale and recently laid eggs. Eggs are the primary overwintering stage.**





**Crawlers usually occur in early to mid May (ca. lilac full bloom)**

Settled crawlers of pine needle scale on needles



# Pine needle scale in mixed stages of development



Crawler





## Natural Enemies of Pine Needle Scale



Lady beetles that specialize in armored scales (*Coccidophilus* spp., *Chilocorus* spp.)



## Natural Enemies of Pine Needle Scale



## Parasitic Wasps



# Obscure scale

Host: oaks



Photograph courtesy of Emmett Muennik



Cover removed to expose developing scale



# Poplar/Willow Scale



UGA5024021



**Bark cracking  
(right) and bubbling  
(below) associated  
with poplar scale  
on aspen**



Oak lecanium



European elm scale



## Soft Scales

## Families Coccidae, Eriococcidae

Pine tortoise scale



Cottony maple scale



# Some Important Soft Scales in Kansas

- European fruit lecanium scale
- European elm scale
- Pine tortoise scale





**Soft Scale Example – Cottony Maple Scale**





**Overwintering stage –  
Adult females that have  
not matured eggs.**





**Females swell with eggs in late spring**





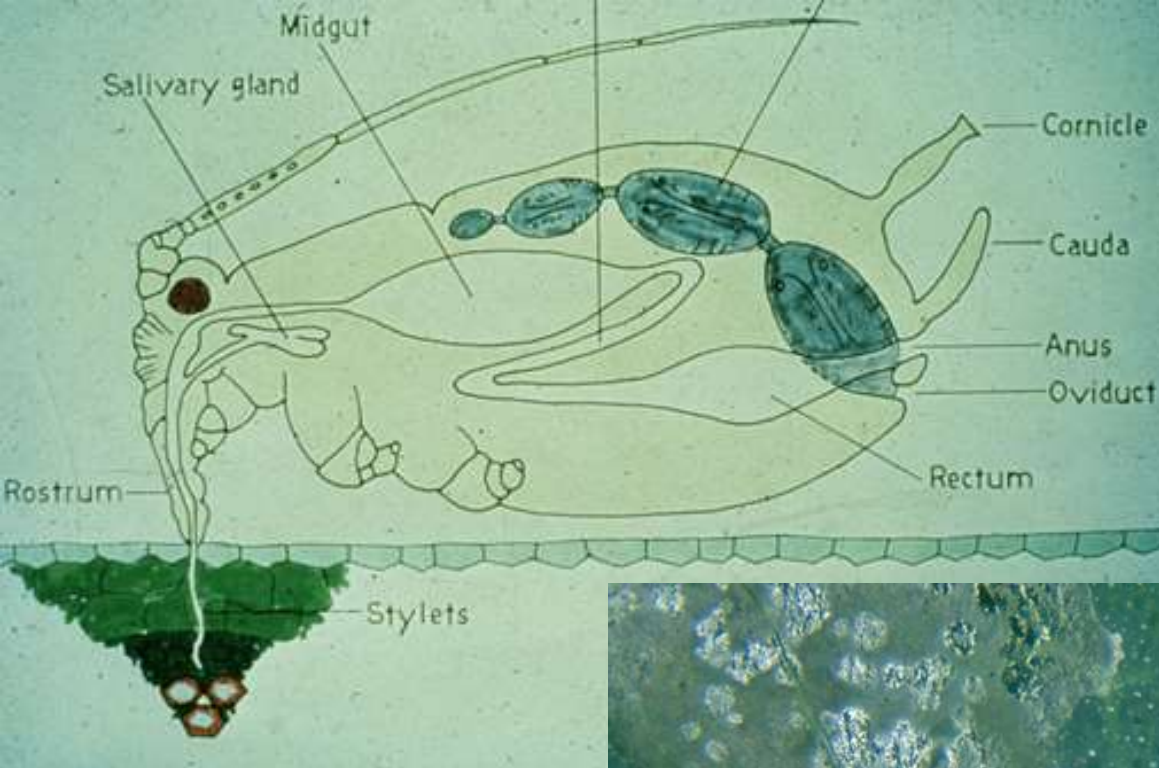
**Crawlers move to the leaves in summer**





**Overwintering stage –  
Adult females that have  
returned to the twigs in  
late summer.**



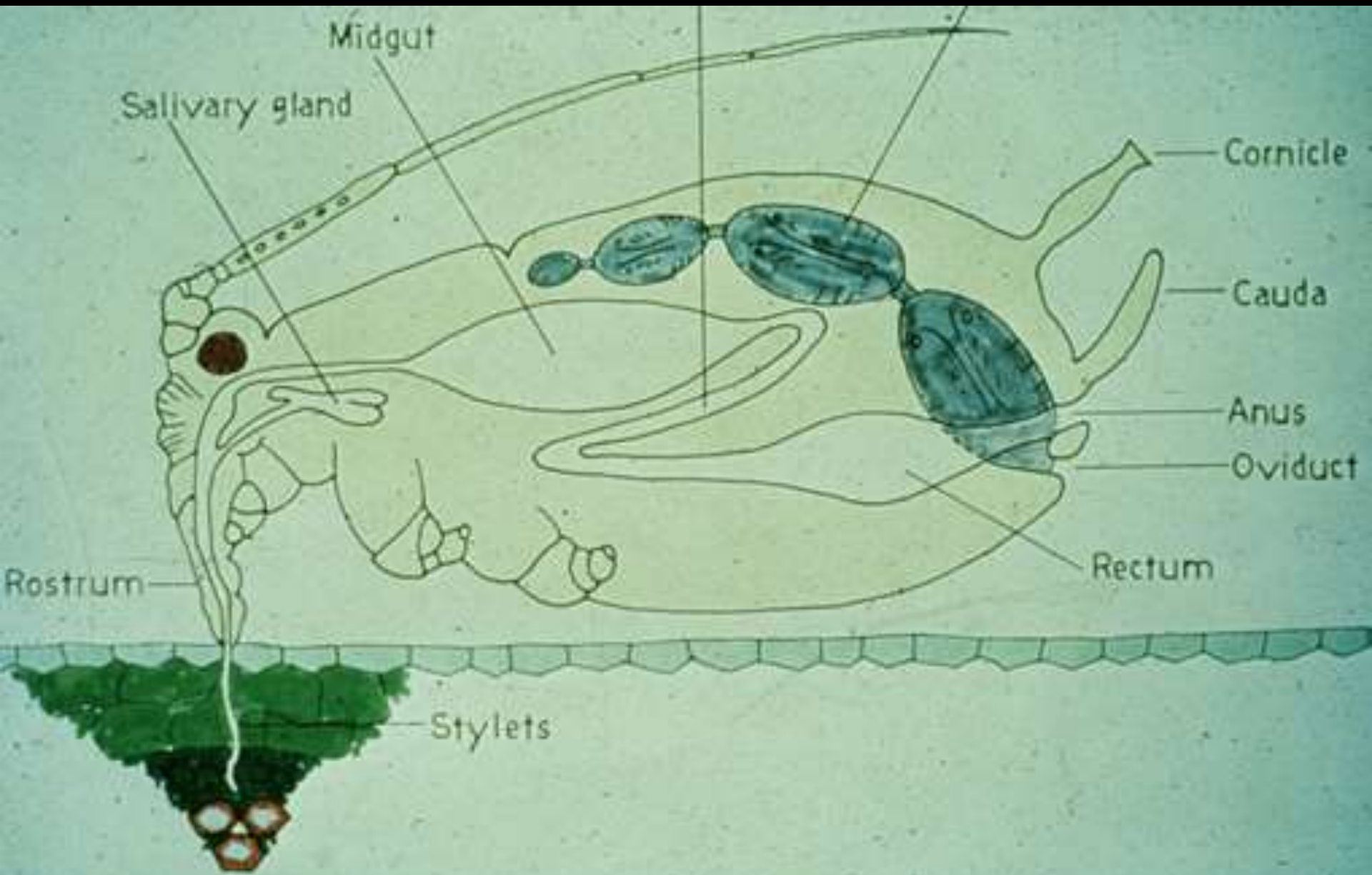


**Like aphids, soft scales suck sap from the phloem and excrete honeydew.**



**Honeydew droplets excreted by  
soft scale**

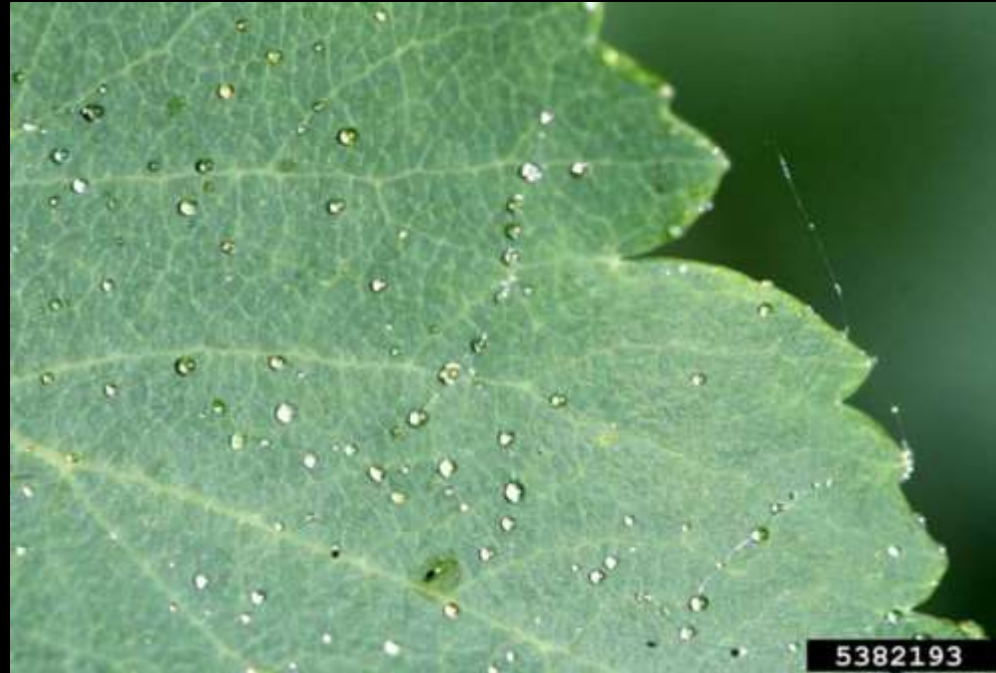






# Honeydew Producing Insects\*

- Aphids
- Soft scales
- Whiteflies
- Mealybugs
- Psyllids (some)
- Leafhoppers (phloem feeding species)



**\*All suck sap from the phloem**

# Sooty Molds

Fungi that grow on honeydew-contaminated surfaces





**Sooty mold  
growing on  
linden aphid  
honeydew**

**Sooty mold on bark of  
elm resulting from  
European elm scale  
honeydew**



**Sooty mold on bark (below)  
and sidewalk (right)  
resulting from honeydew  
produced by aspen aphids**



# Sooty mold from aphids and soft scales



# European Elm Scale





**Overwintering stages of European elm scale on twigs**



**Crawlers appear in midJune and are present for about a month**



# European elm scale crawlers





**European elm scale nymphs originally move to leaves where they feed during much of summer**



**Honeydew is excreted.  
Where it lands and  
persists, sooty molds  
grow.**





**Branch 'flagging' in late summer can be due to stress associated with high scale populations.**



**Crawlers return to twigs in late summer for overwintering.**



**Soft Scale Example – Striped Pine Scale**



**Overwintered females  
begin to swell with eggs in  
mid-late spring**





**Eggs hatch and crawlers are present from early June through early July.**



**Females settle at the base of needles**

**Males settle on the needles**





# Soft Scales vs. Armored Scales



**Soft scales produce honeydew**

**Armored scales do not produce honeydew**



# Soft Scales vs. Armored Scales



**Soft scales typically produce several hundred eggs**

**Armored scales typically produce a couple of dozen eggs**



# Soft Scales vs. Armored Scales



**Soft scales retain mobility through their lifetime, moving from foliage to twigs**

**Armored scales are only active during the crawler period**



# Soft Scales vs. Armored Scales



**Soft scales typically produce crawlers for several weeks in late spring and early summer**

**Armored scales typically produce crawlers for a week or two in spring**



# Principles of Scale Control

- **Hand removal**
- **Sprays directed at crawlers**
- **Oils**
  - **Dormant season treatment**
  - **Post-crawler treatment**
- **Systemic insecticides**





**Scraping  
oystershell  
scale**

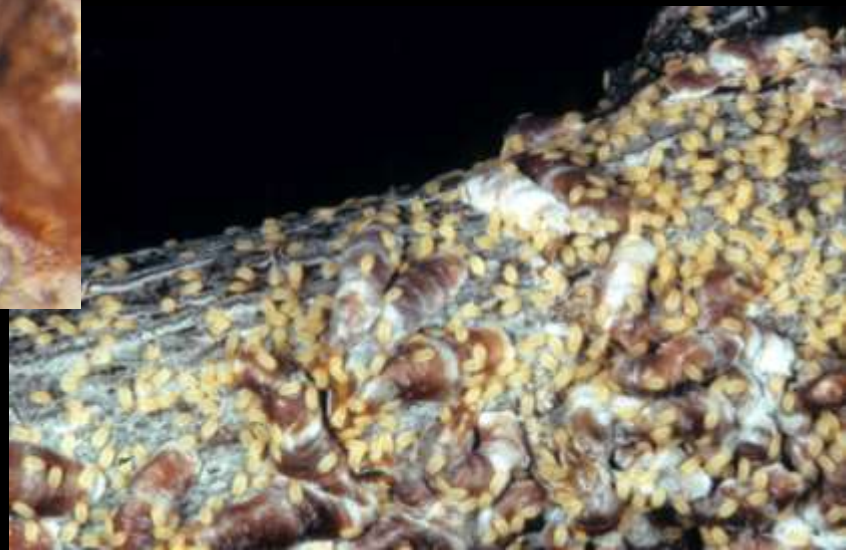




# Crawler treatments



***Crawler stages of scale insects are highly vulnerable to insecticides!***



# Crawler Treatment Strategies

- Apply insecticides with long residual activity *when crawler period is expected to begin.*
- Apply insecticides with short residual activity *at peak period of crawler activity*



# Monitoring for Scale Insect Crawlers Using Double-sided Sticky Tape



Photographs courtesy of University of California Statewide IPM Program

# Monitoring for Scale Insect Crawlers Using Double-sided Sticky Tape



Photographs courtesy of University of California Statewide IPM Program



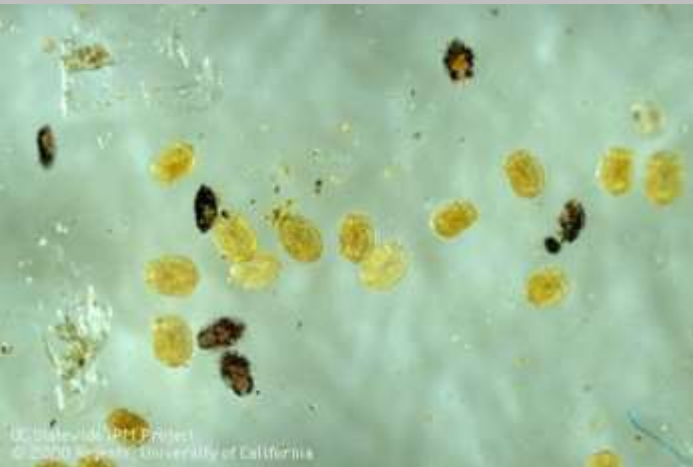
# Scale Monitoring Using Sticky Tape

- Use double sided clear tape, black electrical tape, or even white tape coated with a thin layer of petroleum jelly
  - Best tape color depends on crawler color



# Scale Monitoring Using Sticky Tape

- Use double sided clear tape, black electrical tape, or even white tape coated with a thin layer of petroleum jelly
  - Best tape color depends on crawler color)
- Flag the branch and check several times per week starting 10-14 days before expected emergence



# Crawler Treatments with Residual Activity (weeks)

- **Persistent pyrethroids**
  - Bifenthrin (Onyx, Talstar)
  - Permethrin (Astro, etc.)
  - Cyfluthrin (Tempo)
- **Carbaryl (Sevin)**
- **Pyriproxifen (Distance, Fulcrum, etc.)**
- **Acetamiprid (TriStar)**
- **Dinotefuran (Safari, Zylam, etc.)**



**Insecticides that kill  
many insect species  
and are sprayed on  
foliage slaughter  
natural enemies!**



# Scale Crawler Treatments with Long Residual Activity

- Bifenthrin (Onyx, Talstar, etc.)
- Permethrin (Astro, Permethrin, etc.)
- Cyfluthrin (Tempo)
- Carbaryl (Sevin)
- Pyriproxifen (Distance, Fulcrum, Endeavor)
- Acetamiprid (TriStar)
- Dinotefuran (Safari, Zylam, Transtect)

# Residual Scale Crawler Treatments *that Conserve Natural Enemies*

- Bifenthrin (Onyx, Talstar, etc.)
- Permethrin (Astro, Permethrin, etc.)
- Cyfluthrin (Tempo)
- Carbaryl (Sevin)
- **Pyriproxifen** (Distance, Fulcrum, Endeavor)
- Acetamiprid (TriStar)
- Dinotefuran (Safari, Zylam, Transtect)

# Pyriproxifen as a scale insect treatment

- Trade names Distance, Fulcrum, Endeavor
- Acts on hormones insects use in development (IGR)
- Mostly works on scales, aphids and related sucking insects
- Very little effect on natural enemies of insect pests



# Pyriproxifen as a scale insect treatment

- Trade names Distance, Fulcrum
- **Acts on hormones insects use in development (IGR)**
  - Juvenile hormone mimic
- Mostly works on scales, aphids and related sucking insects
- Very little effect on natural enemies of insect pests





# Pyriproxifen as a scale insect treatment

- Trade names Distance, Fulcrum
- Acts on hormones insects use in development (IGR)
- **Mostly works on scales, aphids and related sucking insects**
  - Fungus gnats, mosquitoes are other markets
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# Pyriproxifen as a scale insect treatment

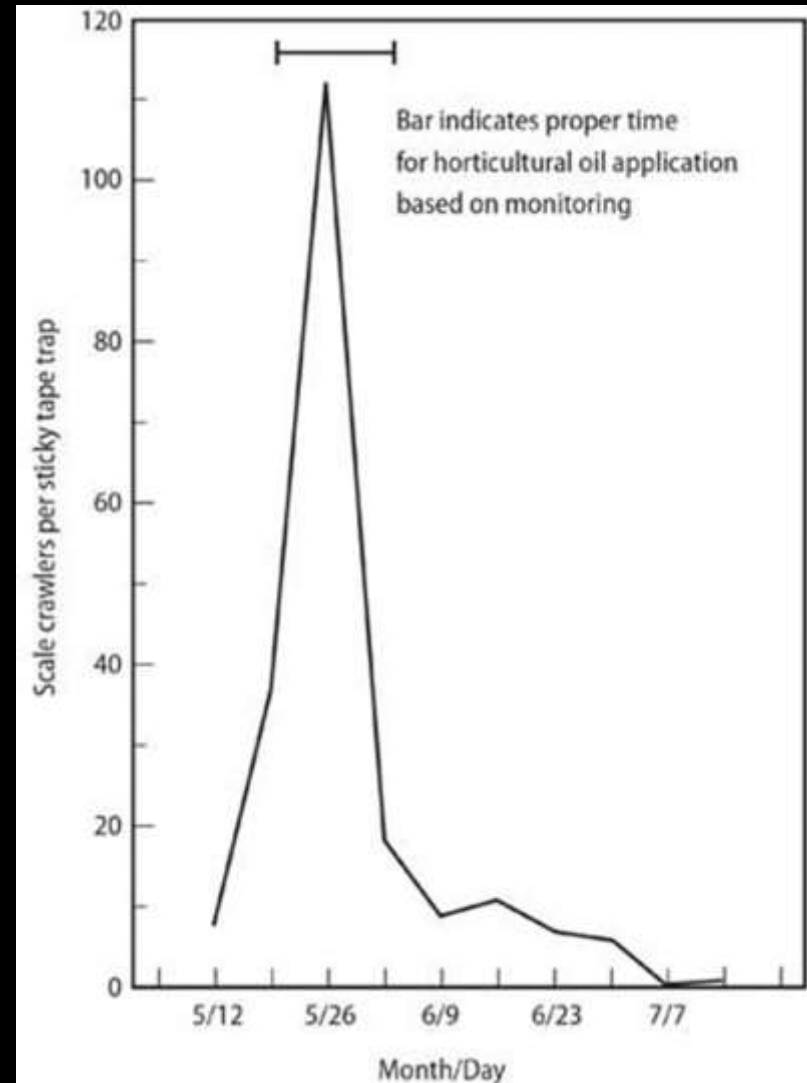
- Trade names Distance, Fulcrum
- Acts on hormones insects use in development (IGR)
- Mostly works on scales, aphids and related sucking insects
- **Very little effect on natural enemies of insect pests**
  - ***Allows integration of biological controls with chemical controls***



# Contact Treatment *without* *Residual Effects*

- Horticultural oils
- Insecticidal soaps

Timing: *Around peak period of crawler activity*



# Soaps vs. Oils against young scales



# Oils: Better on armored scales

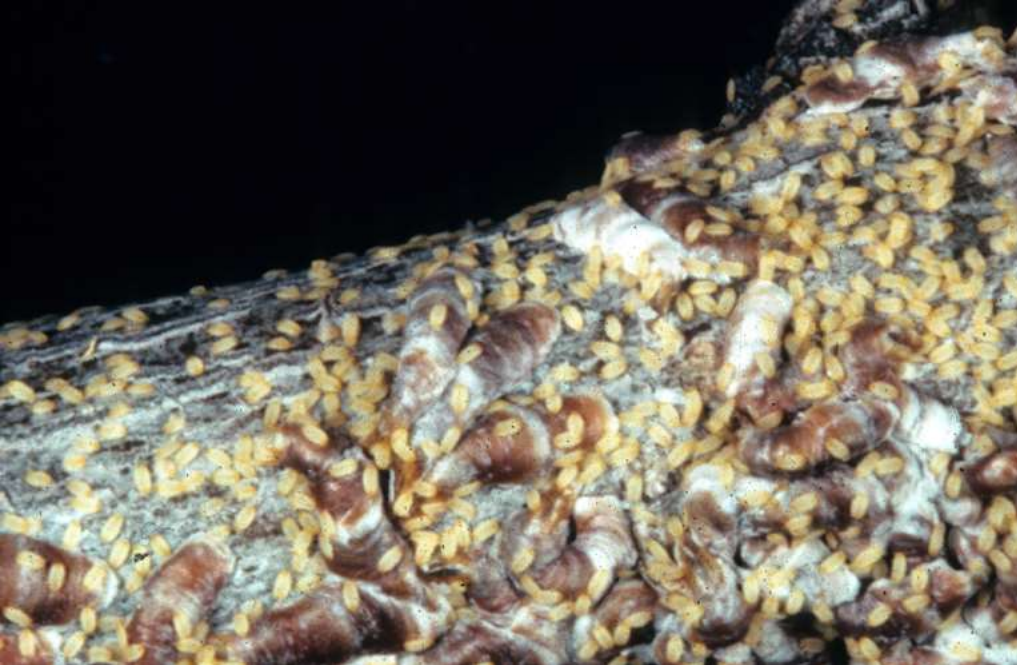


# Soaps: Better on soft scales





Oils used during the dormant season can help control scales – *with very little impact on natural enemies*



Current horticultural oils can be used on trees with foliage.

Crawlers and young settled scales are targets.



TRUSTED SINCE 1926  
**BONIDE**<sup>®</sup>

Kills Insects by Smothering.

For use on...

- Fruit Trees
- Shade Trees
- Evergreens
- Ornamentals
- Flowers
- House Plants

Use Year-Round

**All Seasons**<sup>®</sup>  
 Horticultural & Dormant Spray Oil

*C.o.n.c.e.n.t.r.a.t.e*  
 MAKES 12 GALLONS

ACTIVE INGREDIENT	Petroleum Oil (Superior type U.S. No. 22)	99.00%
OTHER INGREDIENTS		1.00%
TOTAL		100.00%

KEEP OUT OF REACH OF CHILDREN  
**CAUTION**  
 (See Back Panel for Additional Precautionary Statements)

Net Contents 16 FL. OZ. (1 Pt.) (473 ML.)

218

# Systemic Insecticides and Scale Insects?

- **Soil applications**
  - Dinotefuran (Safari, Zylam, Transtect)
  - Acephate (Orthene, Lepitect)
  - Imidacloprid (Merit, Mallet, Zenith, etc.)
    - *Soft scales only*
- **Trunk spray applications**
  - Dinotefuran (Safari, Xylam, Transtect)
  - Acetamiprid (Tristar)



Systemic insecticides applied to the soil for root uptake *are primarily effective against phloem-feeding soft scales*

**'Soft' Scales**

**Armored Scales**



# Scale insect control

## Imidacloprid applied as soil drench?



# Soft Scales vs. Armored Scales



**Feeding Site: Phloem**

**Soft scales produce honeydew**



**Feeding Site: Cells, often of the cambium**

**Armored scales do not produce honeydew**



**Imidacloprid  
Control Range**

**Yes – Soft Scale**



**No – Armored  
Scale**

# Soil Systemic Insecticides and Scale Insects?

- Imidacloprid (Merit, Mallet, Zenith, etc.)
  - ***Soft scales only***
- Dinotefuran (Safari, Zylam, Transtect)
  - ***Soft scales and armored scales***



Retail formulation

# Dinotefuran formulations

## Commercial formulations for ornamentals

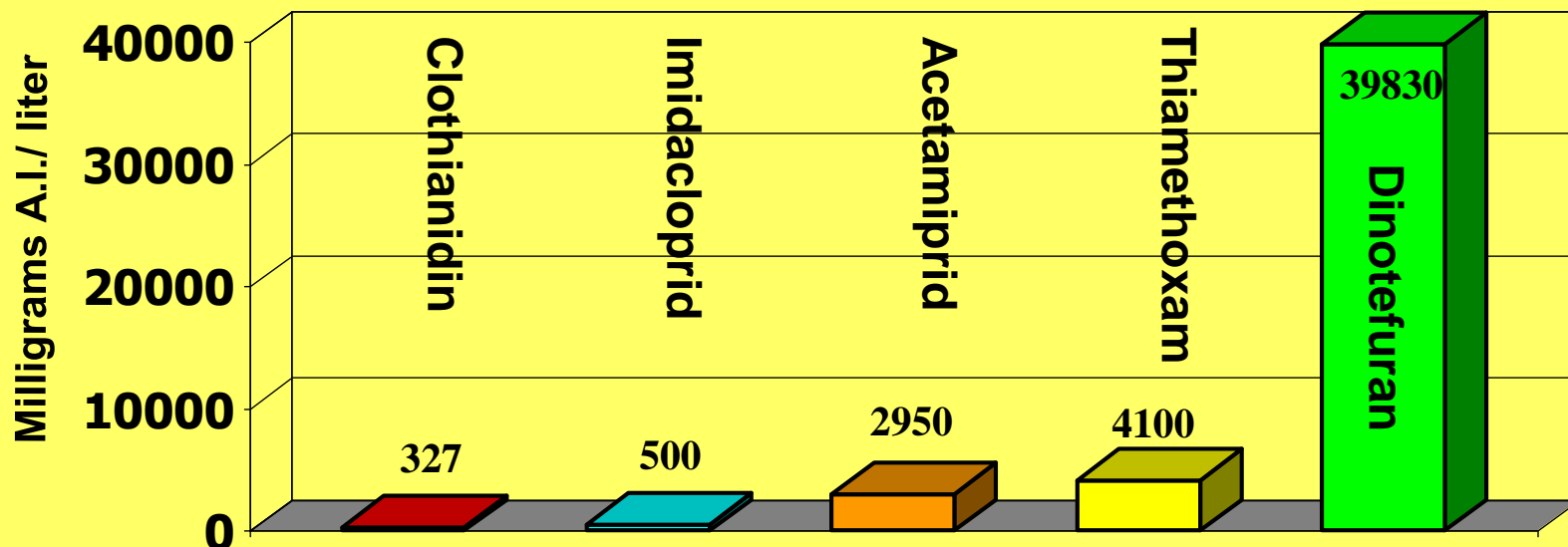


DoMyOwnPestControl.com



# Relative Water Solubility of Neonicotinoids:

## *Water Solubility (Active Ingredient)*



### ***Information sources***

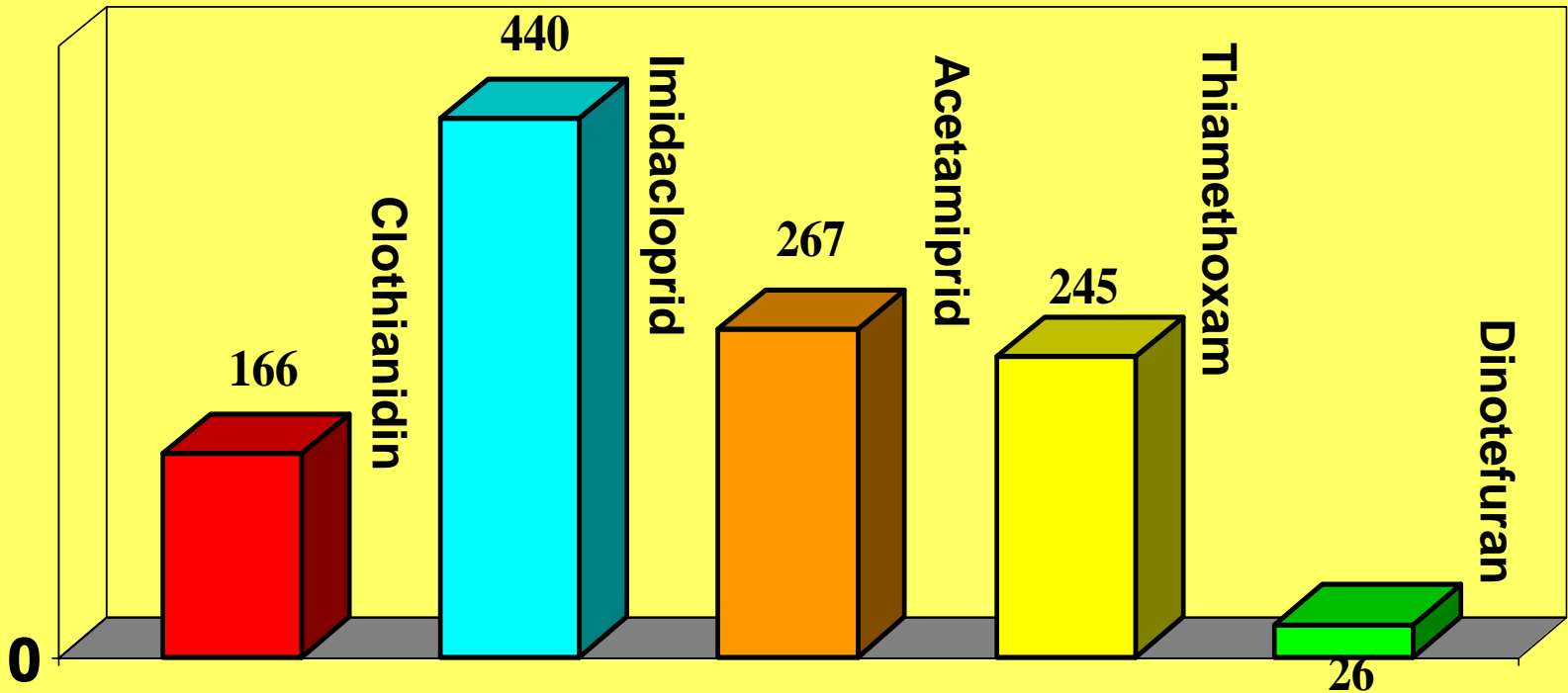
*Clothianidin (Celero), Acetamiprid (Tristar), Dinotefuran (Safari) – EPA Pesticide Fact Sheet  
Imidacloprid (Marathon), thiamethoxam (Flagship) – MSDS for Products*

Slide information courtesy J. Chamberlin



*Longwood  
Gardens*

# $K_{oc}$ Values of Neonicotinoids:



Source Data: EPA Pesticide Fact Sheets



*Longwood Gardens*



# Dinotefuran (Safari, Zylam)

- **Neonicotinoid insecticide**
- **Primarily labeled to control insects that suck sap (Order Hemiptera)**
  - Aphids
  - Soft scales
  - ***Armored scales***
- **Has systemic activity in plants**
  - **More mobile in plant than other neonicotinoids**



**Basal trunk spray with  
dinotefuran (Safari, Zylam)**



**Whole tree sprays produce surface residues on all foliage. Natural enemies are killed. Natural controls are wasted.**



**Treatment area limited to bark of lower trunk. Impacts on natural enemies are minimized**



**Basal trunk spray with  
acetamiprid?**





Retail formulation

# Acetamiprid formulations

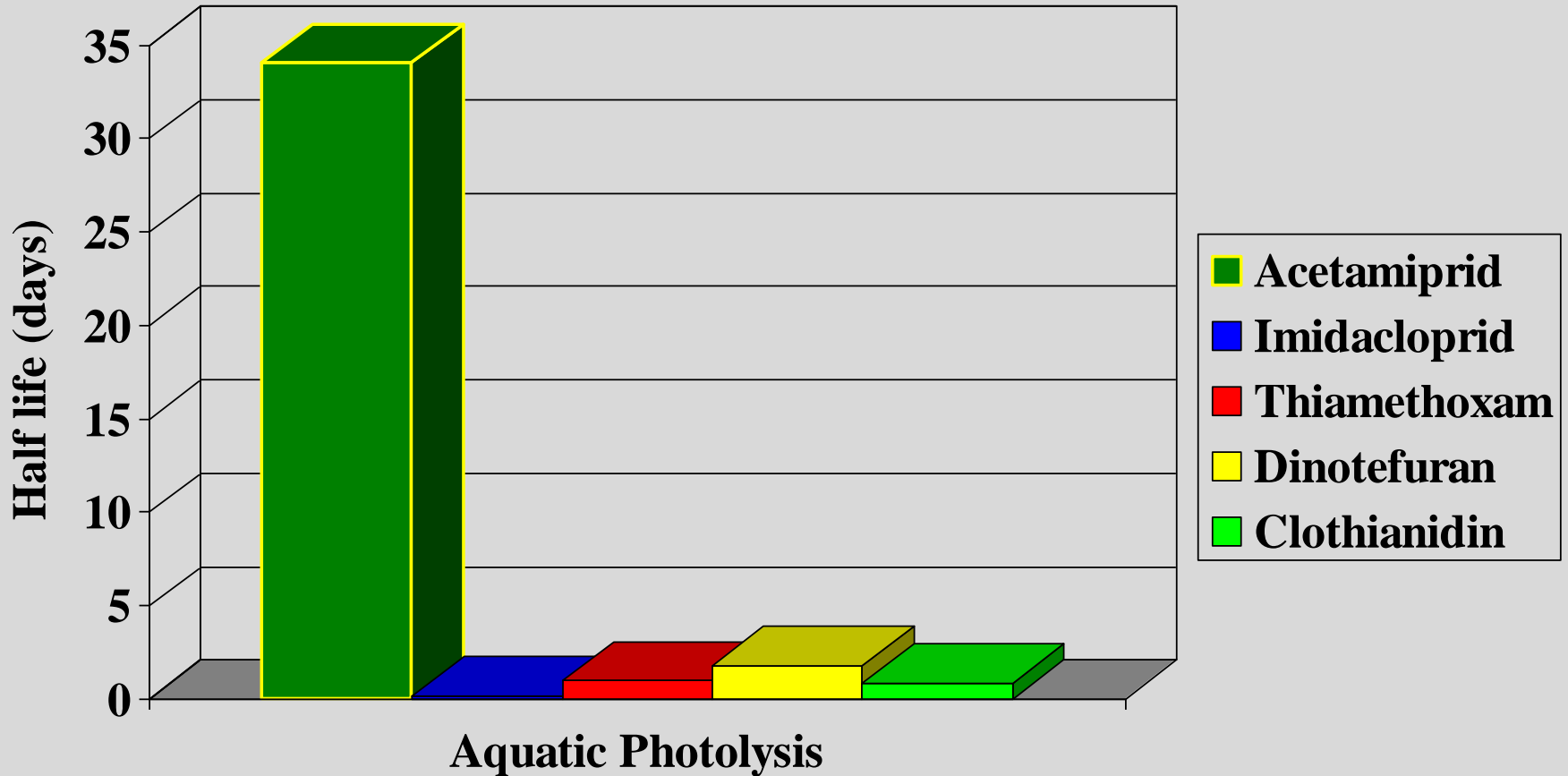
Commercial formulation for ornamentals



Commercial formulation for fruits and vegetables



# Comparison of UV Stability



Data obtained from published EPA registration documents

# UV Stability

Neonictinoids are generally not UV stable. Foliar persistence can be shortened by this feature.

**Acetamiprid** is an exception.



# Acute Toxicity of Neonicotinoids to Adult Honey Bees

(Oral LD50 – micrograms/bee)



• Acetamiprid	14.53
• Imidacloprid	0.005
• Dinotefuran	0.056
• Thiamethoxam	0.005
• Chlothianidin	0.0003





**European Elm  
Scale – *and  
resistance to  
neonicotinoid  
insecticides***



**Prior to about 1995  
European elm scale  
was controlled by  
spraying elm trees  
with insecticides in  
spring to kill  
overwintering stages  
on the twigs.**

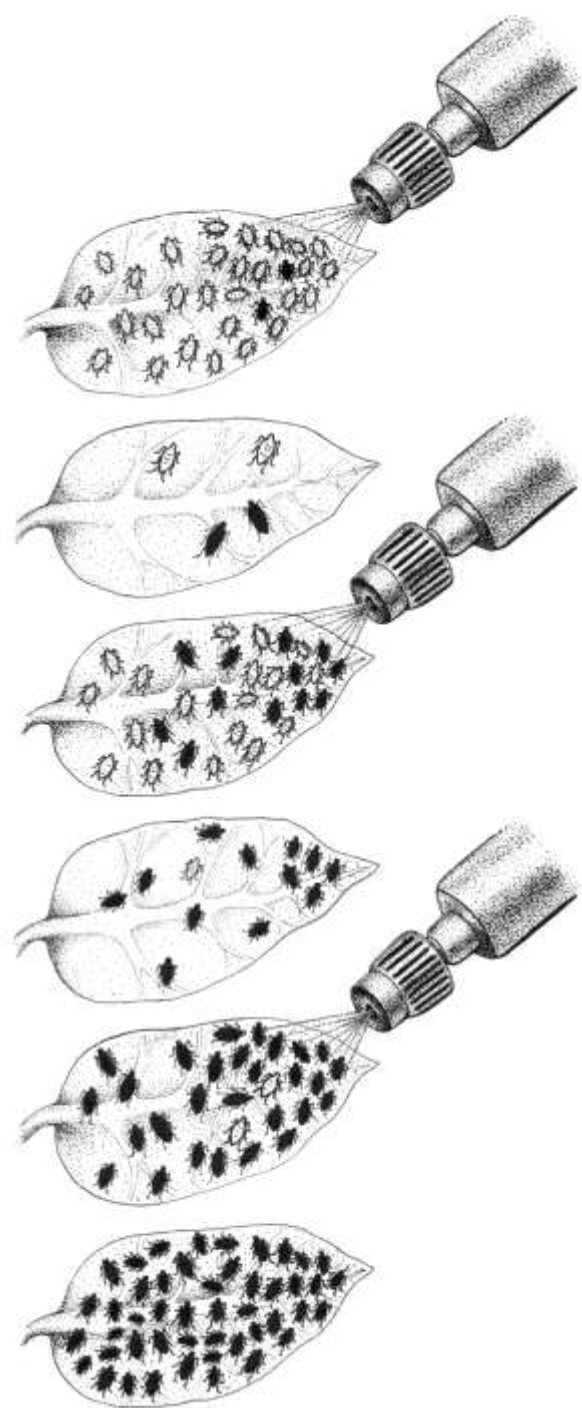


**European elm scale was one of the first shade tree insects against which the new insecticide imidacloprid was tested (ca 1993).**

**The results were fantastic.**

**Soil injection of elm was embraced rapidly by the Colorado tree care community**

**Insecticide resistance develops by selecting individuals that have genetic traits that allow the insect to resist effects of the pesticide**





## Recipe for Resistance

**Sustained applications of neonicotinoids have been applied to almost every scale-infested elm over large areas in Colorado for almost 2 decades.**





European Elm Scale in  
Colorado – *A poster child  
example of how to  
develop insect resistance  
in a shade tree pest*



# Some Neonicotinoid Insecticides Used for Woody Plants

- **Imidacloprid** (Merit, Criterion, Marathon, many generics)
- **Clothianidin** (Arena, Poncho)
- **Thiamethoxam** (Flagship, Meridian)
- **Dinotefuran** (Safari)
- **Acetamiprid** (Tristar)

*If resistance develops to one of these insecticides – it develops in all of these insecticides!*

# European Elm Scale Options in a Post-Neonicotinoid Period?

- **Soil/Trunk Injections**
  - Acephate (Lepitect, AceJet)
  - Azadirachtin
- **Foliar Applications**
  - Pyriproxifen (Distance, Fulcrum, Endeavor)







# Elm Scale trial at the CSU Oval - 2014



# 2016 Evaluations European Elm Scale

- **Highest EES numbers**
  - Imidacloprid (Zenith) applied in 2014
    - 48 scales per foot of twig
  - Untreated check (no insecticide since 2012)
    - 33 scales per foot of twig



# 2016 Evaluations European Elm Scale

- **Lowest EES numbers \***

- **Distance (applied spring 2014)**

- 7 scales/foot of twig (with oil)
- 12 scales/foot of twig (w/o oil)

- **ACE-Jet (acephate) (trunk injection 2015)**

- 10 scales/foot of twig

- AzaGuard (azadirachtin) (trunk injection 2015)

- 11 scales/foot of twig

- Lepitect (acephate) (soil injection late spring 2015)

- 14 scales/foot of twig

- Azasol (azadirachtin) (trunk injection 2015)

- 19 scales/foot of twig

\* Control had  
33 scales/foot

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## – **Azasol (azadirachtin) (trunk injection 2015)**

- 19 scales/foot of twig

# Most Promising “Plan B”

## Treatments from Elm Scale Trial

- **Pyriproxifen (spray)**
  - Trade names: Distance, Fulcrum
- **Azadirachtin (trunk injected)**
  - Trade names: Azasol, Azaguard, others
- **Acephate (trunk injected, soil injected)**
  - Trade names: ACE-Jet (trunk inject); Lepitect (soil drench)

# Pyriproxifen as a scale insect treatment

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- Acts on hormones insects use in development (IGR)
- Mostly works on scales, aphids and related sucking insects
- Very little effect on natural enemies of insect pests



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  - ***Allows integration of biological controls with chemical controls***



**What kinds of natural enemies work on European elm scale in Colorado?**



Convergent lady beetle



Sevenspotted lady beetle



## Primary EES Predators



Larvae of green lacewing



Lady beetles mostly seem to be grazing when there are large numbers of crawlers

What about parasitoids?





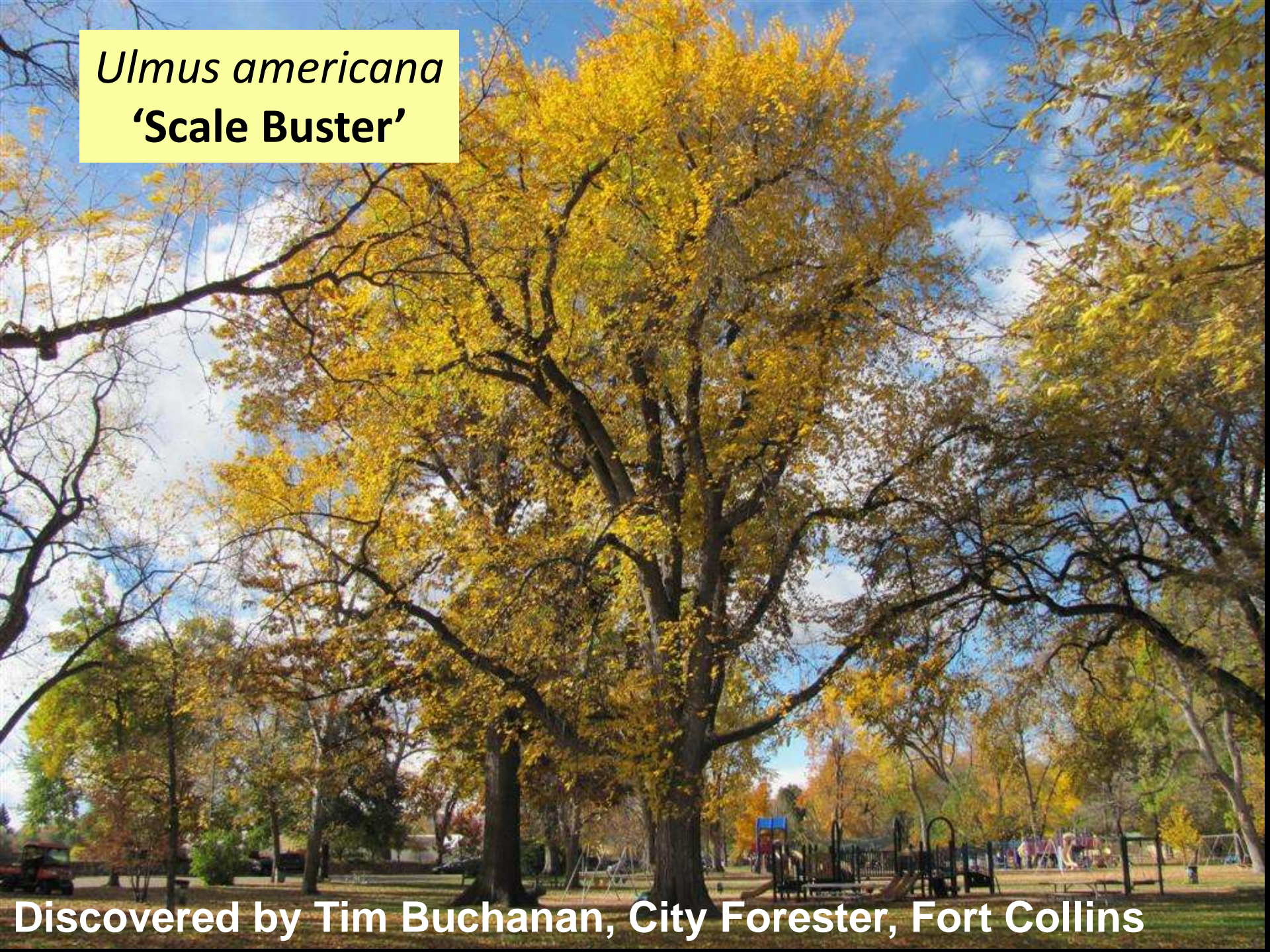
What about parasitoids?



American elms resistant  
to the scale insect?



*Ulmus americana*  
**'Scale Buster'**



**Discovered by Tim Buchanan, City Forester, Fort Collins**



Cuttings from Scalebuster were first taken for propagation in 1996.

Five years later these were planted out around Fort Collins.



## Typical American elm



**'Scale Buster'**





## Observation during 2017 of CU elm scale trial

One untreated tree had the lowest numbers of scale of all trees.

Scales that were present were confined to wound sites/callous tissue





One other tree on campus was also found to never have much scale



The long-term  
future for  
American elm  
in the West?

*It will depend on  
developing **scale-  
resistant**  
cultivars*



# Drippy Blight of Red Oaks

An unusual association between a scale insect and bacterial pathogen





**The insect partner:**

**Pin oak kermes**

*Allokermes galliformis*

**Contribution:**

**Production of wounds  
at feeding site.**

**Damaged tissues  
allow entry (and exit)  
of bacterial pathogen.**







**The pathogen partner:**

**Lqq**

***Lonsdalea quercina* var.  
*quercina***

**Contribution:** Produces  
cankers that contribute to  
twig dieback

**Produces viscous ooze  
that drips from trees**



**Examples of  
bacterial cankers  
developing around  
scale feeding sites**



Result?



Twig dieback, flagging



Abscission of twigs

Which leads to:



Reduction in healthy foliage

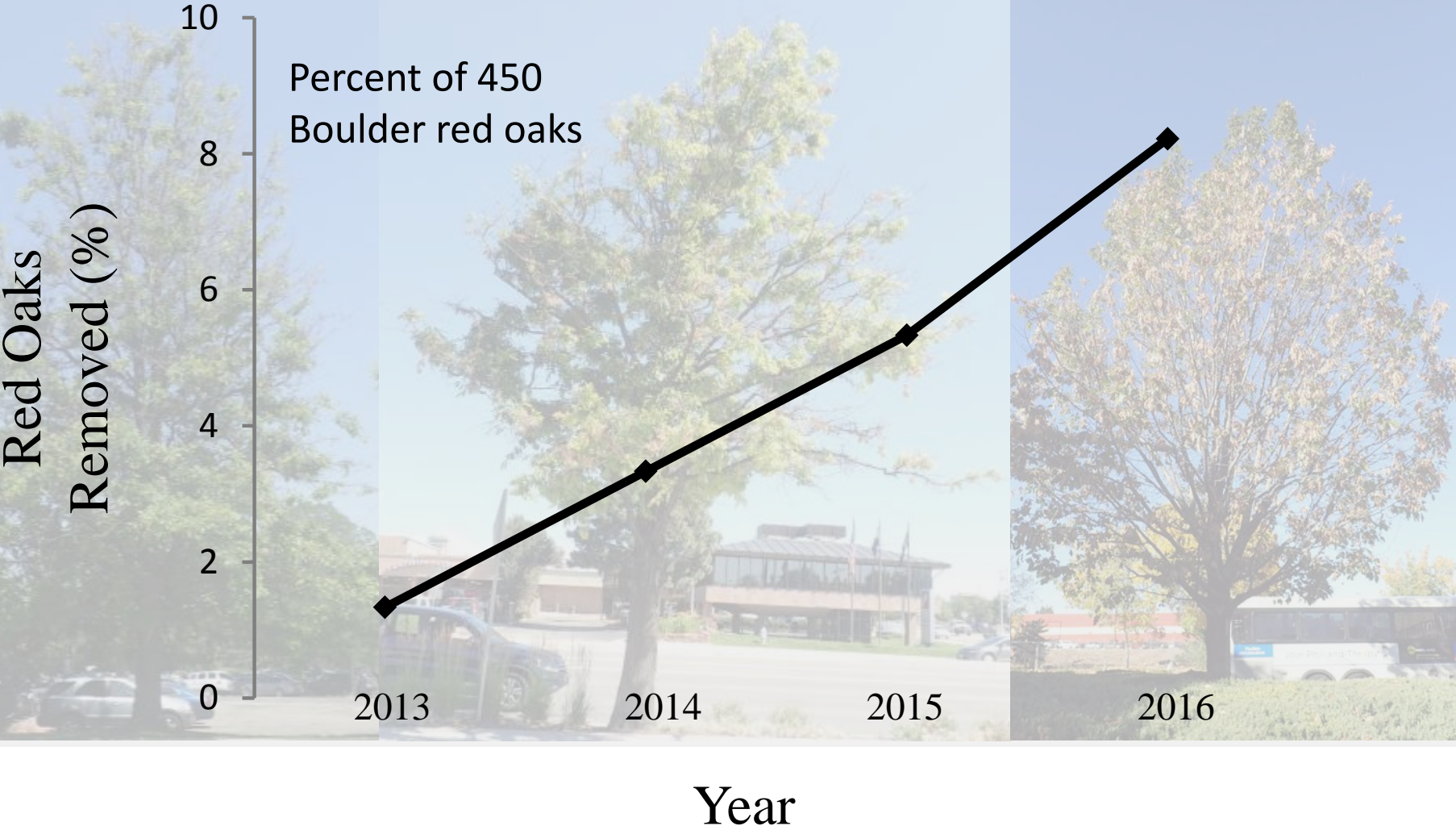


Progressive dieback of canopy



Invasion by flatheaded  
appletree borer

# Trees that have sustained injury decline and become candidates for removal

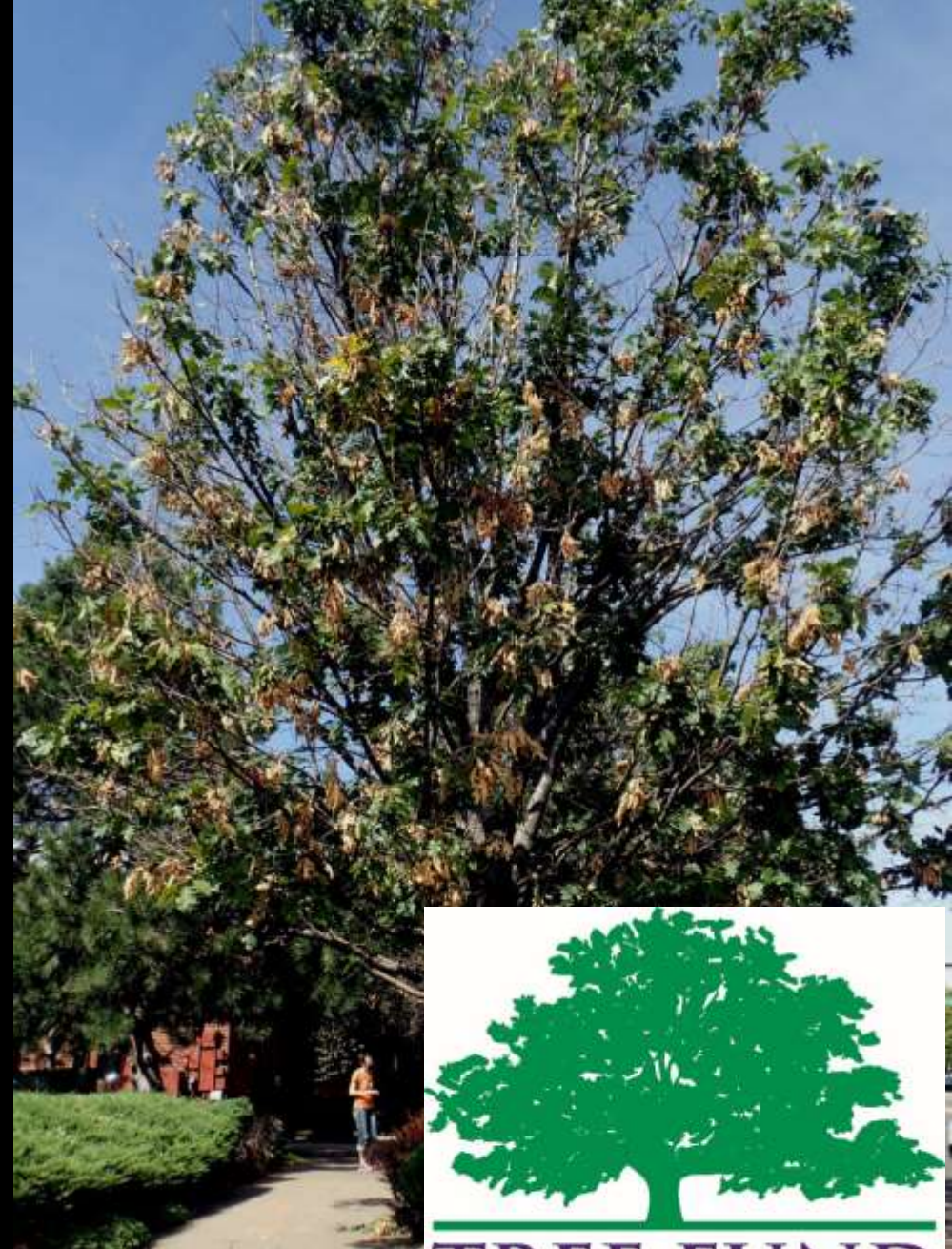




**Important Credit!**

The drippy blight work has been done by **Rachael Sitz**





## Important Credit!

The drippy blight work has been done by Rachael Sitz

and supported by the  
**ISA Tree Fund**

# *Allokermes galliformis* development

**First Instar  
Crawlers**



**Settled First  
Instars**



**Second  
Instars**



**Third Instar  
Female**



**Adult Female**



JAN

FEB

MAR

APR

MAY

JUN

JULY

AUG

SEPT

OCT

NOV


DEC

**Growing Season**





Eggs develop in late August and September



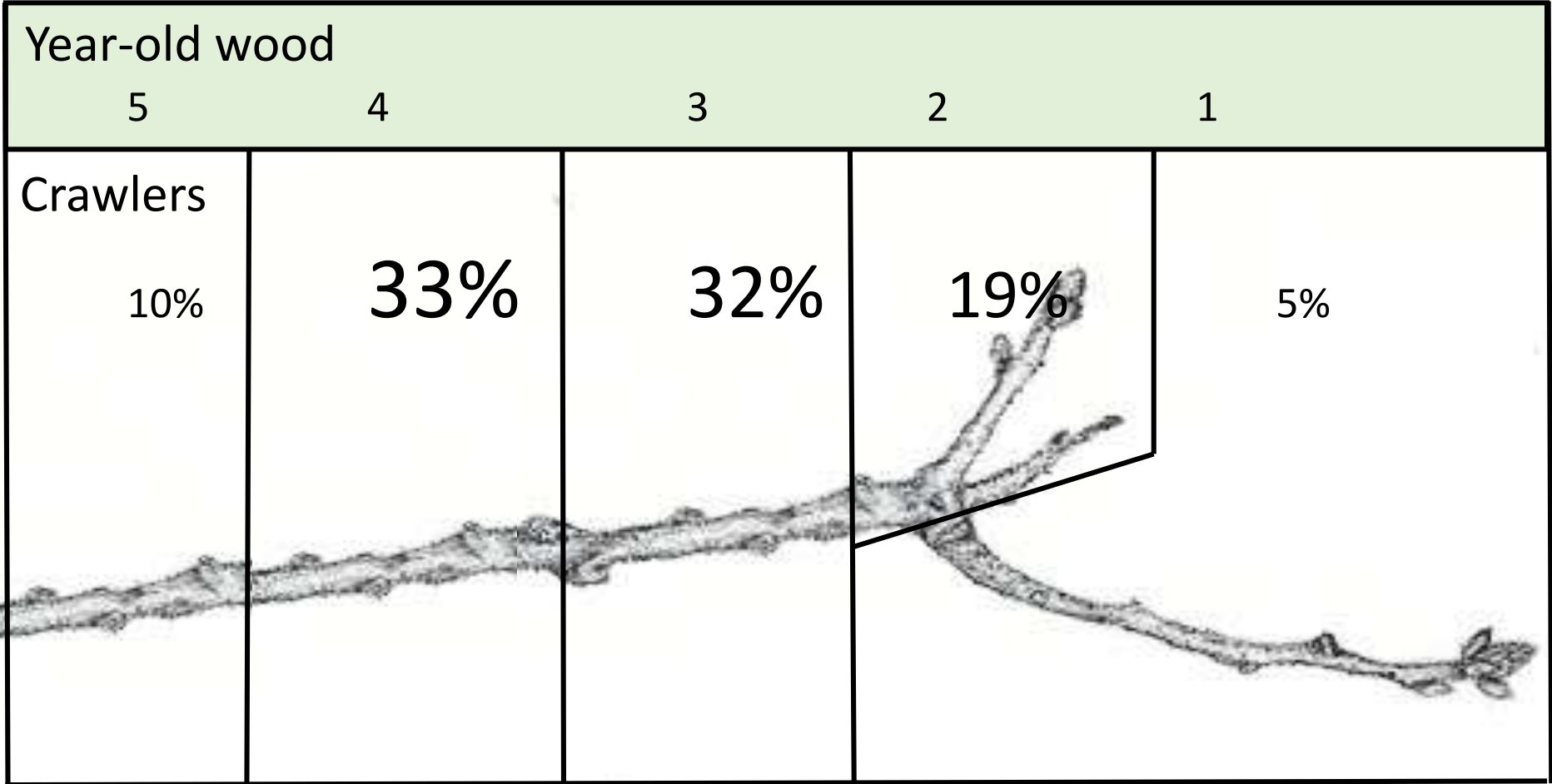
Eggs hatch from midSeptember into November

Average number of eggs produced?

In 2015 the average was 2488 eggs/female

In 2016 the average was 4726 eggs/female

# Most of the scales spend winter on wood that is 2-4 years old



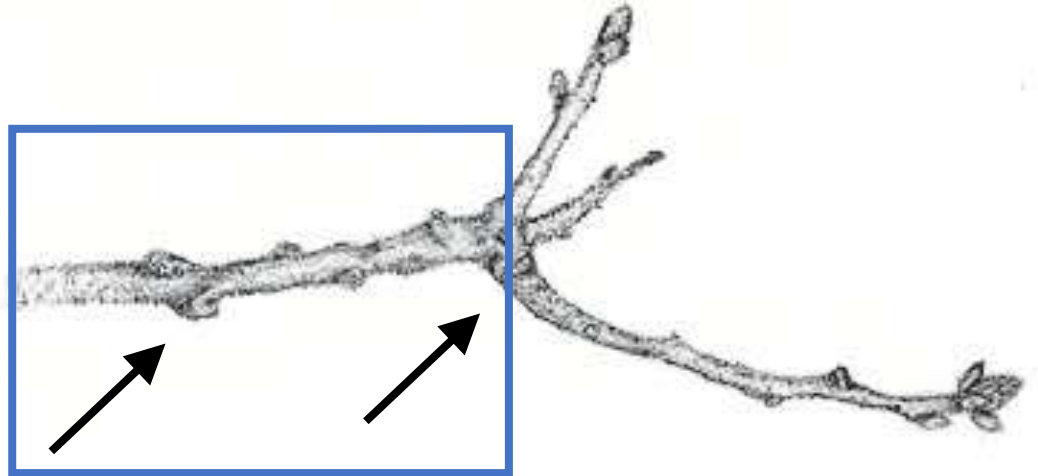
Percent of 5,480 crawlers

# Insect overwintering locations

Majority settle on:

3 to 4 year old growth

Growth rings & bark fissures

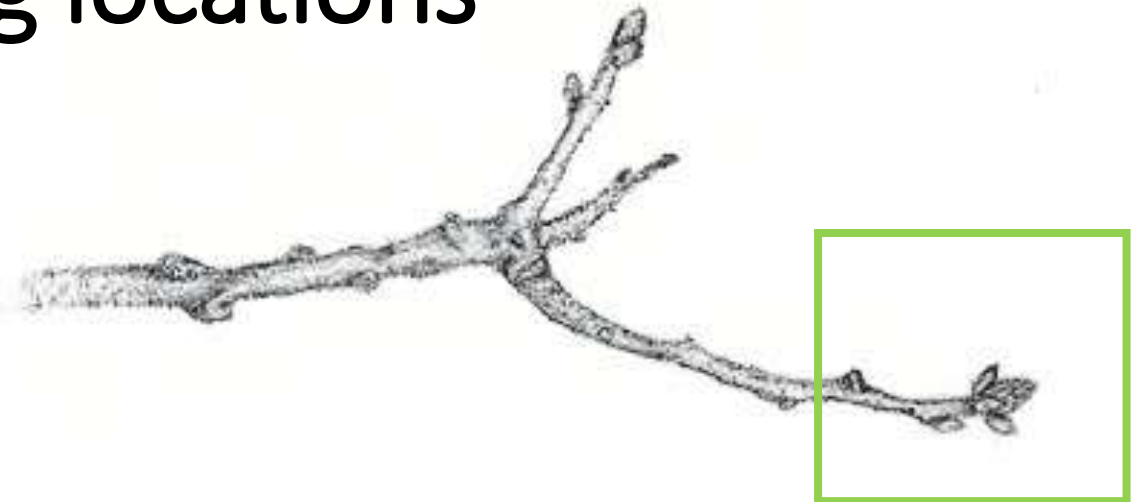


# Insect feeding locations

Primarily move to:

New growth

Become sessile



**There is a spring migration around bud break as the scales move to the new growth**



Scale settled near bud

At this point they permanently settle.

The female will grow enormously over the next 2-3 months.



Developing scales clustered at growth ring



Oozing, dripping, and twig dieback/abscission accelerate in late June and peak in July.

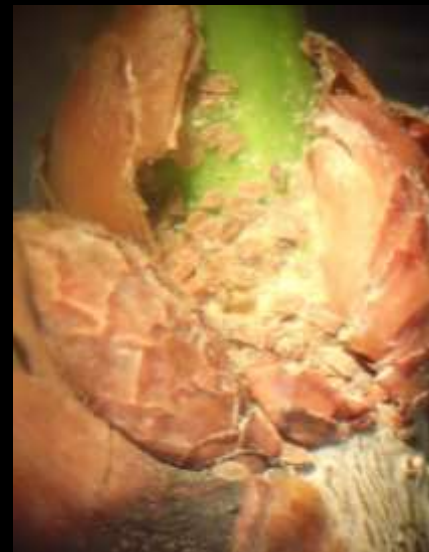
# Management of Drippy Blight

- Principal Target – **the Scale**
- Sprays?
  - Dormant season - target stages on 2-4 year wood
  - Bud break – concentrate at buds
  - Treatments
    - Horticultural oils, Distance, other scale products
- Soil Applied systemics?



# Management of Drippy Blight

- Principal Target – the **Scale**
- Sprays?
  - Dormant season - target stages on **2-4 year wood**
  - Near bud break – **concentrate at buds**
  - Treatments
    - **Horticultural oils, Distance, other scale products**
- Soil Applied systemics?



# Management of Drippy Blight

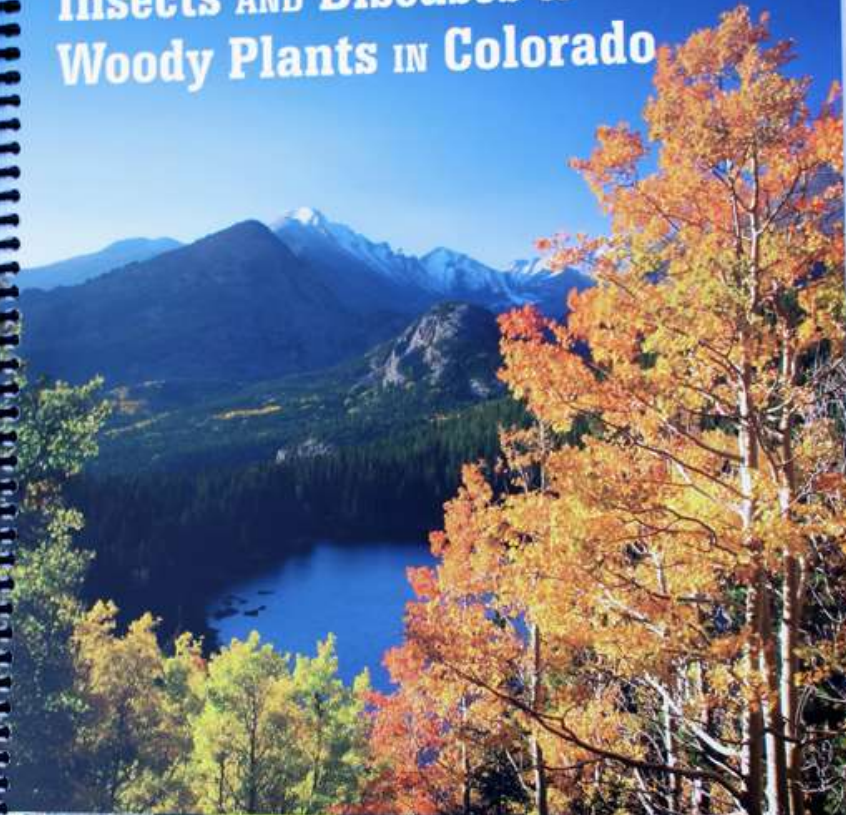
- **Principal Target – the Scale**
- **Sprays?**
  - Dormant season - target stages on 2-4 year wood
  - Bud break – concentrate at buds
  - Treatments
    - Horticultural oils, Distance, other scale products
- **Soil-applied systemics**
  - **More mobile products (e.g., dinotefuran) may be best**



# **This presentation will be posted at the Insect Information web site**

- **Housed at** Department of  
Bioagricultural Sciences and Pest  
Management
  - **Search** “BSPM CSU”
- **Within** “Extension and Outreach”
- “Insect Information”
  - **Extension presentations for 2018 posted at  
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# Insects AND Diseases OF Woody Plants IN Colorado



Colorado State University  
Extension 



Cost: \$40

## Bulletin 506A

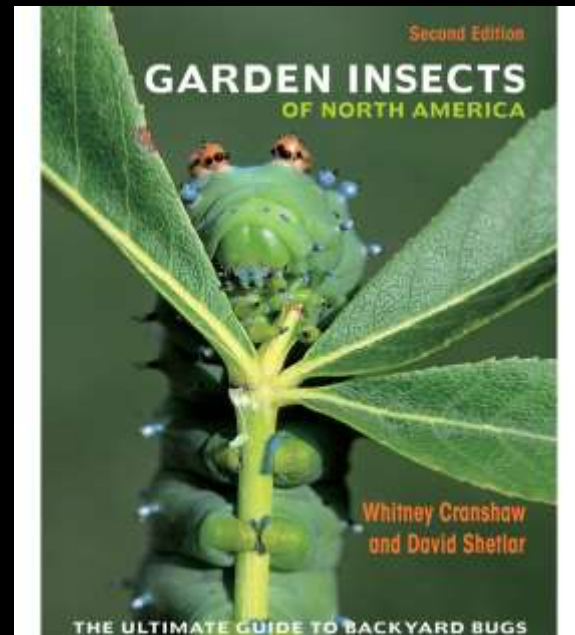
Available from CSU  
Extension Publications

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# ***Garden Insects of North America, 2<sup>nd</sup> Edition***

- Complete revision
- Co-authored (with David Shetlar, Ohio State University)
- Contains over 3100 photos, most all new
- Retail price \$35



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