Tree Colonization Behavior as a Basis for Management of *Euwallacea* nr *Fornicatus* Populations in Avocado Plantations and Ornamentals

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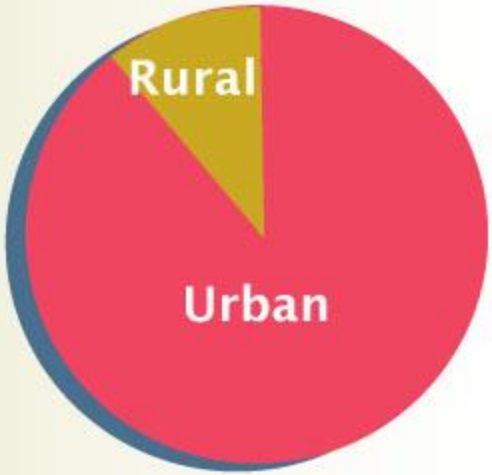
Israel – Where we are

Geography

Population per km²



Out of a total of 7,8 million inhabitants:
76% Jews
17% Moslems
7% Other minorities

Precipitation in the Middle East

Visit:

http://www.moag.gov.il/agri/files/agriculture/index.html

Annual rainfall (mm, multi-year average)

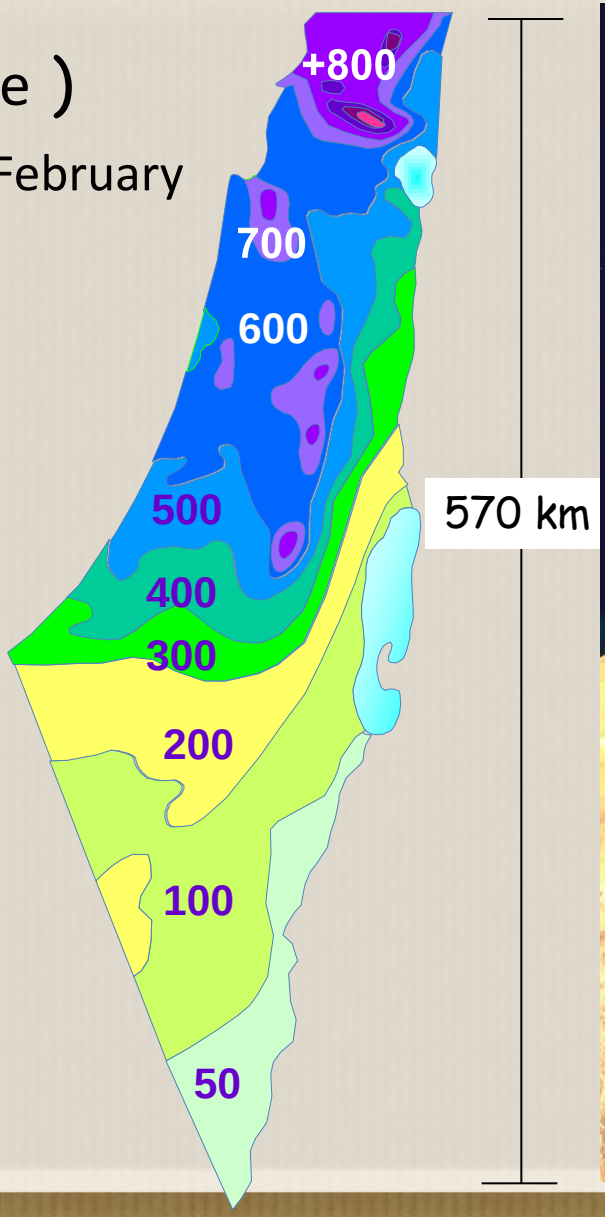
Rainfall- mostly December – February

Area: 22,000 Km2

Arable land: 437,000 ha

Irrigated land: 162,000 ha

Non -irrigated land: 138,000 ha



Water Resources

Three Main Water Sources:

- Sea of Galilee (Lake Kinneret)
- Coastal aquifer
- Mountain aquifer

80% of the water is in the North
20% in the South

35% of the irrigable land is in the North and
65% in the South

The National Water Carrier

Conveys water from the Sea of Galilee southwards

- Regional water systems are incorporated into the Nation Water Carrier
- Water can be shifted from one pipeline to another as needed.

Fact: Existing water resources have been over used

Solution: Enhancement of water sources.

Sea of Galilee

Irrigation Water Sources

- Existing potable water reservoirs (lakes, aquifers, streams)
- Marginal water (saline water, treated sewage effluents)
- Rainfall enhancements
- Desalination

Water

Treated Sewage Effluents

- Farmers are obliged to exchange fresh water quotas with urban effluents
- More than 75% of reclaimed water is used
- The plan is to reclaim most of the sewage
- Agricultural use is allowed according to the regulation of the Ministry of health – permission and monitoring

Rain Enhancement

- Limited only when there are appropriate clouds
- Estimated increase of up to 15% in rain

Marine water Desalination

Water

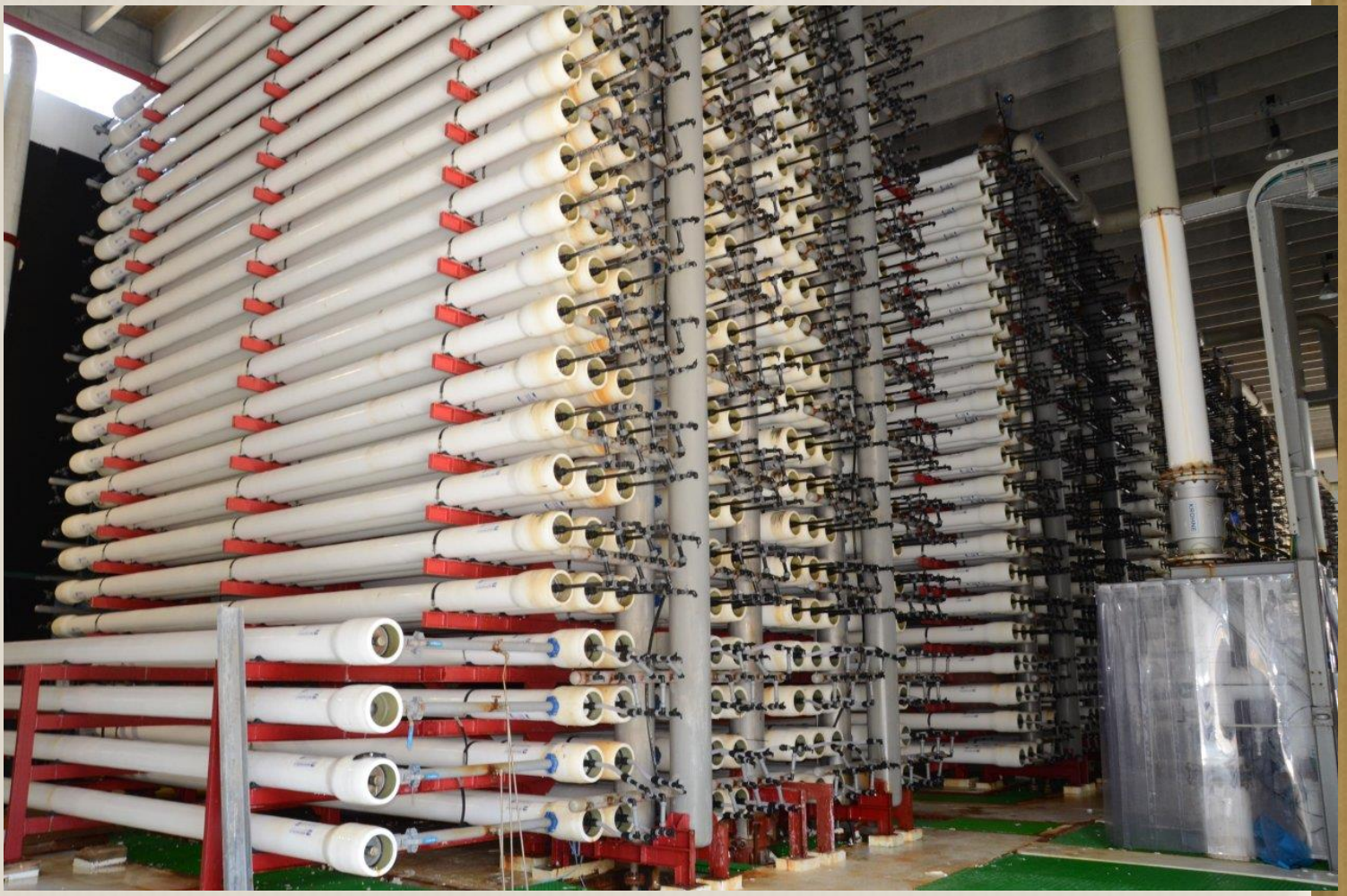
Ashkelon

First large reverse osmosis plant:
120 million m^3/year
Production price: US$ 0.75/m^3
By 2013: total plant production of
600 million m^3/year

"Main Street" Filtration Pools

Pumping System

Osmosis Process Area



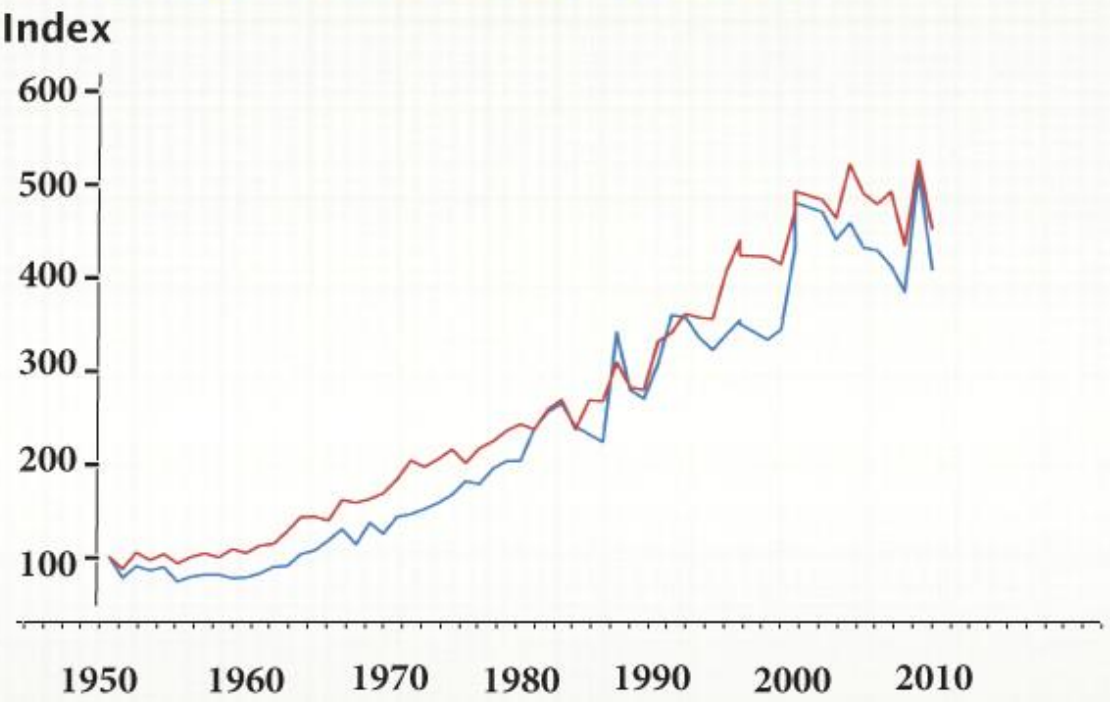
Water

Productivity and Efficiency

From the early 1950s,
agricultural productivity has risen:

4.5-fold per unit area

4.0-fold per cubic meter of water



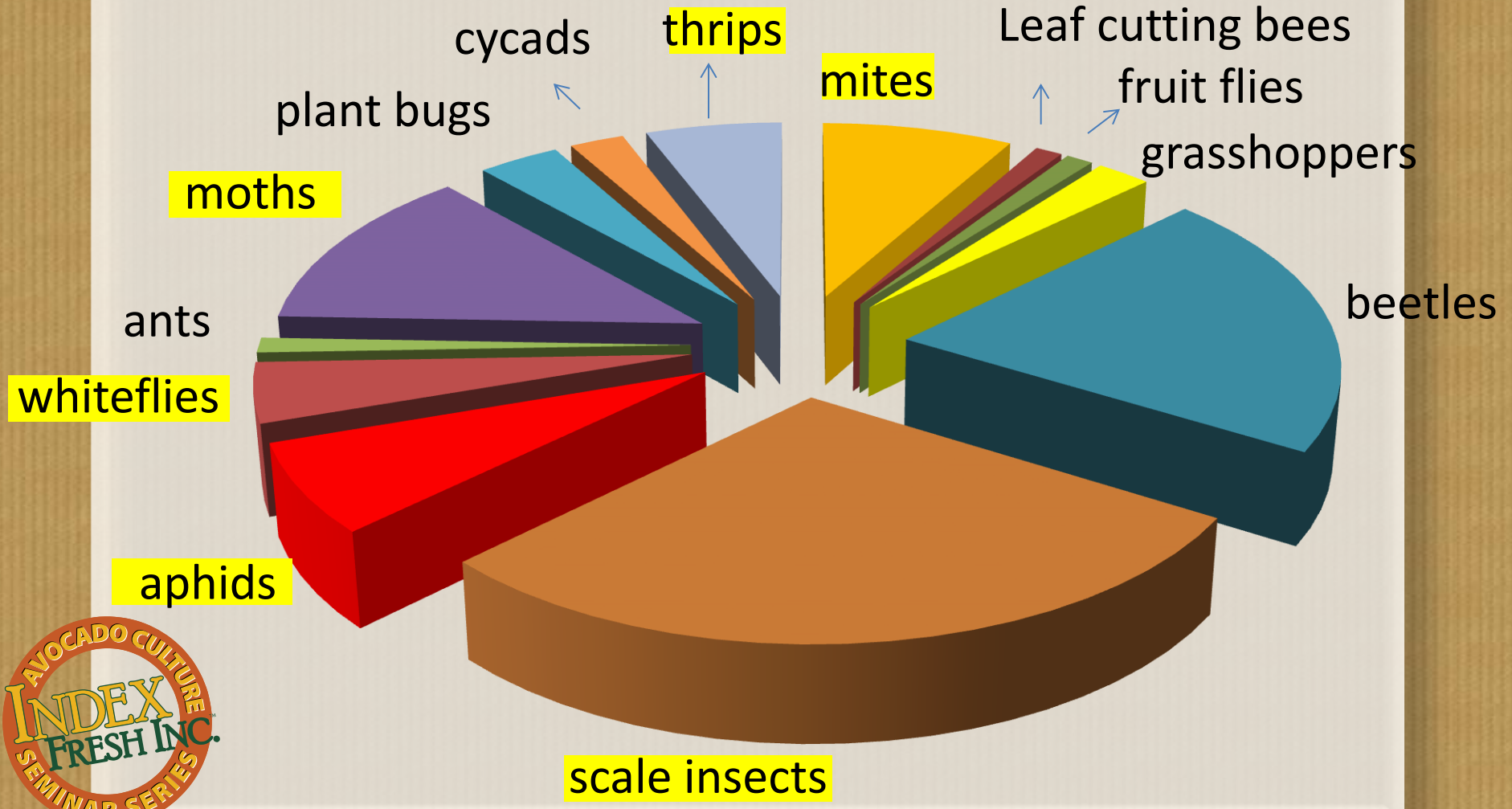
Efficient Irrigation

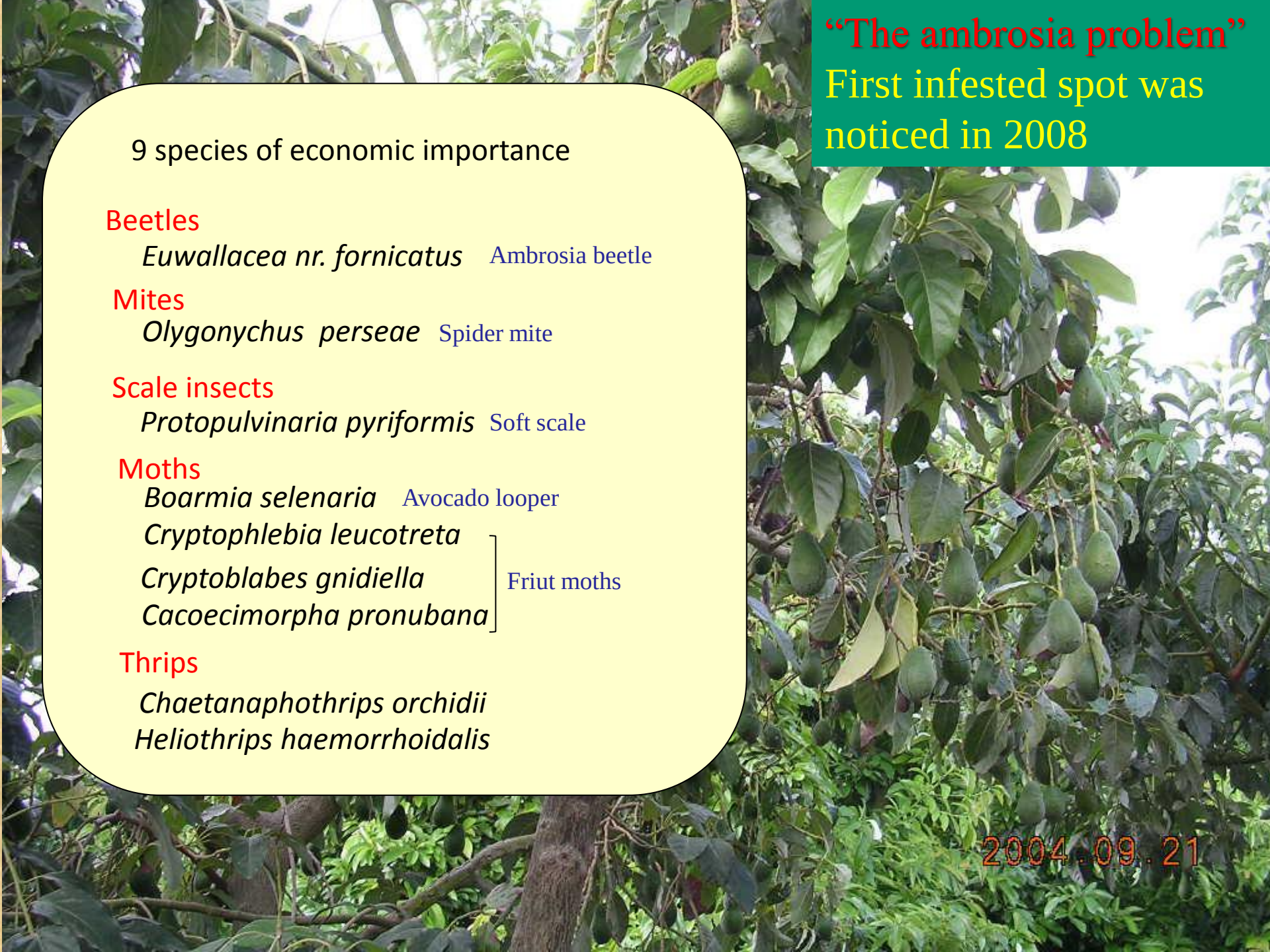
- The most economic way to use water
- Water loss prevention under farmer's control
- Improved irrigation practices and technologies
- Optimal supply of plant needs
- Drip irrigation

Precision Agriculture
Thermal Imaging for Water Status Mapping

- Thermal imaging exposes differences in water status of plants which cannot be detected visually.
- With adequate analysis and models, thermal images can be transformed into water status maps for decision making in irrigation.

89 Phytophagous Insects and Mites Associated with Avocado Trees in Israel





"The ambrosia problem"

First infested spot was noticed in 2008

9 species of economic importance

Beetles

Euwallacea nr. fornicatus Ambrosia beetle

Mites

Olygonychus perseae Spider mite

Scale insects

Protopulvinaria pyriformis Soft scale

Moths

Boarmia selenaria Avocado looper

Cryptophlebia leucotreta

Cryptoblabes gnidiella

Cacoecimorpha pronubana

Friut moths

Thrips

Chaetanaphothrips orchidii

Heliothrips haemorrhoidalis

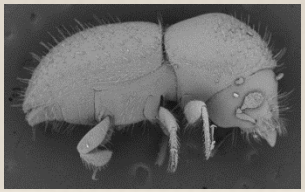
The Avocado Ambrosia Beetle

♂

♀

♂

♀



Polyphagous Shot Hole Borer

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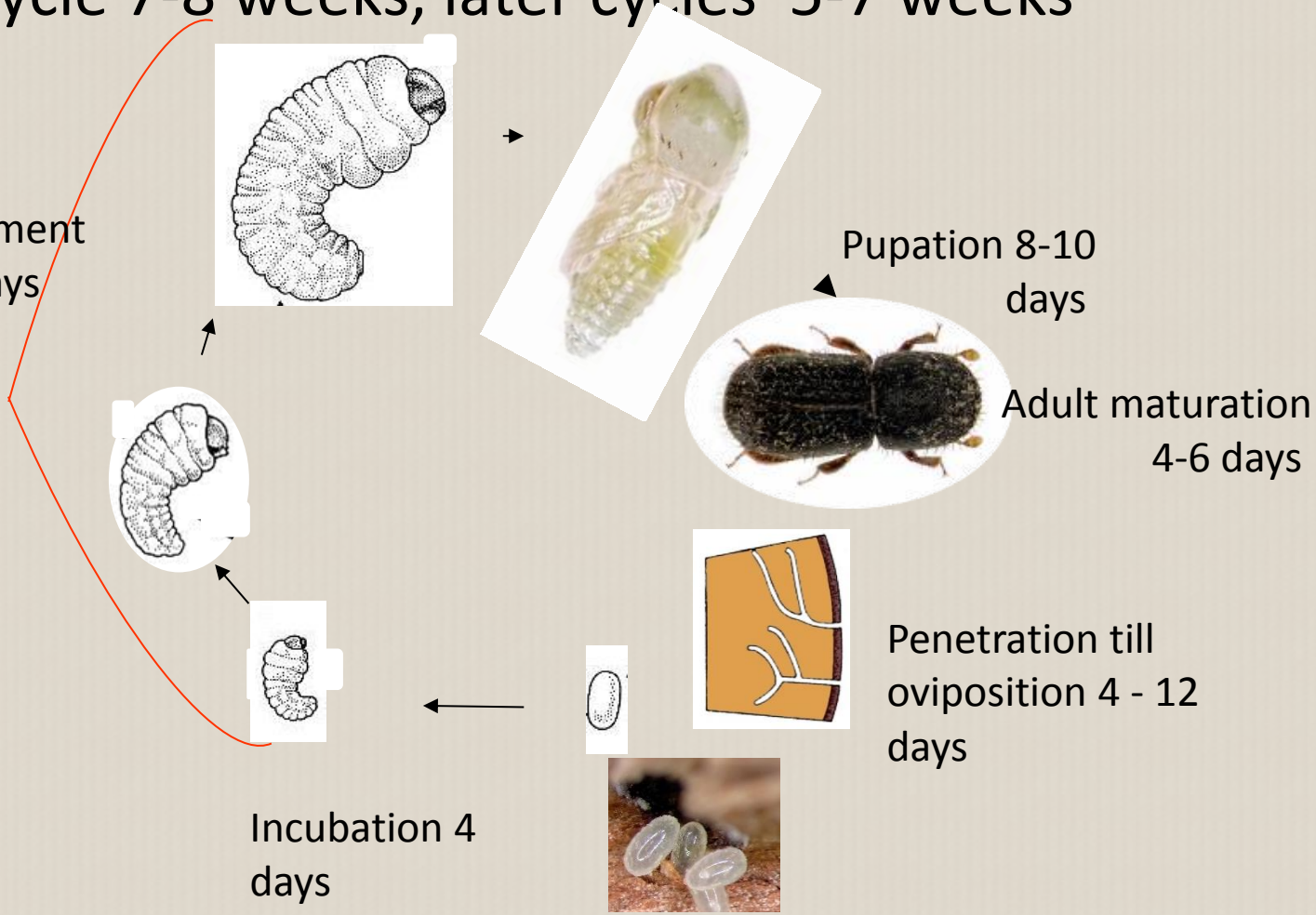
Polyphagous Shot Hole Borer

Polyphagous Shot Hole Borer

Development of *Euwallacea* sp. nr *fornicates* ~ 25^{0}C
First cycle 7-8 weeks, later cycles 5-7 weeks



Polyphagous Shot Hole Borer

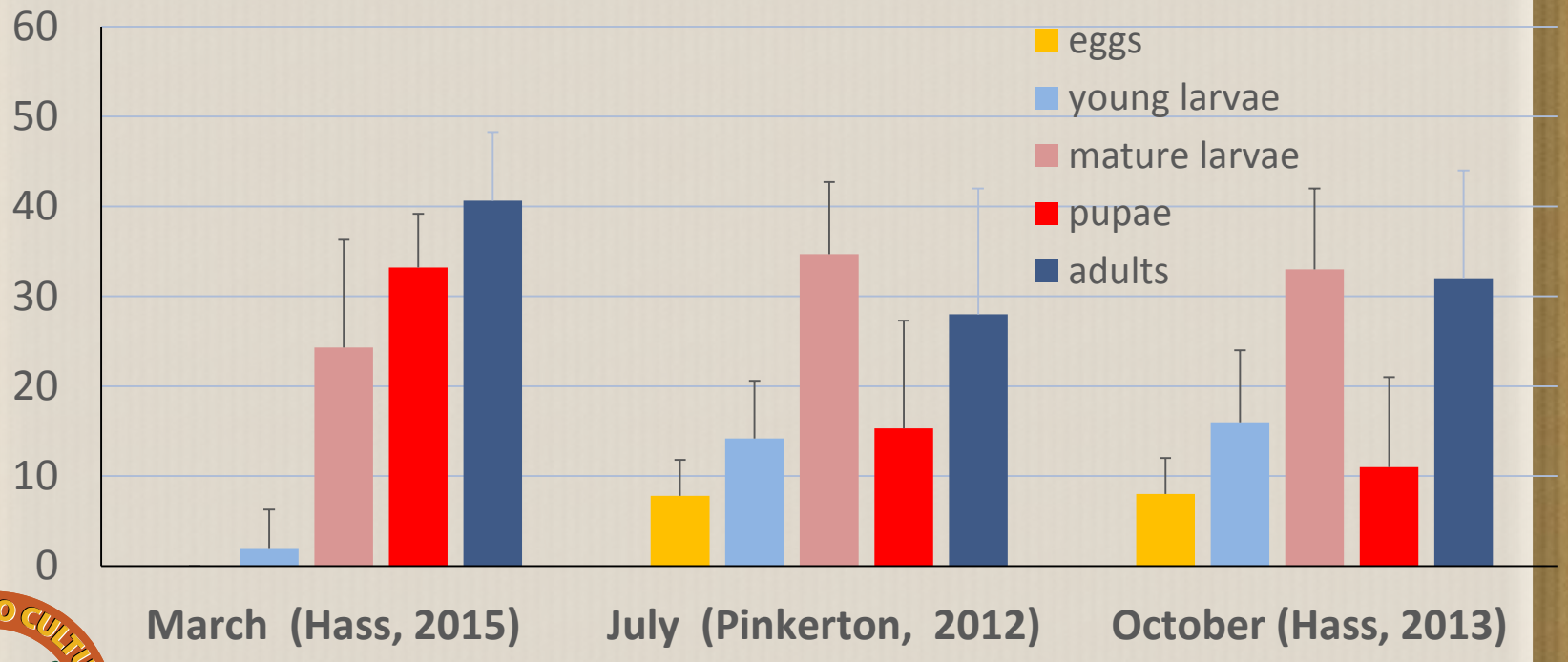
Emergence is Set by the Deteriorating of Surrounding Tissue

Emergence in avocado takes place between 1-2 years after the initial attack

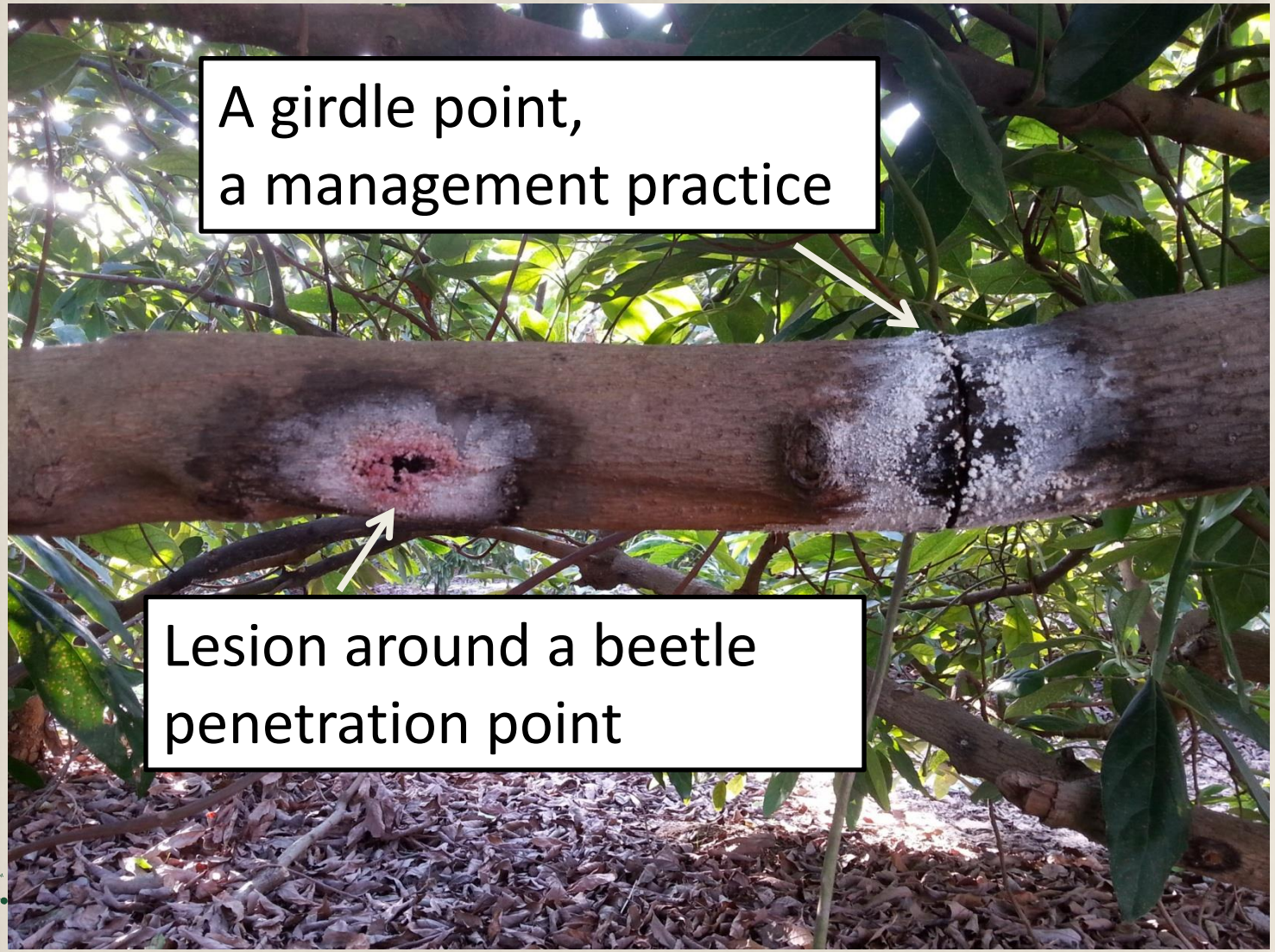
Polyphagous Shot Hole Borer

Polyphagous Shot Hole Borer

Stage Distribution of *Euwallcea fornicatus* in Avocado Sampled in the Central Coast area of Israel (n=155-221).



Polyphagous Shot Hole Borer



Typical Response of Healthy Avocado Tissue to the Attack

A Developed Lesion

Drilling the fungi injection points (tested oak trees)

Fungi Injection (Tested Oak Trees)

Polyphagous Shot Hole Borer

2 Weeks
After Inoculation

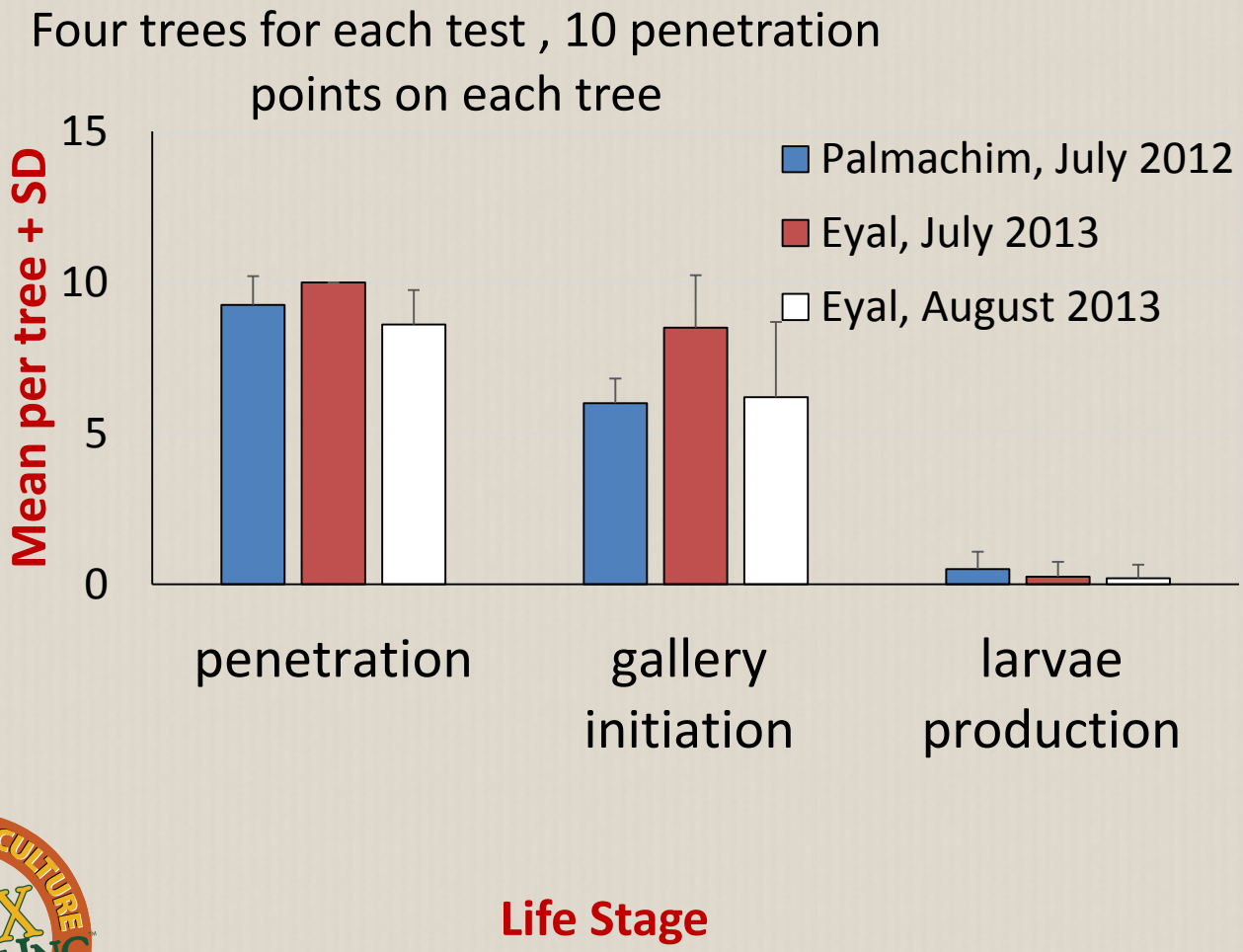
6 Weeks After Inoculation

Polyphagous Shot Hole Borer

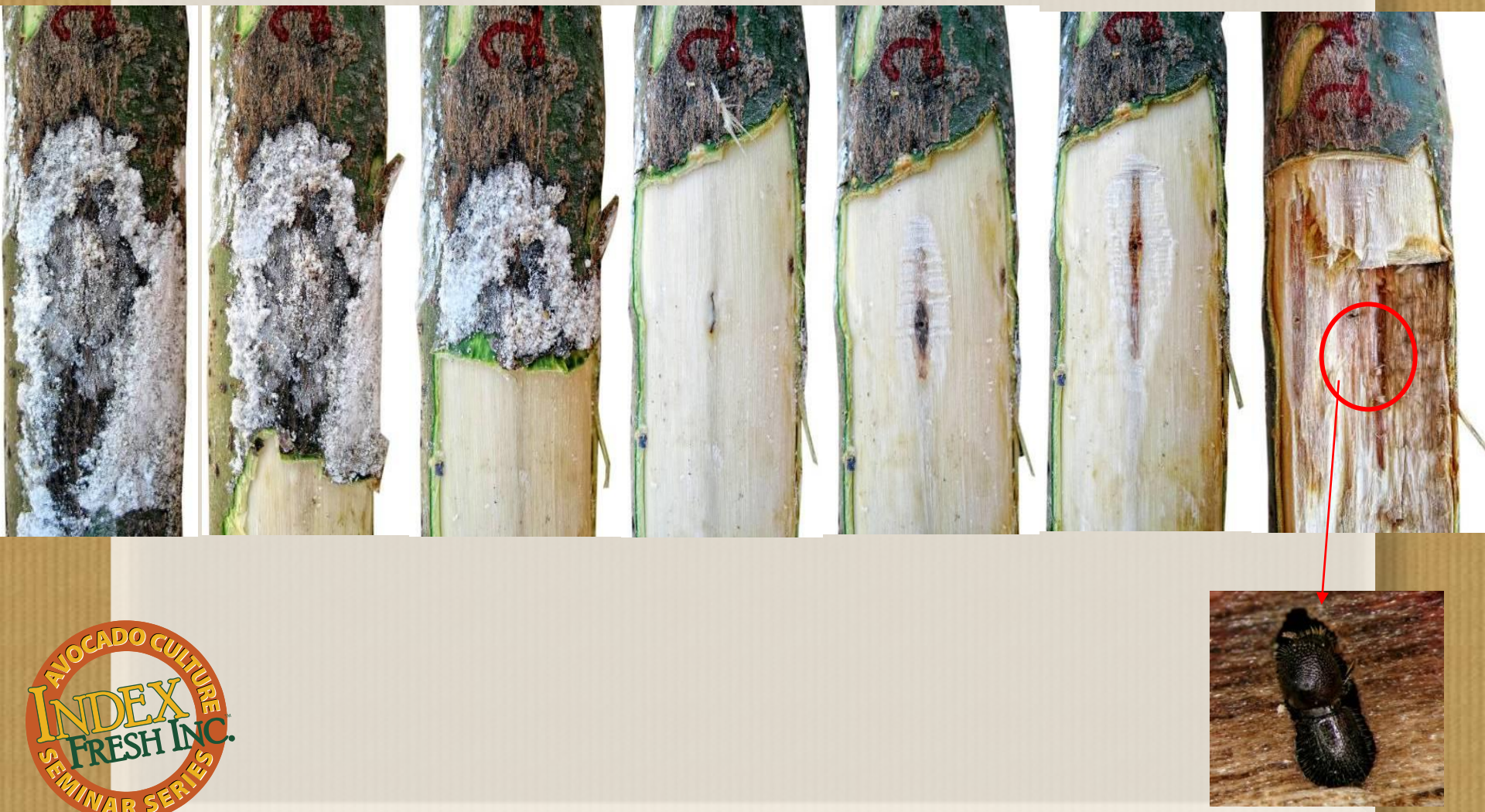
Polyphagous Shot Hole Borer

Polyphagous Shot Hole Borer

Failure of Branch Colonization



Many of the Attacks in Avocado Do not End in Successful Establishment of the Beetle, but the Fungus Alone



Attack Induction through Controlled Colonization (Eyal plantations, Hass)

27 July 2013 - Colonization

29 August 2013 - Defense response, no development

6 August 2013 – Early response

21 July 2014 – Natural mass colonization – successful development

(Continued)

Attack Induction through Controlled Colonization (Eyal plantations, Hass)

Emergence is expected during the summer and fall of 2015, and may be early summer of 2016 depending to the deterioration rate of the branch.

Polyphagous Shot Hole Borer

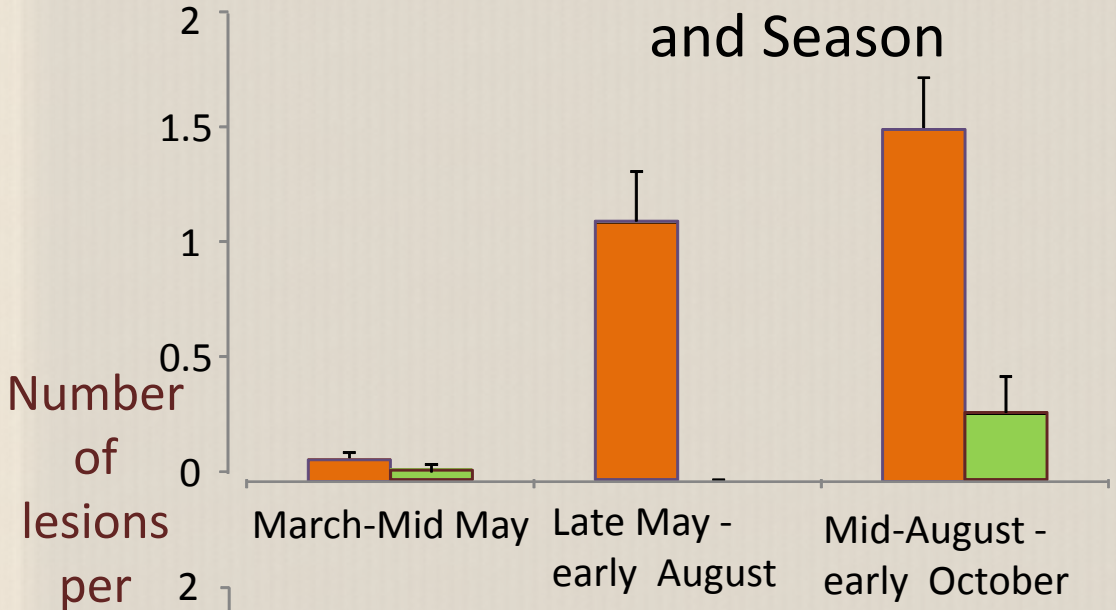
Polyphagous Shot Hole Borer

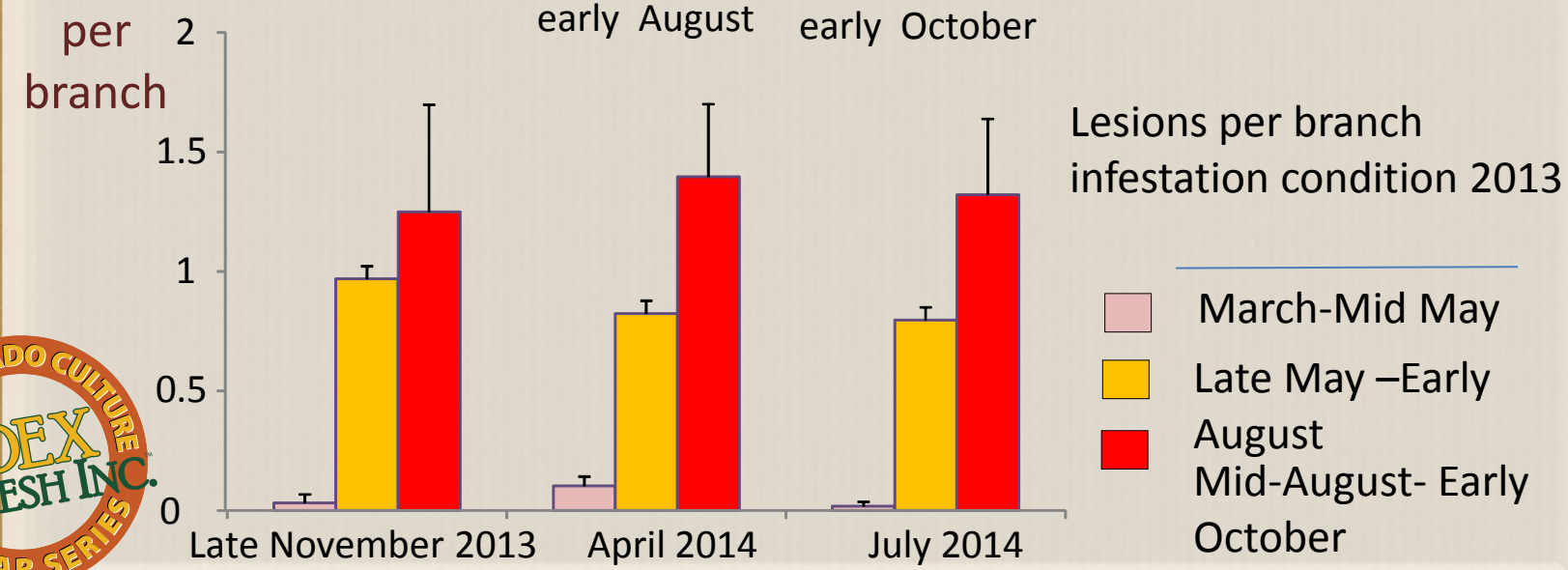
The first successful colonization occurred in fall 2014.

April 2015: Population egg structure includes parent beetles and immatures, including pupae.

Emergence and branch desiccation is expected in fall 2015.

Branch Colonization as Related to Previous Infestation and Season





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Polyphagous Shot Hole Borer

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Polyphagous Shot Hole Borer

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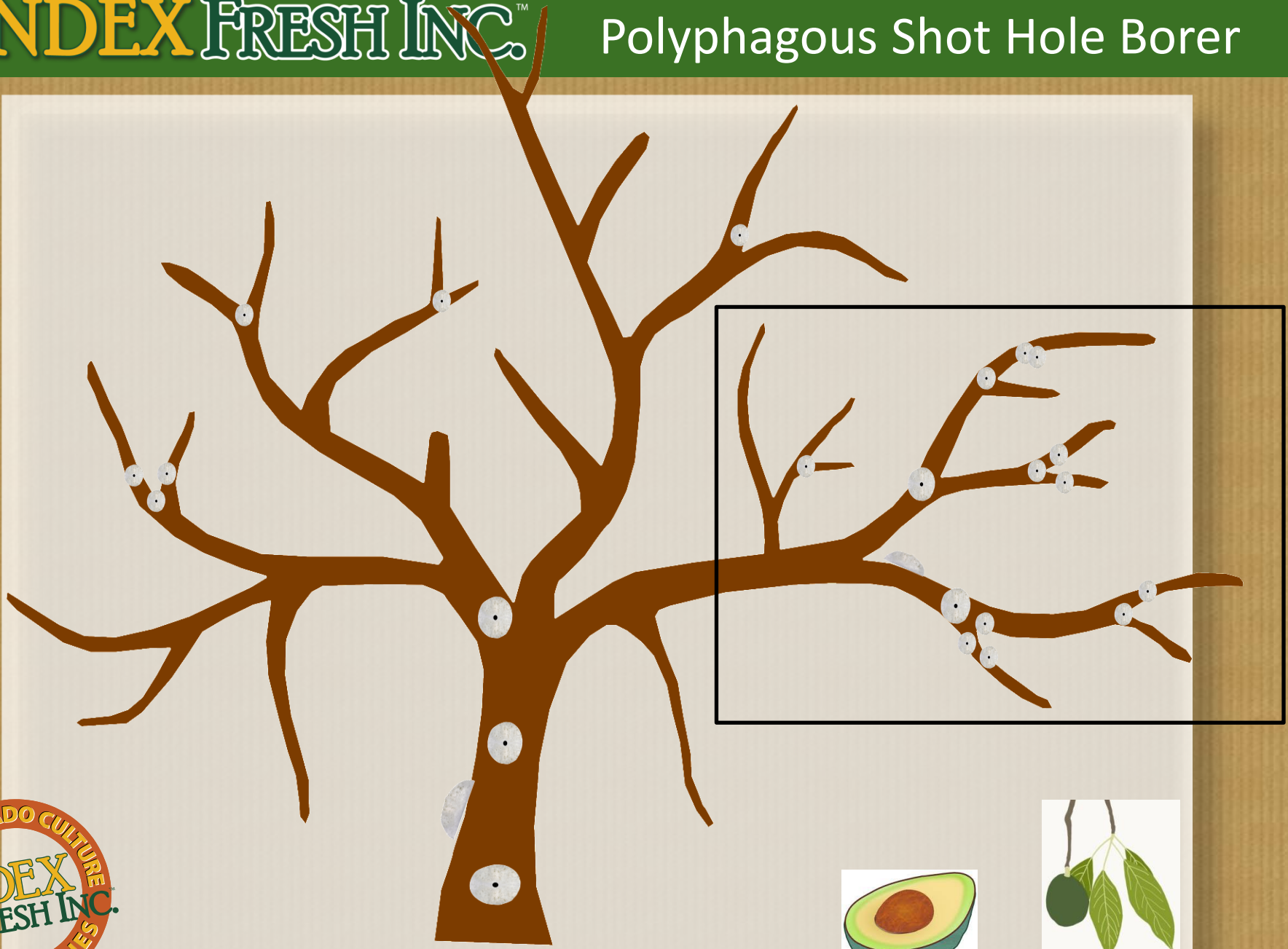

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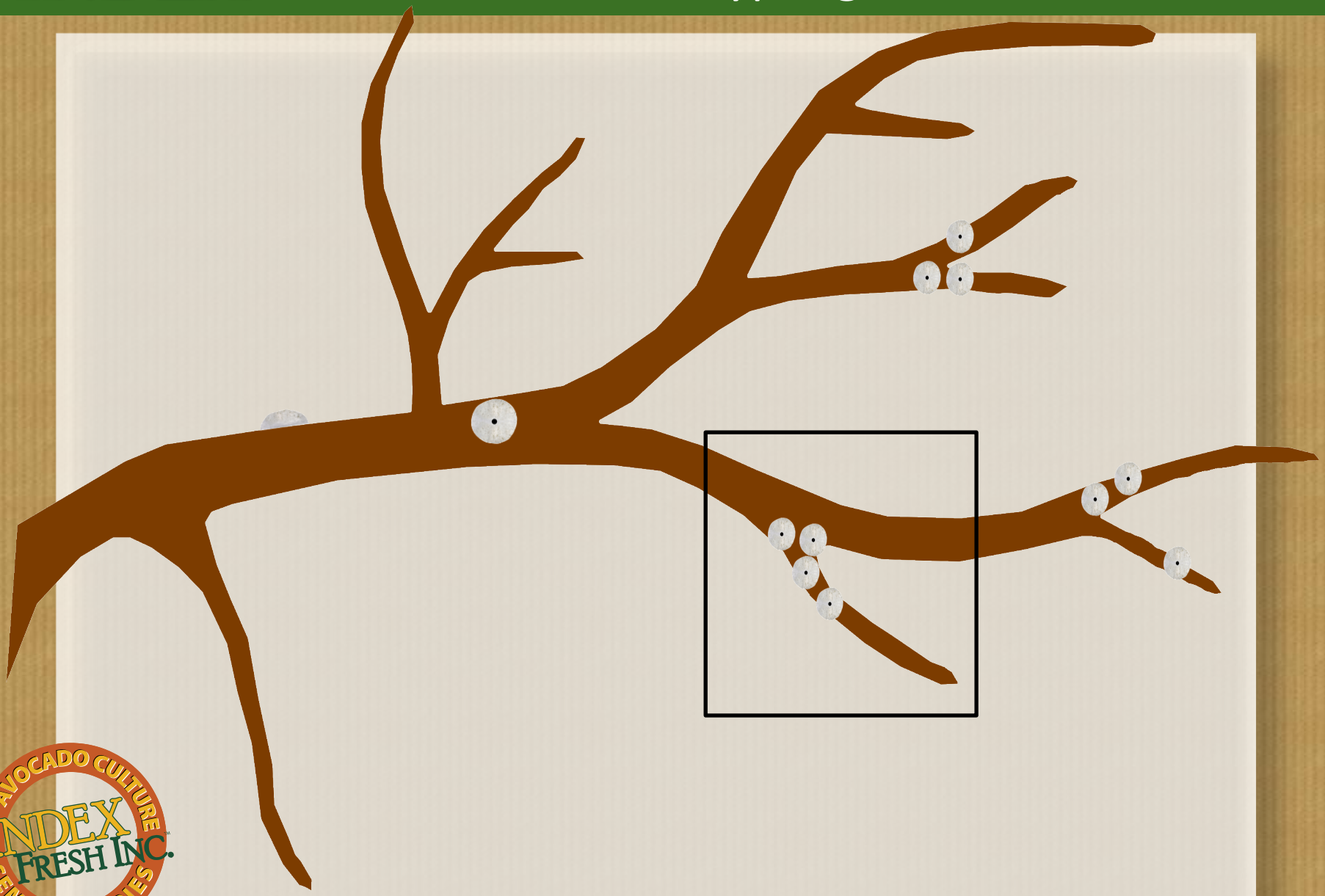
Polyphagous Shot Hole Borer



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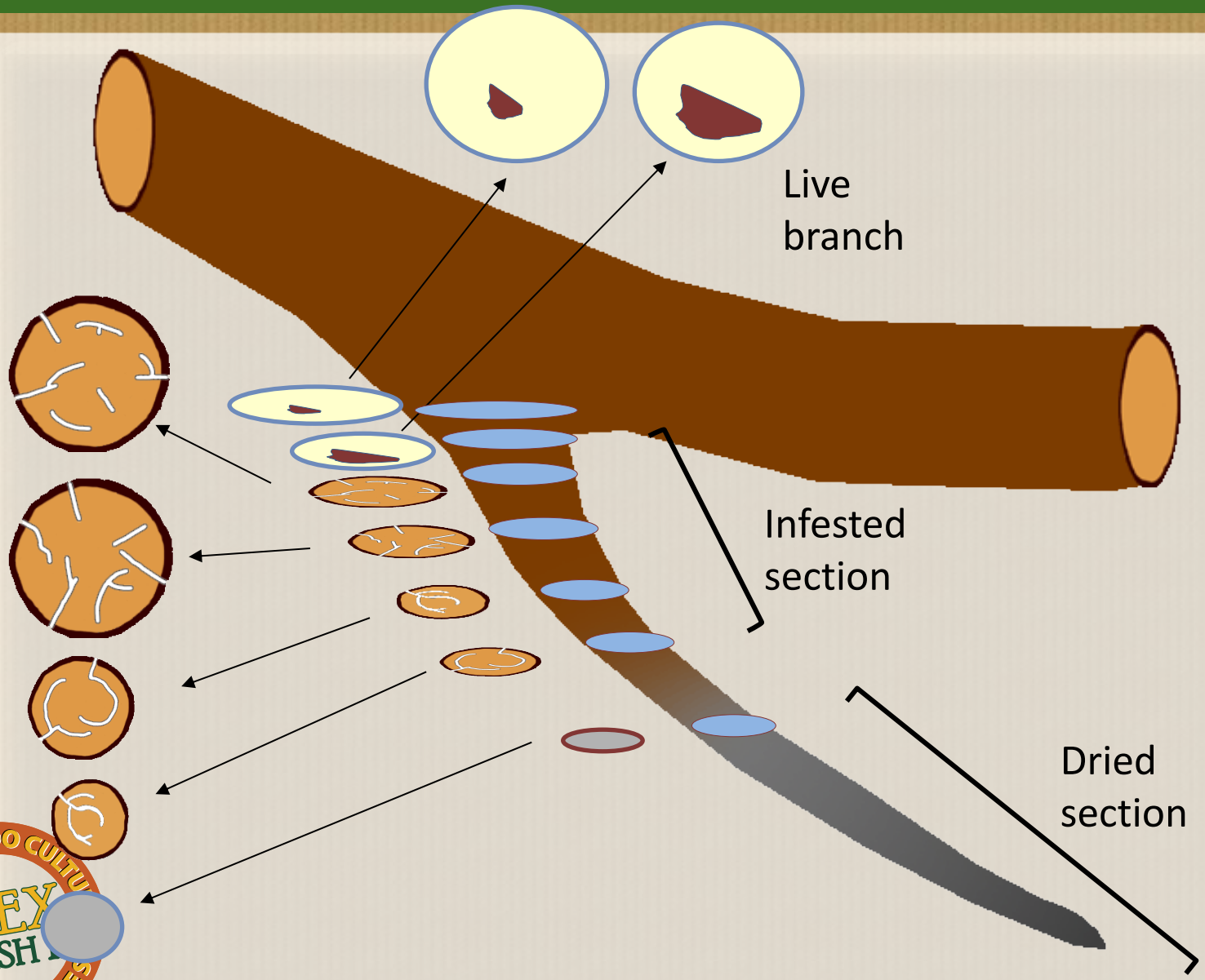
Polyphagous Shot Hole Borer



Thick Branches May Support The Colonization During Two Warm Seasons

Polyphagous Shot Hole Borer

Polyphagous Shot Hole Borer

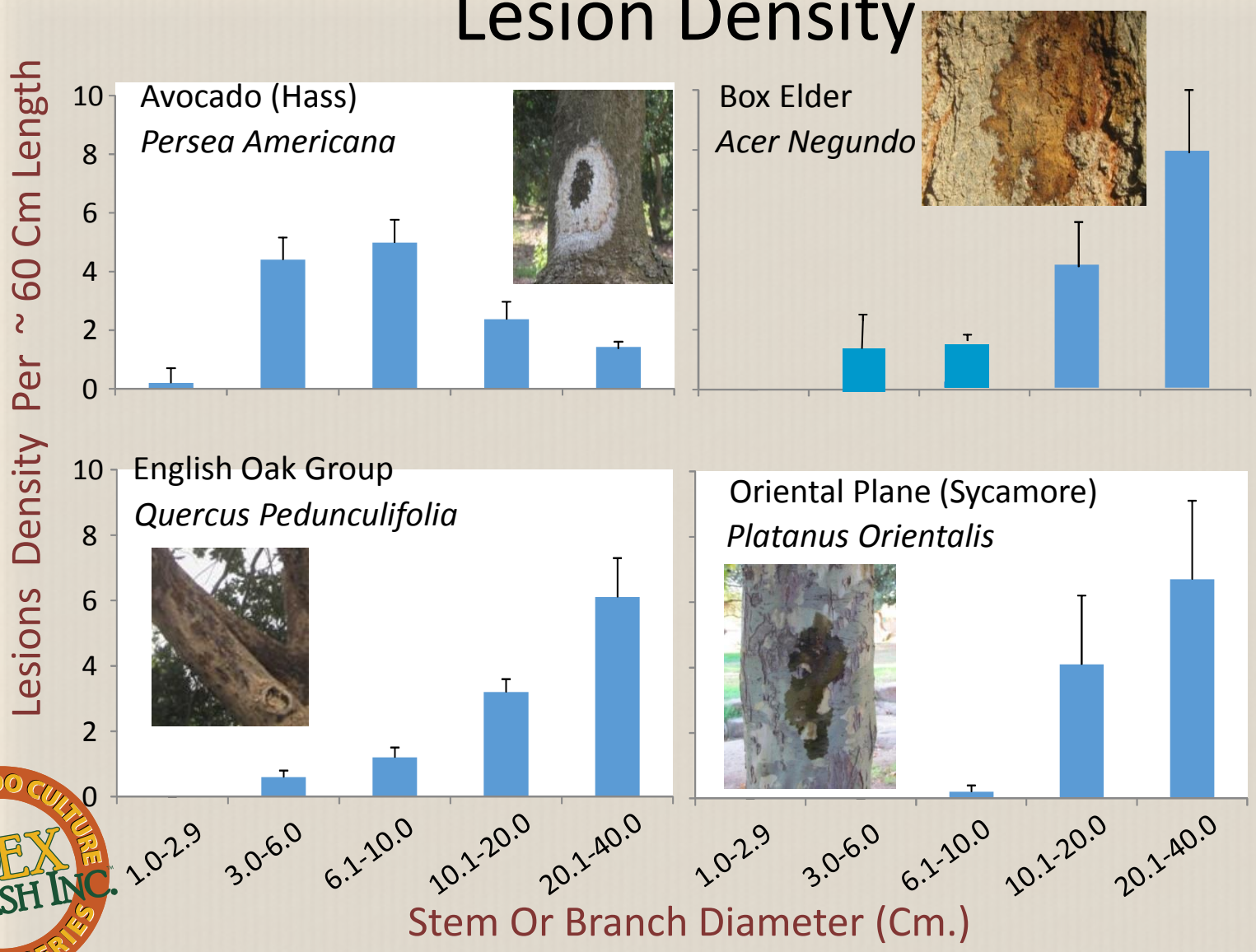
Gallery Densities in Low Stem Section of 3 Suitable Tree Species

Box Elder

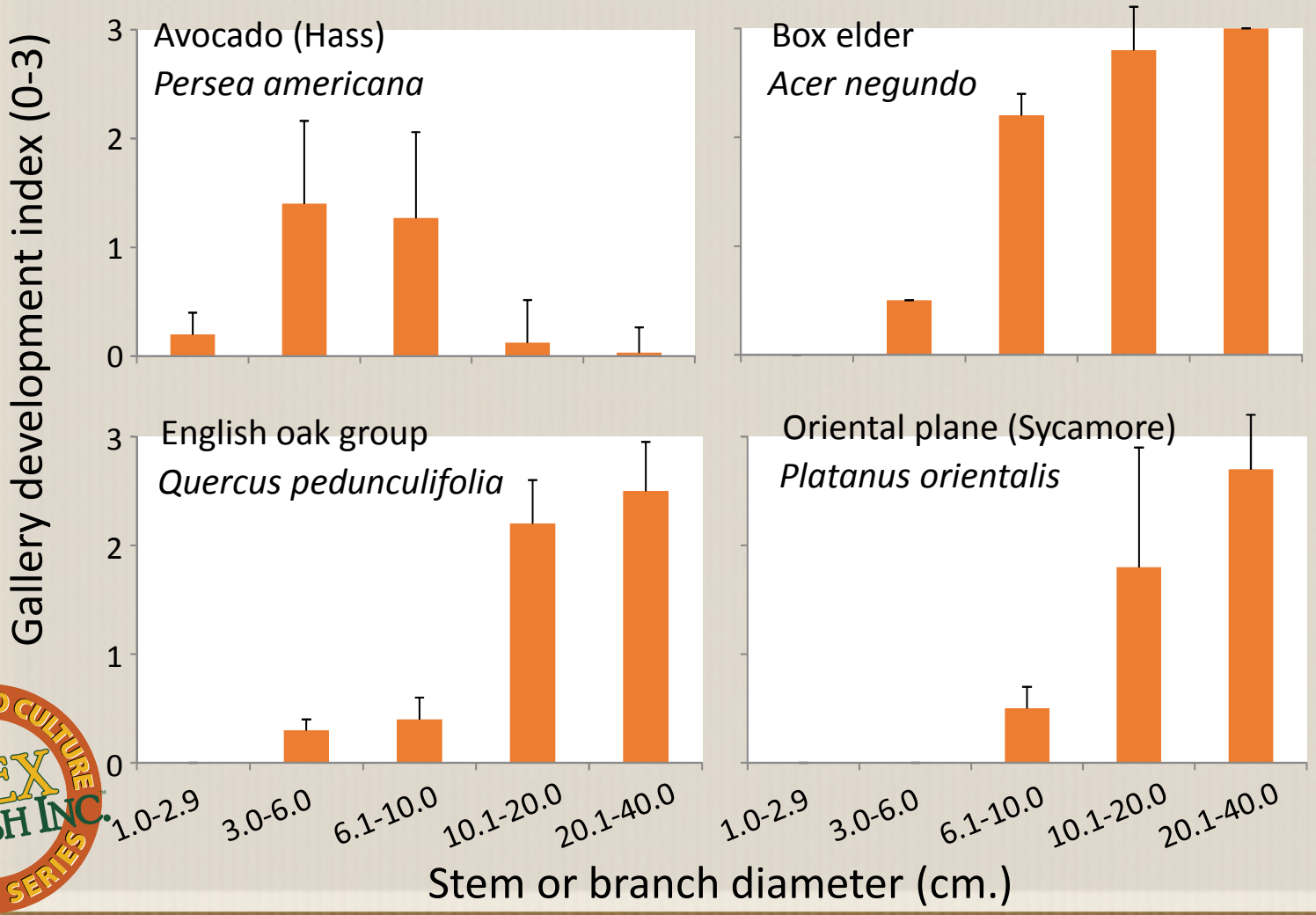
English Oak

Avocado (Pinkerton)

Lesion Density



Gallery Development Index



Schematic distribution within Elder box and English oak of the ambrosia inflicted lesions

Fully developed gallery initiated in healthy or weak branch of stem section. Slight response of the tissue

Factors related to attack densities and successful development

1)Tree wpecies and avocado variety
2) Seasonality, intensifying along the warm season
3) Poor phytosanitation
4) Alternating bearing, “on year”

1) Tree species and avocado variety (Relative susceptibility)

Attack frequency

Gallery density

Offspring production

Between different reproduction suitable tree species

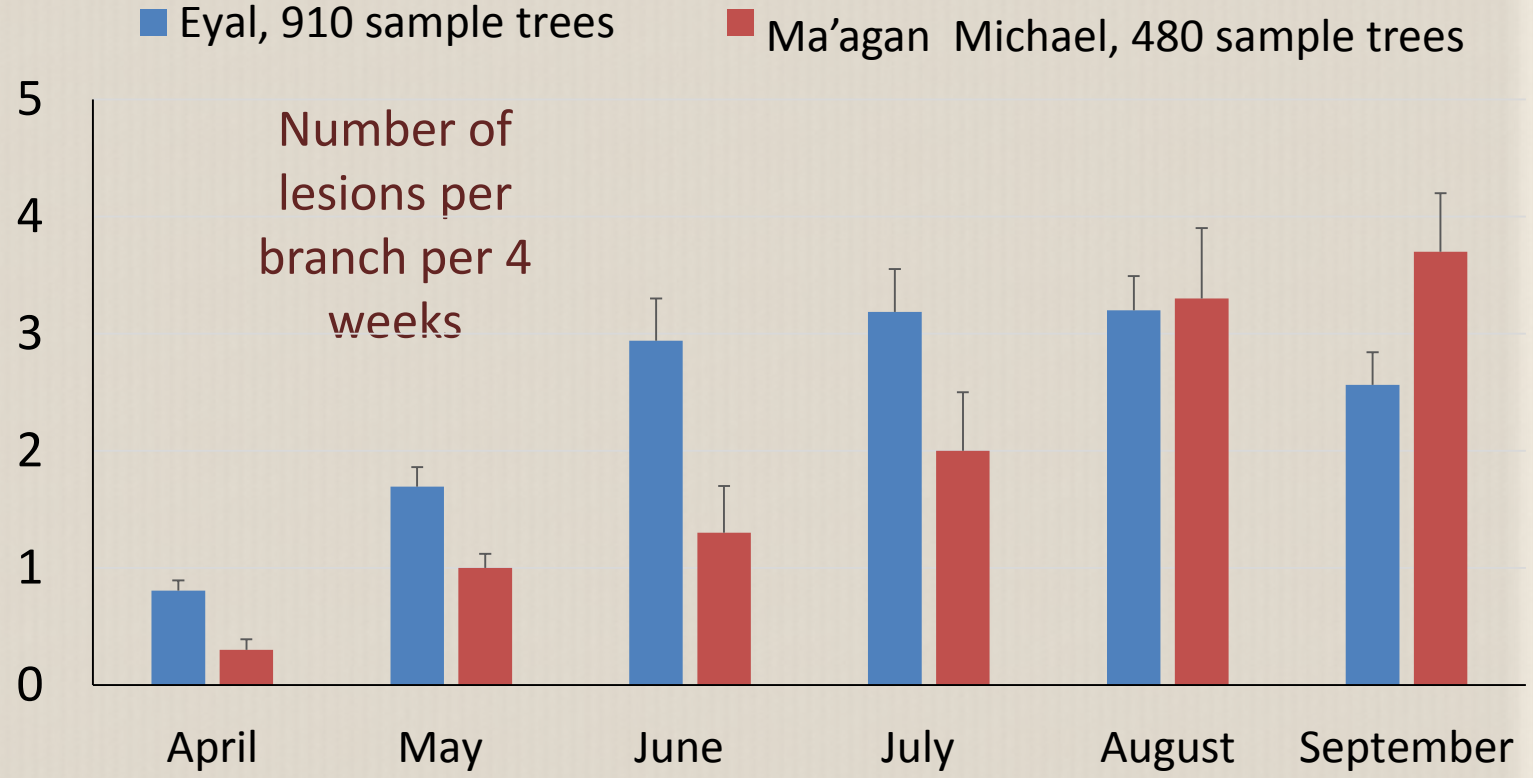
Box Elder > *Quercus pedunculiflora* *Quercus robur* > Castor Bean > *Platanus orientalis* > Avocado > White Mulberry

Between different avocado varieties

Fino > Hass > Reed > Pinkerton > Nabal > Ettinger Fuerte > Galil Ardit

2) Seasonality, intensifying along the warm season

Density (mean ± SE) of new conspicuous lesions on stem and main branches during the 2013 warm season induced by *Euwallacea* nr *fornicatus*



10 yr old Avocado orchards (Hass)

3) Poor Phytosanitation

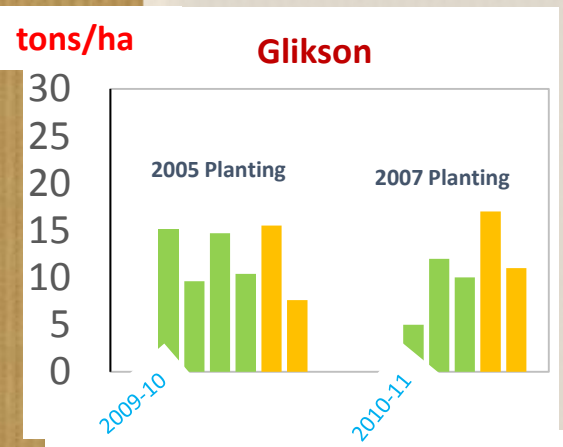
4) Alternating Bearing, "On Year"

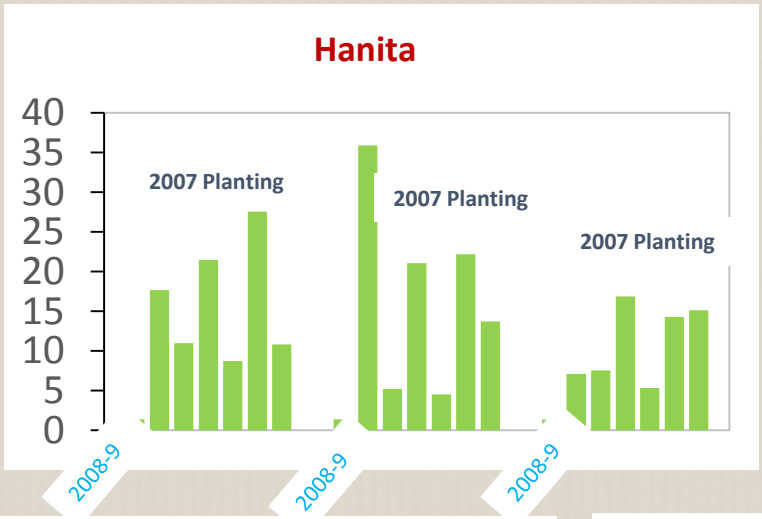
Information accumulated by the research team and many grower reports suggest high density lesions and dying branches after high fruit bearing season

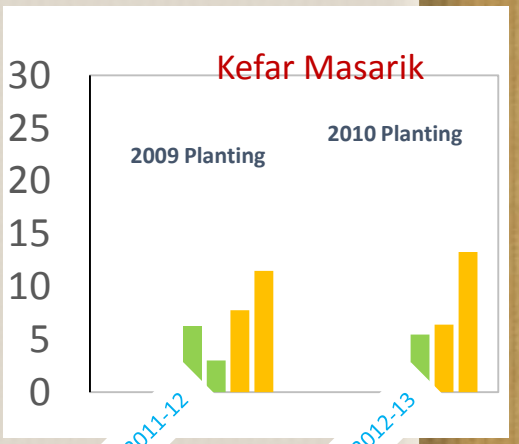
Polyphagous Shot Hole Borer

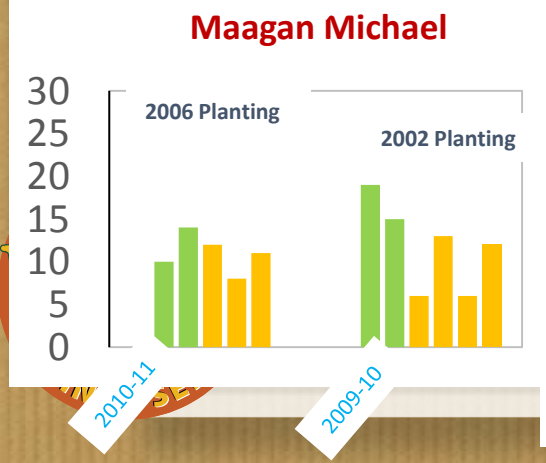
Information about fruit yield (tons/ha) (2009-2015) in Avocado orchards (Hass) as related to "ambrosia" infestation and planting year

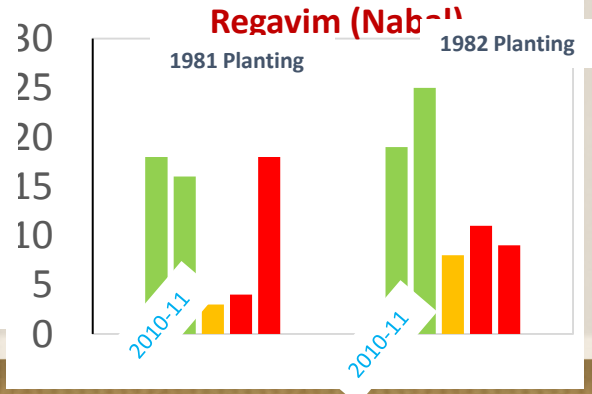
Non- infested
Moderate infestation
Severe infestation

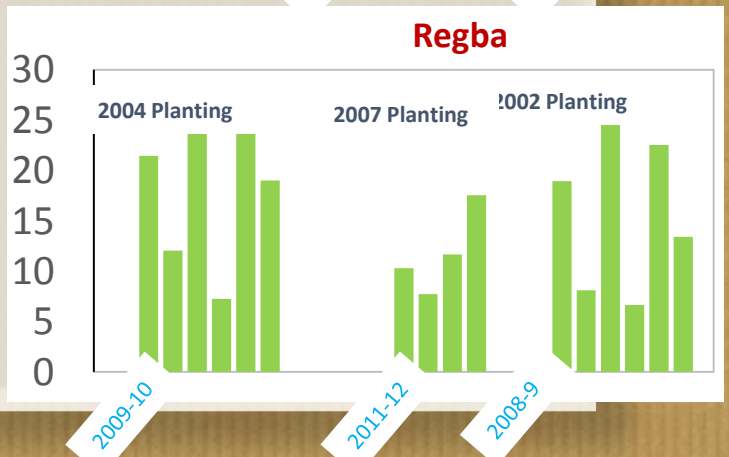








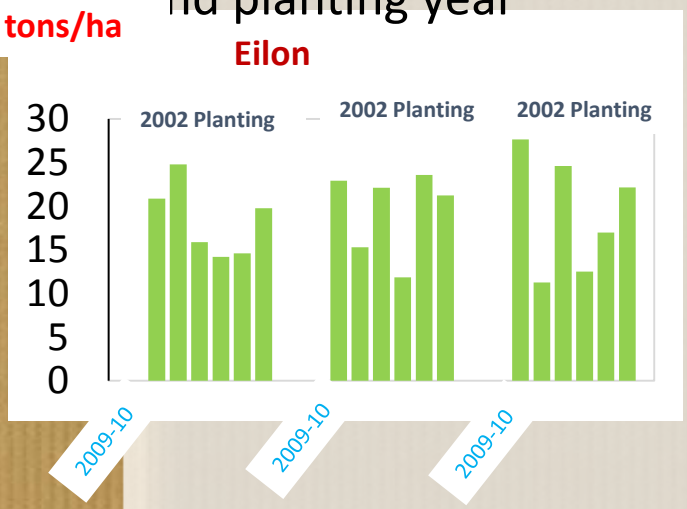


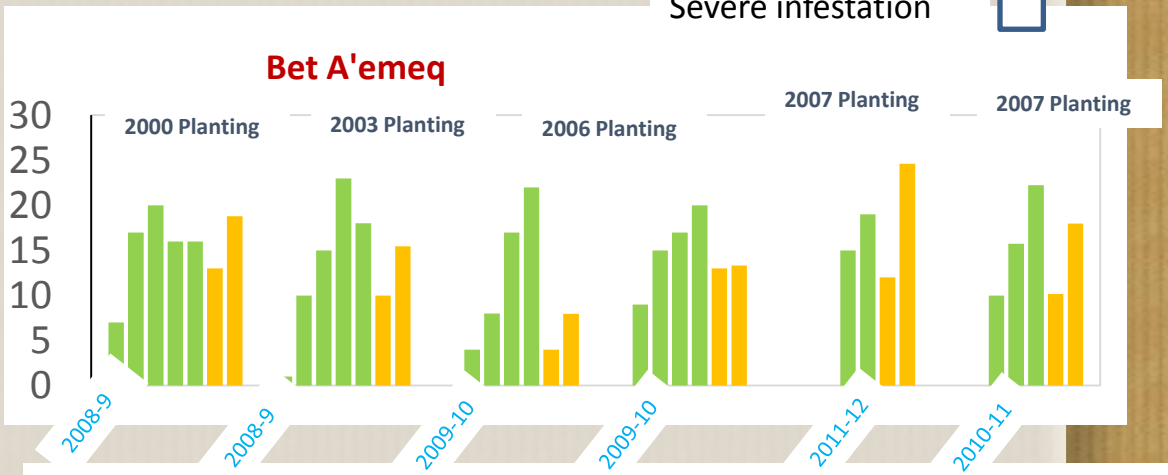


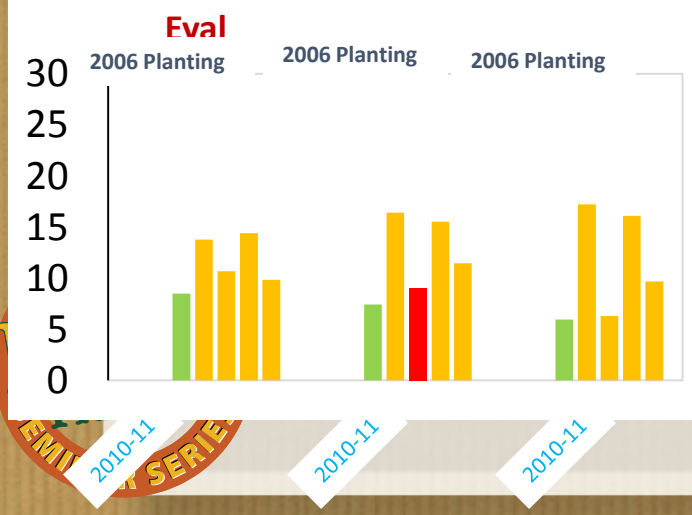
Polyphagous Shot Hole Borer

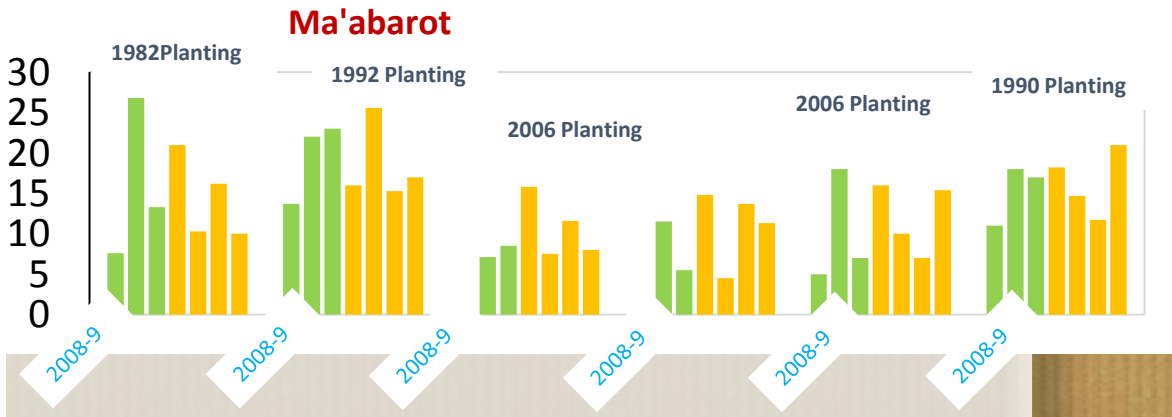
Fruit yield (tons/ha) (2009-2015) in Avocado orchards (Hass) as related to “ambrosia” infestation and planting year

Non- infested
Moderate infestation
Severe infestation









Management strategies?

1) Chemical control
   - Cover spray
   - Systemic insecticides by drip irrigation
   - Systemic insecticides by stem injection

2) Biological control
   - Macrobial
   - Microbial

3) Chemical ecology
   - Kairomones
   - Plant volatiles and others

4) Prevention

5) Resistance/tolerance
   - Resistant cultivars
   - Endophytes

Short term

Mid term

Long term

Limitations

No natural enemies*

No known pheromones

Flight throughout the warm season

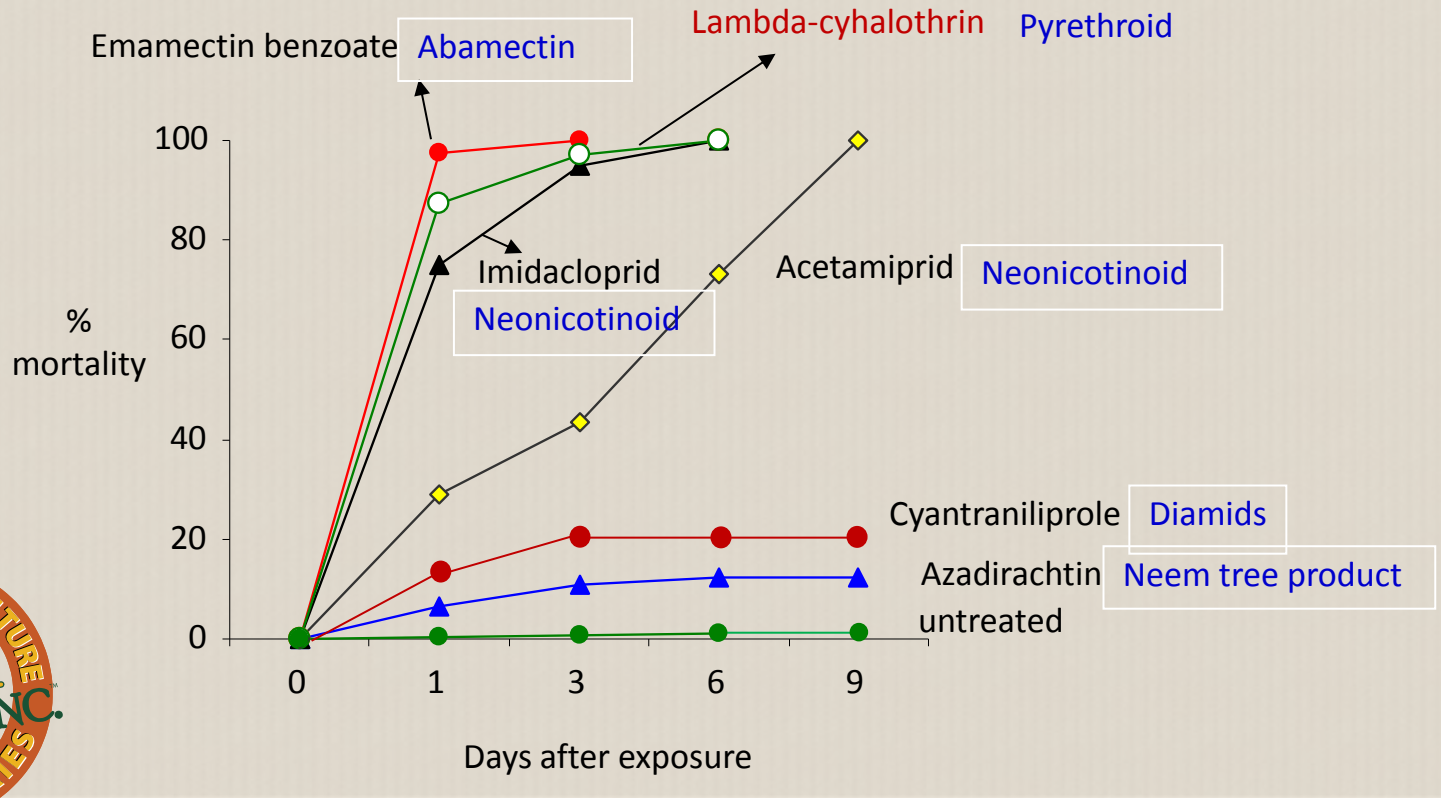
*adults of the genera *Tarsonemus* (Prostigmata) and heteromorphic deutonymphs of the family Histiostomatidae (Astigmata).

Treatment with *Beauveria Bassiana* Products

Euwallacea nr *fornicates*

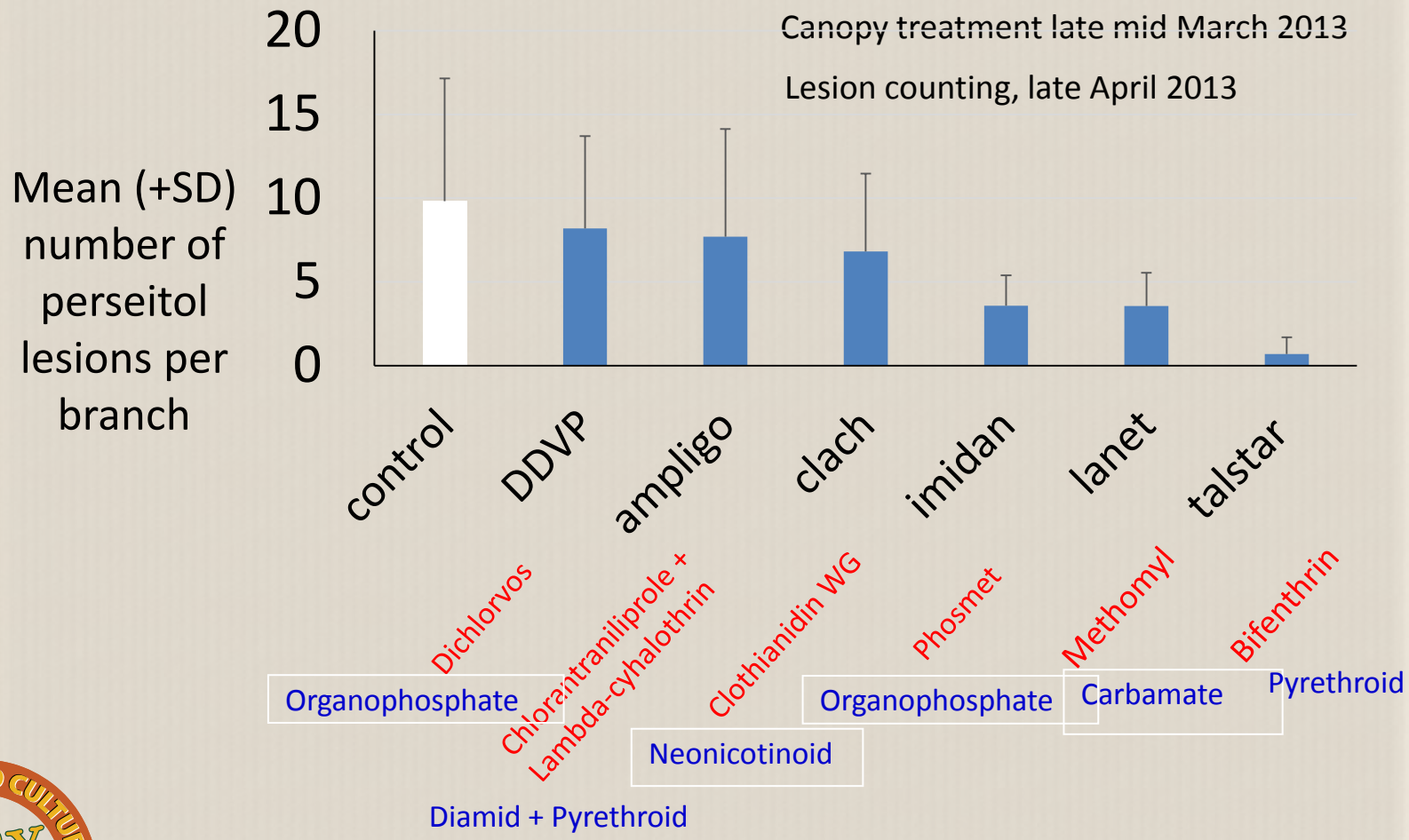
Orthotomicus erosus

Systemic insecticides (mostly) tested against the larvae feeding on fungus growing on PDA with the incorporation of 10 ppm of the tested chemical



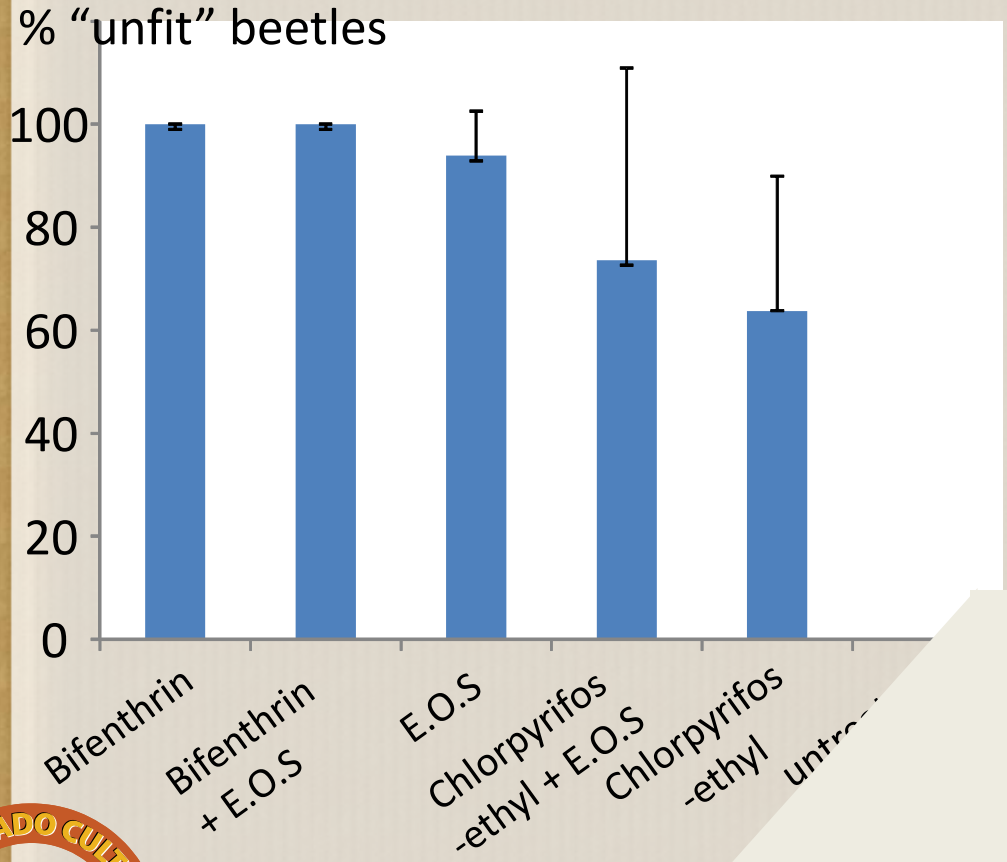
Polyphagous Shot Hole Borer

Eyal, Hass, 10 yr old plantations



Polyphagous Shot Hole Borer

Emergence of *Euwallacea* nr *fornicatus* from insecticide treated avocado pruning slash



Lab: 25^{0}C, 60% RH

Tested material:

Bifenthrin (Pyrethroid)

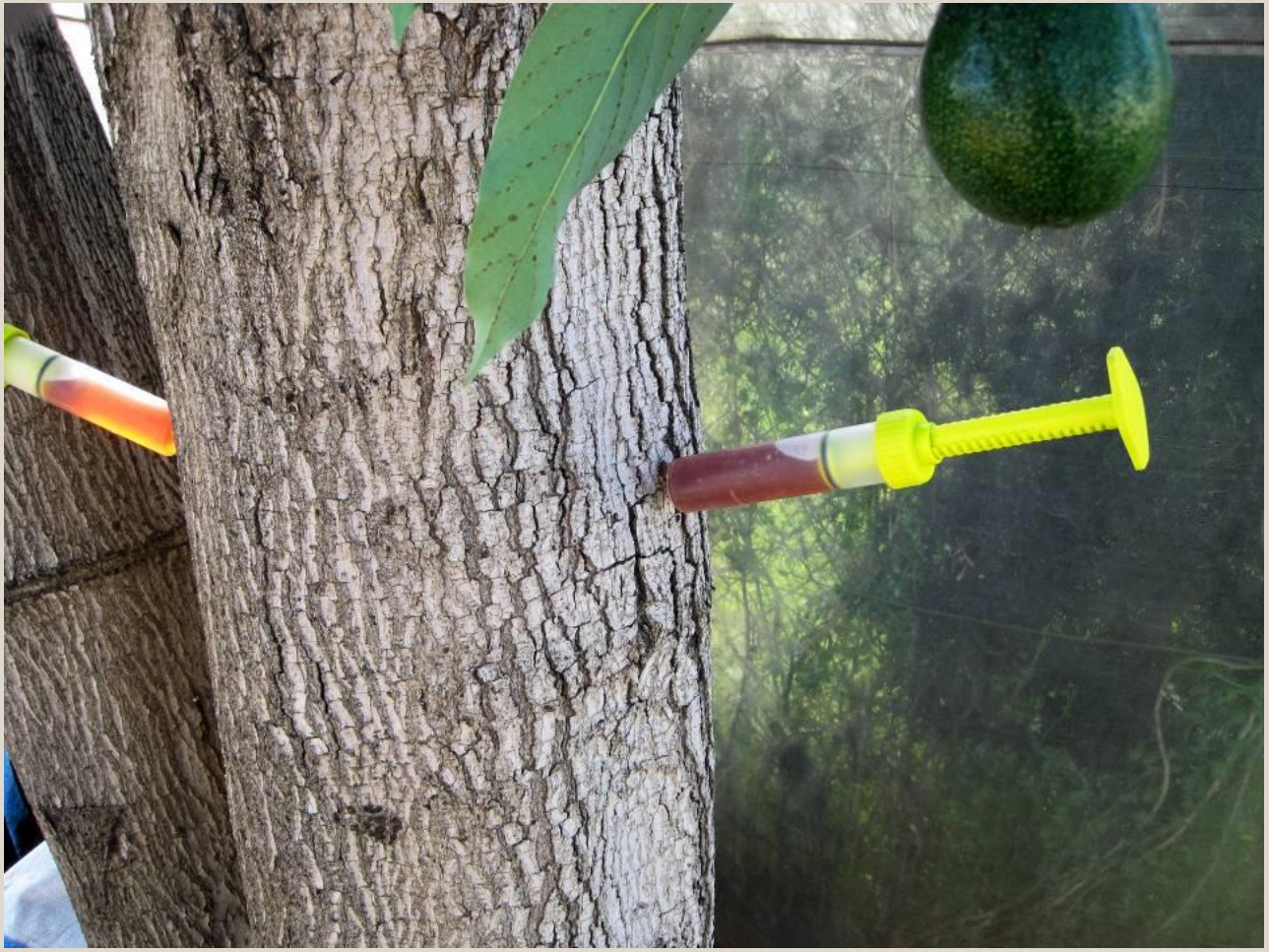
Chlorpyrifos -ethyl (Organophosphate)

E.O.S Ecological mineral oil, ZICOS Korea (SK)

Tested compounds

	Mean (± SD) number of days until emergence after treatment	Number of days until emergence of the last beetle after treatment
"unfit" beetles	12.7±4.7	25
"fit" beetles	15.1±5.0	30

A week after the injection was performed



Stem Injection: Box Elder

- 8 adult trees were injected with Thiamethoxam (neonicotinoid) during rather early phase of the tree colonization.

None survived.

* Mainly in the botanical gardens in Jerusalem

Oak: Application of Imidacloprid and Thiamethoxam

* 12 adult trees were injected with Imidacloprid during early phase of the tree colonization

All survived !

** young trees were soil applied with Thiamethoxam, 18 during early phase of the tree colonization and 5 heavily infested.

Early phase :all survived !
Heavily infested: none survived

* Mainly in the botanical gardens in Jerusalem

** Mainly, Netanya, street trees

(Continued)

Oak: Application of Imidacloprid and Thiamethoxam

Polyphagous Shot Hole Borer

Sycamore (*Platanus*): application of Imidacloprid and Thiamethoxam (summer 2015) mainly as preventive measure

6 adult heavily infested trees were soil applied with Imidacloprid, none survived (different areas in the coastal area)

.

Recommended management in avocado plantations (light and moderate invested plots)

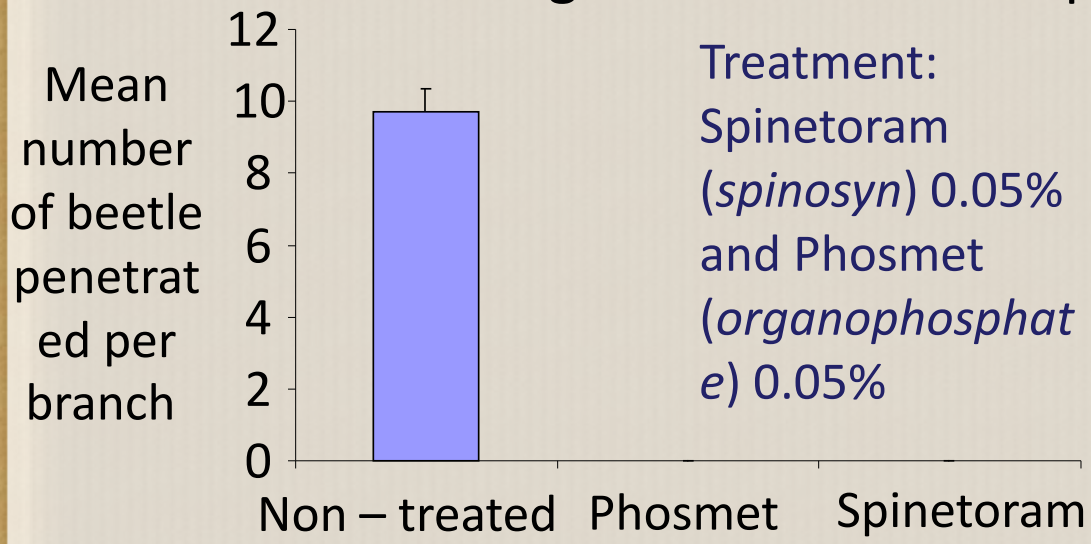
1) Extensive monitoring.

2) Removed thin <6 cm diam. attacked branches.

3) Removed wilting branches, treat the branching point with the main branch with Bifenthrin (Pyrethroid) 1%.

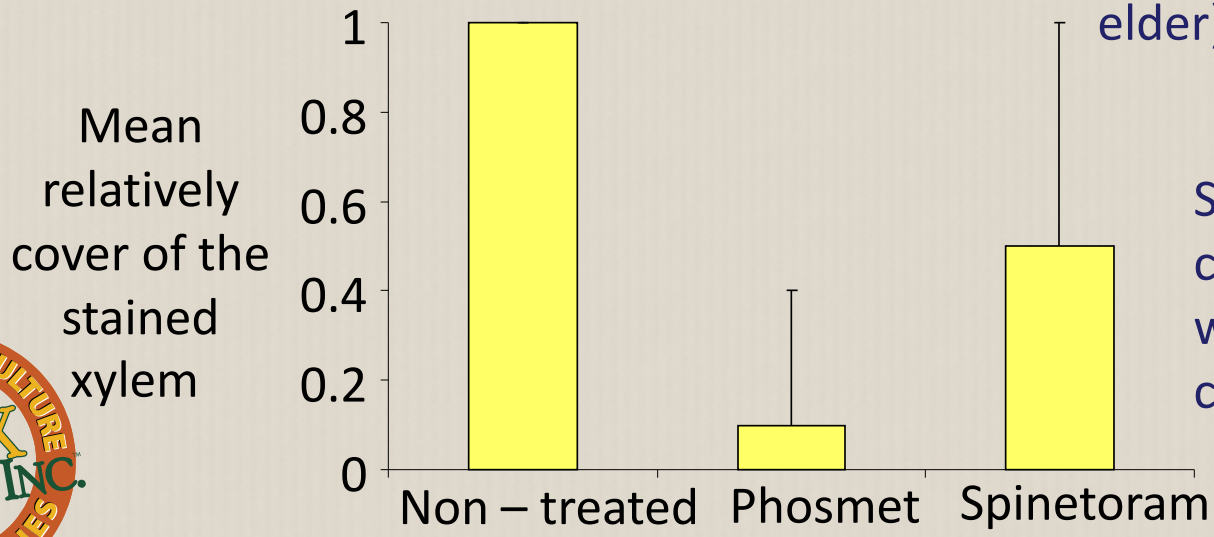
4) Attacked thick branches > 6 cm diam. Treat the lesion spot about 30 cm on both sides along the branch with Acetamiprid (neonicotinoid), and about a week later repeat the treatment with Bifenthrin (1%).

Testing two chemical compounds



Treatment: Spinetoram (*spinosyn*) 0.05% and Phosmet (*organophosphate*) 0.05%

One applications (1 August 2013) Maagan Michael plantations. Three days later selected branches were artificially colonized by the beetles (box elder)



Sampling was conducted 4 weeks after the colonization

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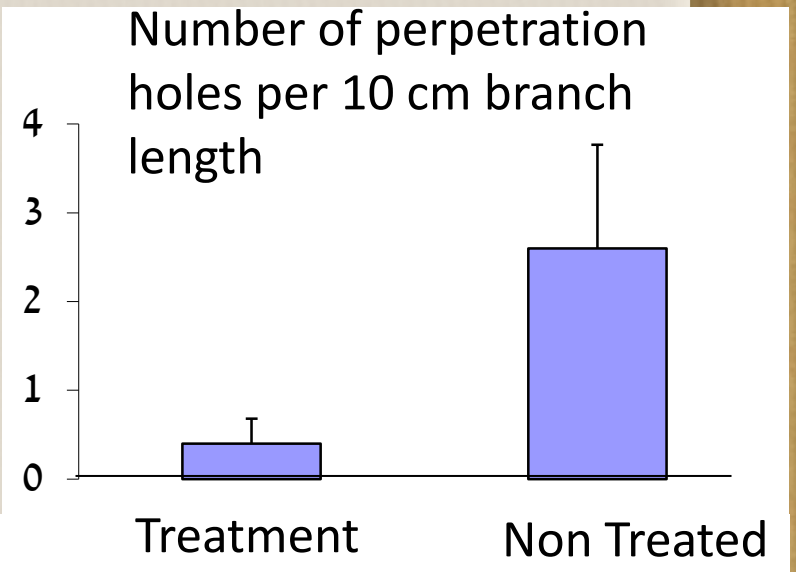
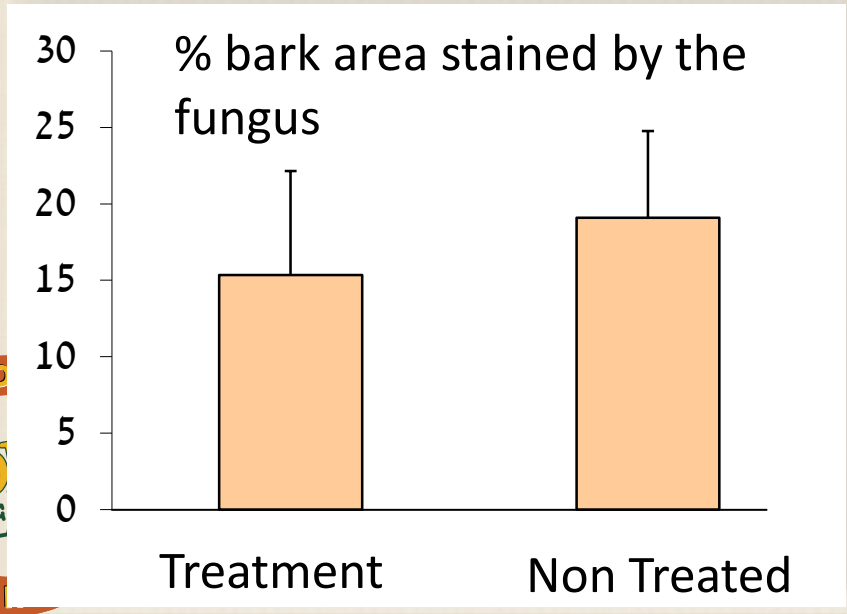
Insecticide treatments in commercial avocado plantation (1)

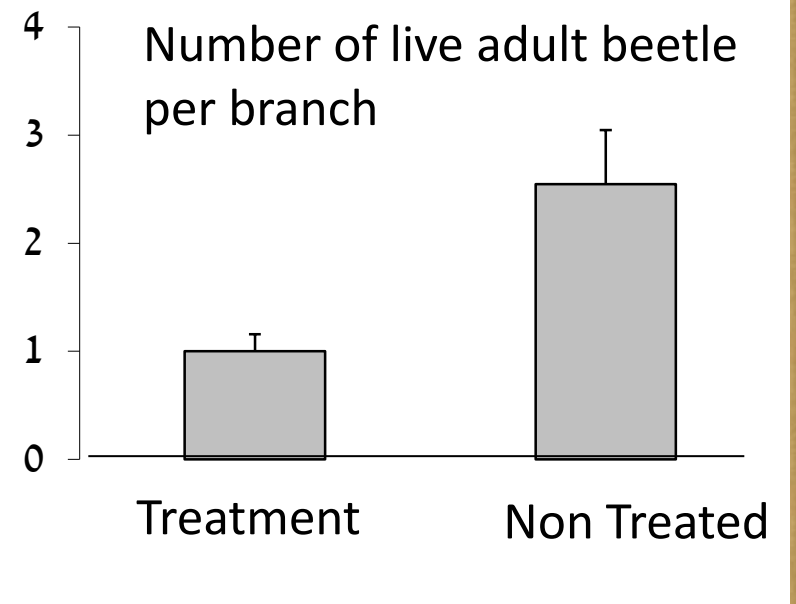
Two consecutive applications (1 and 15 July 2012) Maagan Michael plantations.

Treatment: Methomyl (*Carbamates*) 0.2% + Dichlorvos (*organophosphate*) 0.15%

Sampling was conducted 30 days after the last application



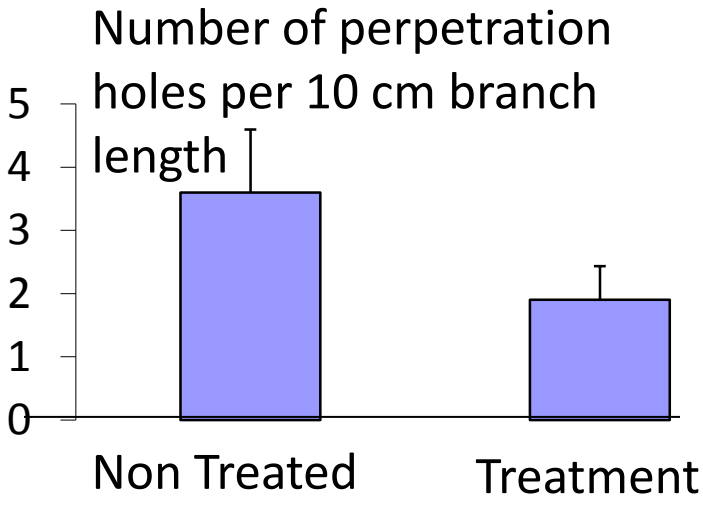


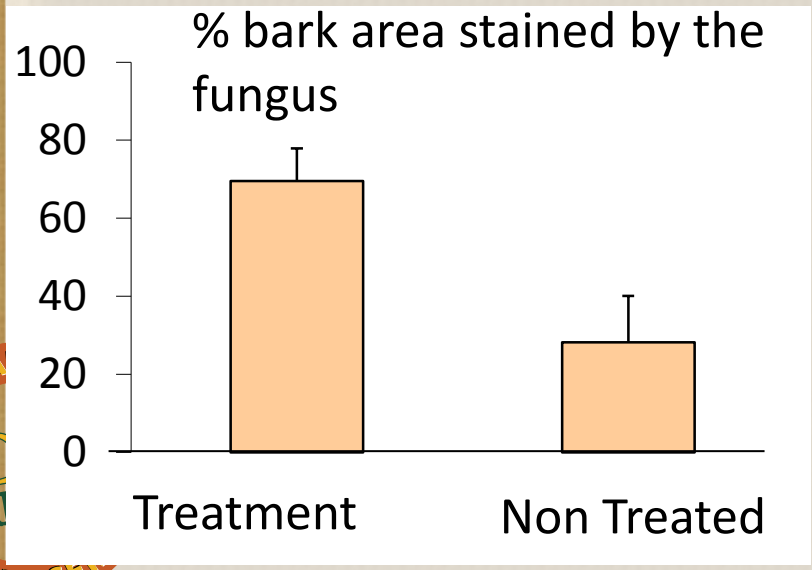


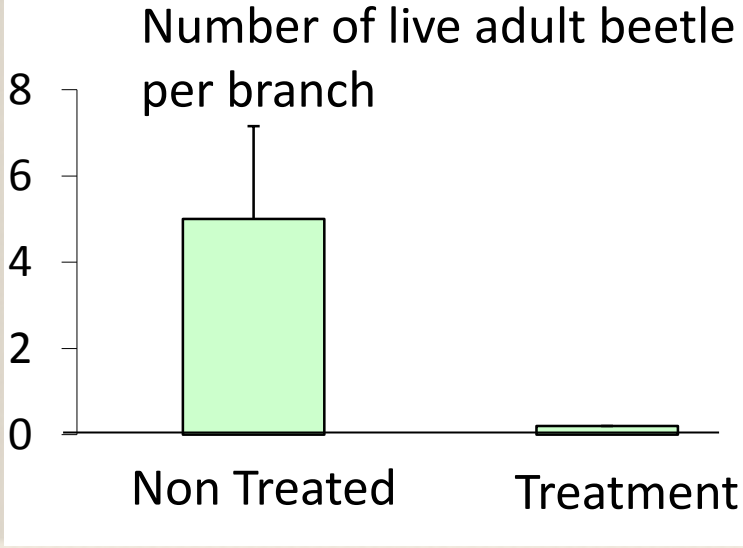
Insecticide treatments in commercial avocado plantation (2)

Two consecutive applications (15 and 30 April 2013) Nordia plantations.

Treatment: I- Methomyl (*Carbamates*) 0.2% + Dichlorvos 0.2%; II - Methomyl 0.2% and Chlorpyrifos-ethyl (*organophosphate*) 0.2%;
Sampling was conducted 30 days after the last application







Polyphagous Shot Hole Borer

Tree colonization behavior as a basis for management of Avocado ambrosia beetle *Euwallacea* nr *fornicatus* populations in avocado plantations

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