Seed Orchard Pests

Behavior and Management with Systemic Insecticide Treatment in the Inland Northwest

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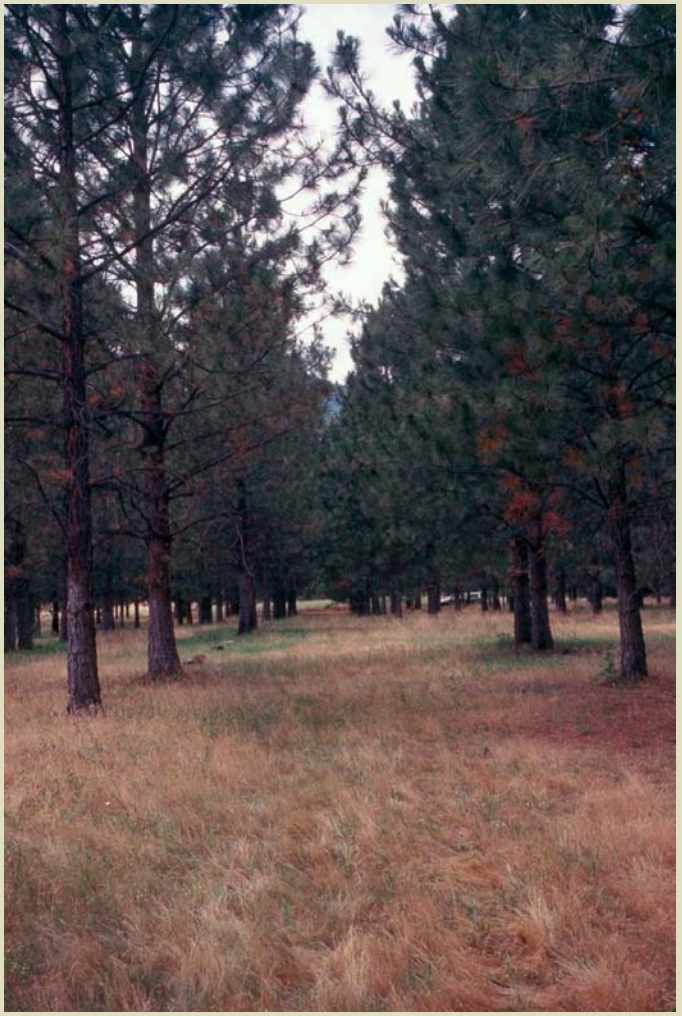
What is a Seed Orchard?

A great place to grow bugs

- Widely spaced**
- Cone-bearing branches near the surface of the ground
- Increased temperature**
- Increased light**
- Fertilized and Irrigated
- Predictable availability of a seed crop (application of stress or GAA induction of cone production)**



Seed Orchard Pest Species

- *Dioryctria* cone worm
- One of the most serious conifer seed orchard pests
- Attacks most common orchard crops

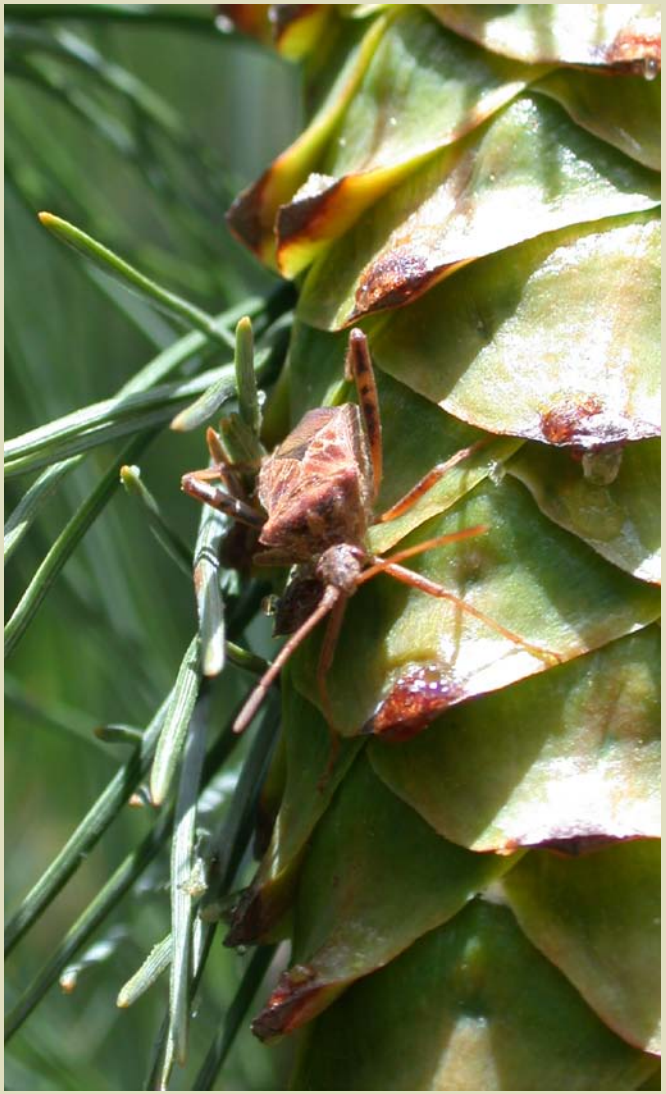
- *Conophthorus* cone beetle
- Attacks only pine
- Flies early and girdles the cone before moving in

Seed Orchard Pest Species

Leptoglossus – Conifer Seed Bug

- Piercing-sucking feeder
- Feeds on most common orchard crops
- Operates primarily in warmer weather

- More on this bug later



Systemic Insecticide Trials

Field Techniques – Drilling and Placing Plugs

- Drilling in Douglas-fir at Cherry Lane Seed Orchard (Potlatch)

- Injecting in western white pine at Grouse Creek Seed Orchard (USFS)

Systemic Insecticide Trials
Field Techniques – Harvesting Cones

- Western White Pine at Grouse Creek Seed Orchard (USFS)

Systemic Insecticide Trials

Why Systemics?

- Reduced non-target effects (potentially more beneficial insects)
- Potentially increased impact on early-flying and in-cone pests
- Potential reduced environmental impacts

Systemic Insecticide Trials

2007 Results – *Dioryctria* in Douglas-fir at Cherry Lane

Treatment		Infested cones (%)
Control		34.5 ± 8.6 a
Azadirachtin		25.5 ± 6.6 a b
Imidacloprid		20.0 ± 9.7 a b
EB – lo dose		12.7 ± 5.6 b
EB – hi dose		9.1 + 4.1 b

- Significant decrease in *Dioryctria* infestation (%) based on treatment
- Treatments injected later than desired, and sample sizes (per tree) were limited
- These factors may have influenced treatment efficacy

Systemic Insecticide Trials

2008 Results – *Dioryctria* in Douglas-fir at Cherry Lane

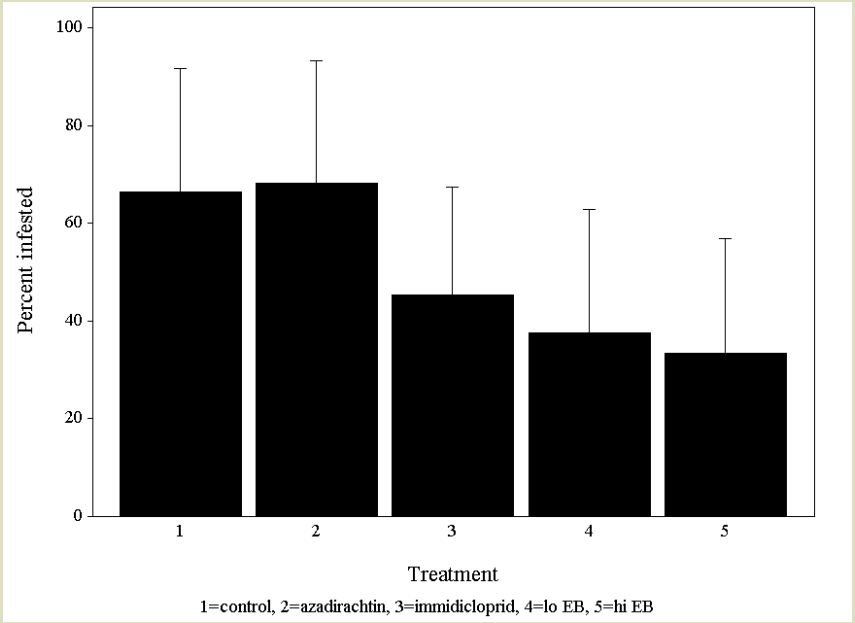
Treatment		Infested cones (%)
Control		11.5 ± 8.1 a b
Azadirachtin		28.0 ± 9.5 a
Imidacloprid		10.9 ± 4.9 a b
EB – lo dose		6.0 ± 3.5 b
EB – hi dose		9.1 + 6.0 a b

- Overall, less damage than previous year
- Only significant difference – EB had significantly less damage than Azadirachtin
- Treatments were injected later in the season than we wanted, and cones were sampled only at the end of the season (15 cones/tree)

Systemic Insecticide Trials
2008 Results – Cone Infestation WWP Grouse Creek

- Not great protection, but imidacloprid and EB treatment results significantly improved over control and azadirachtin

Treatment	% Infested	
Control	66.4 ± 6.5	a
Azadirachtin	68.2 ± 6.5	a
Imidicloprid	45.2 ± 5.7	b
EB – low	37.5 ± 6.5	b
EB – high	33.5 ± 6.0	b



Systemic Insecticide Trials
Modifications Initiated in 2010

- Two insecticides vs. three – imidacloprid and emamectin benzoate
- Direct comparison of spring and fall treatment
- Entire tree harvest (with Ponderosa Pine)
- ELISA techniques used where possible
- Additional laboratory techniques involving direct measurements of changes in insect behavior and survival
- Stimulation of Douglas-fir for cone production

Systemic Insecticide Trials
2010 (Autumn) and 2011 (Spring) Treatments in PP

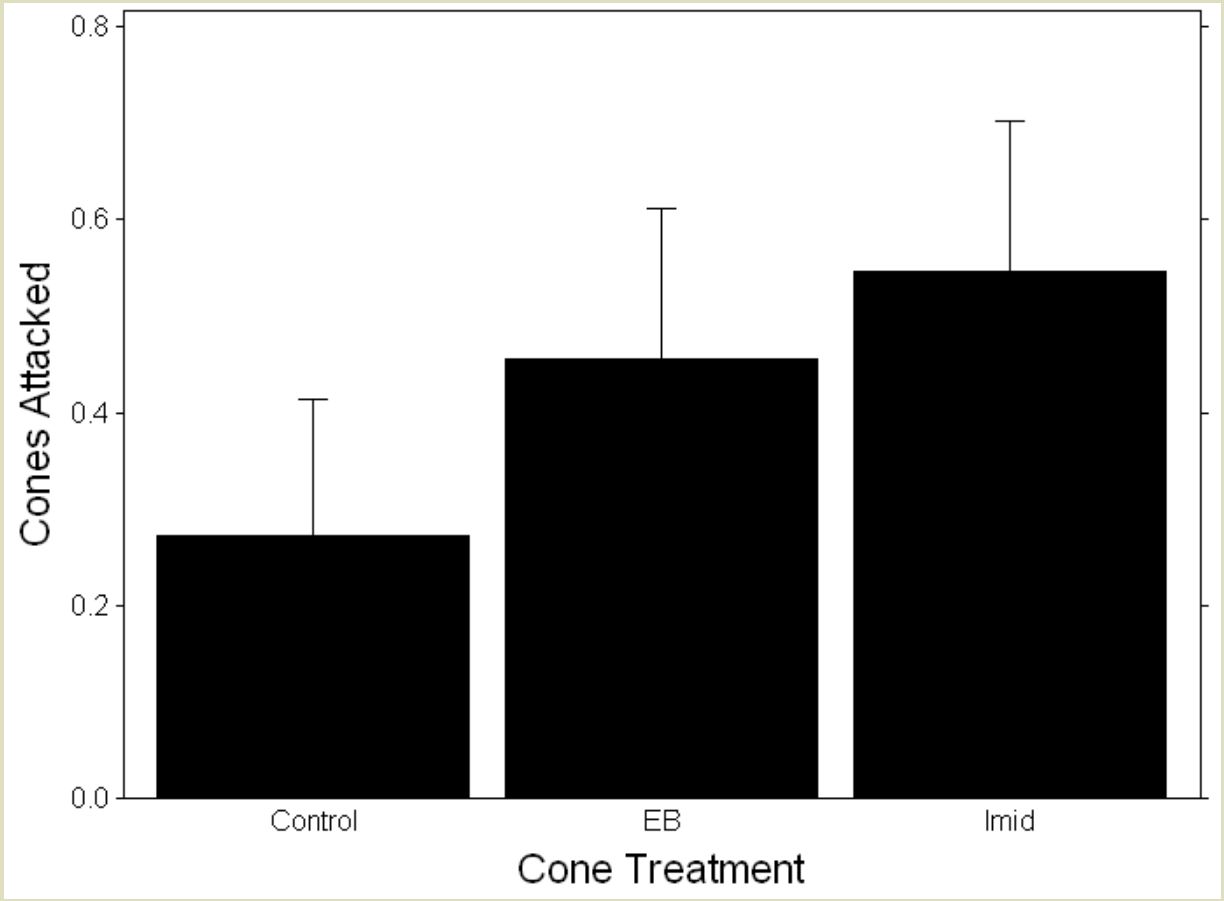
- Effectiveness of EB

			Cones (%) containing		
Treatment	**Applied**	**n**	**No insects[a]**	**Cone beetles[a]**	**Coneworms[b]**
Control	-----	**10**	**15.5 ± 7.0 a**	**39.8 ± 7.4 a**	**44.6 ± 7.2 a**
Imidacloprid	**Fall**	**12**	**30.2 ± 8.3 ab**	**39.5 ± 8.4 a**	**30.4 ± 7.0 ab**
	Spring	**12**	**35.1 ± 5.4 b**	**28.0 ± 5.4 a**	**36.9 ± 3.1 b**
EmamectinBenzoate	**Fall**	**11**	**82.0 ± 9.3 c**	**12.8 ± 6.7 b**	**5.2 ± 4.5 c**
	Spring	**11**	**81.8 ± 4.4 c**	**12.3 ± 2.9 b**	**5.9 ± 2.0 c**

Systemic Insecticide Trials

2011 Lab Experiment with Autumn 2010-Treated Cones

- Selection by cone beetles



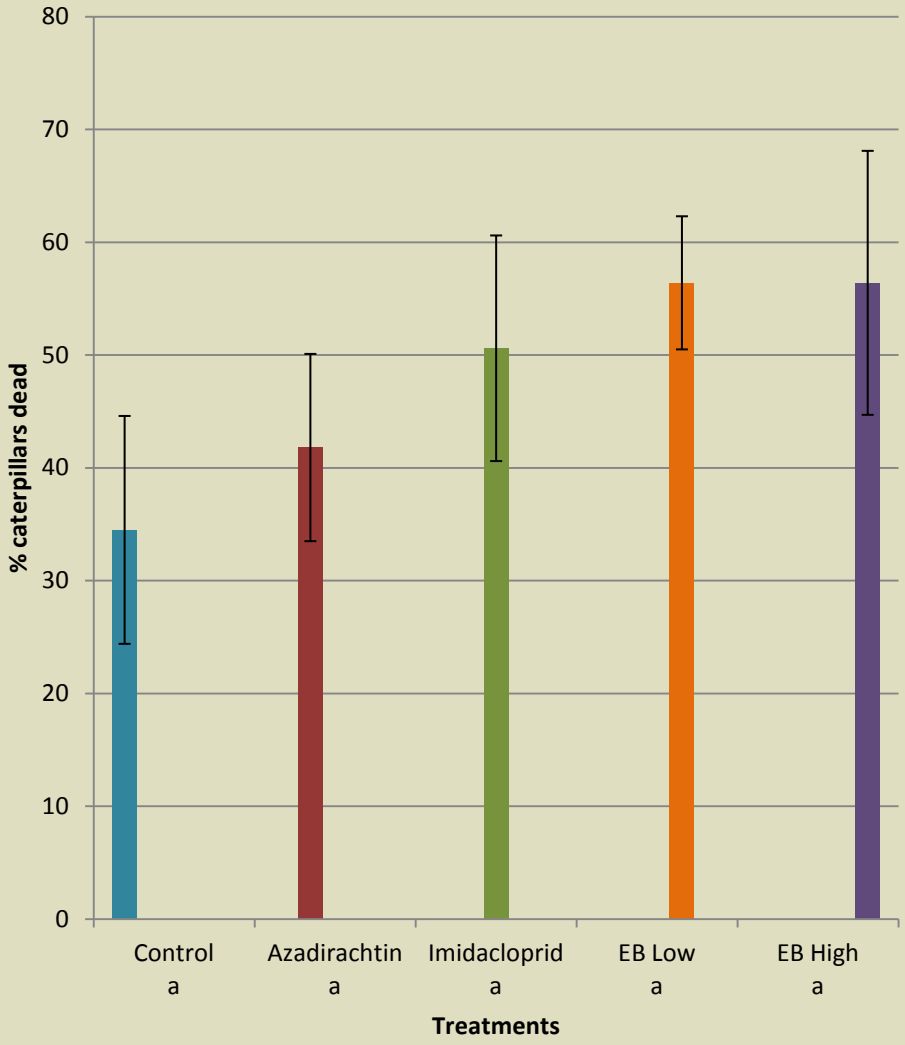
Results looked promising, but statistically, there were no differences among treatments.

χ^2 = 6.07; DF = 12; [P > c^2] = 0.9127

Systemic Insecticide Trials

Douglas-fir Tussock Moth – A Target of Opportunity

- 2008 results of lab-rearing DFTM on Douglas-fir treated the previous year
- EB treatments resulted in highest levels of larval mortality
- There is an ongoing DFTM outbreak in northern Idaho
- We have 1,000+ egg masses in our lab



Systemic Insecticide Trials
(Rough) Cost Estimates

- All of our materials purchased from Rainbow Treecare
- EB Costs: $440/L = $0.44/mL
- Averaged about 30mL/Tree
- **EB Cost/Tree = $13.20**

- Imid Costs: $260/L = $0.26/mL
- Averaged 15mL/Tree
- **Imid Cost/Tree = $3.90**

- We used an Arborjet microinjector. Price: $500

Systemic Insecticide Trials
(Rough) Cost Estimates

- Other Considerations Include:
  - Potential multi-year protection
  - Cost changes for materials
  - Price for seed
  - Labor costs

Western Conifer Seed Bug (WCSB)

Leptoglossus occidentalis

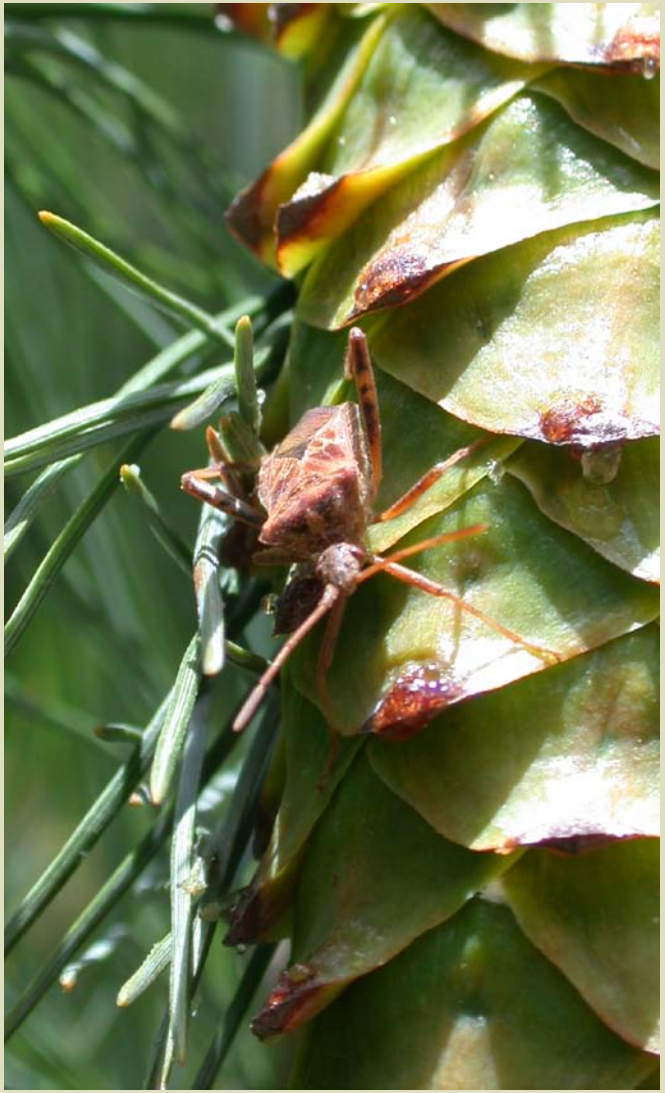
(Heteroptera: Coreidae)

Piercing-sucking feeder of conifer seeds

Over-winters as an adult

A single adult and its offspring can damage up to 310 lodgepole pine seeds in a year[1]

Males may find host cones and attract females



1) Bates and Borden 2005

Western Conifer Seed Bug (WCSB)

Leptoglossus occidentalis

(Heteroptera: Coreidae)

- Females oviposit on foliage near cones, up to 80 eggs per female per year[1]
- High-wire act
- Eggs vulnerable to predation and parasitism


Paul Lenhart


Sean McCann


Ward Strong

Western Conifer Seed Bug (WCSB)

Leptoglossus occidentalis

(Heteroptera: Coreidae)

- Nymphs pass through five developmental stages (instars)
- At the height of development (3rd and 4th instar) a single nymph damages just less than one seed (0.75-0.84) per day[2]

Gerald R. Donehew

2) Hanson 1984; lab tests in harvested coastal Douglas-fir seed

Objectives

1) Examine the feeding and oviposition preference of adult WCSB when presented with four different hosts

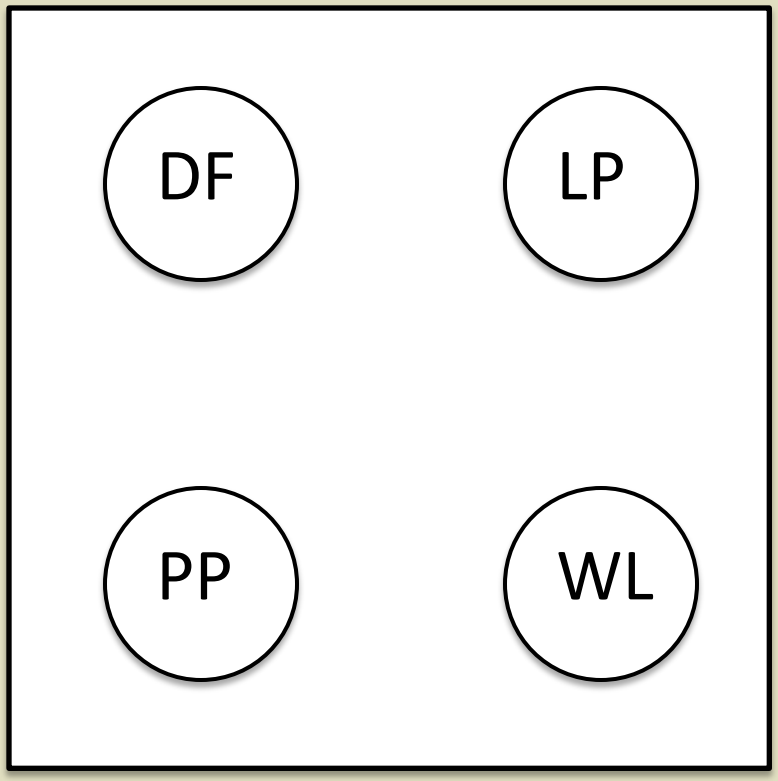
2) Compare suitability of potential hosts on WCSB nymph survival and development

3) Examine feeding preference of adult WCSB presented with different systemic insecticide treatments of the same species

4) Compare suitability for WCSB nymphs of different systemic treatments in the same host species

Host Preference by Adults
Experimental Setup

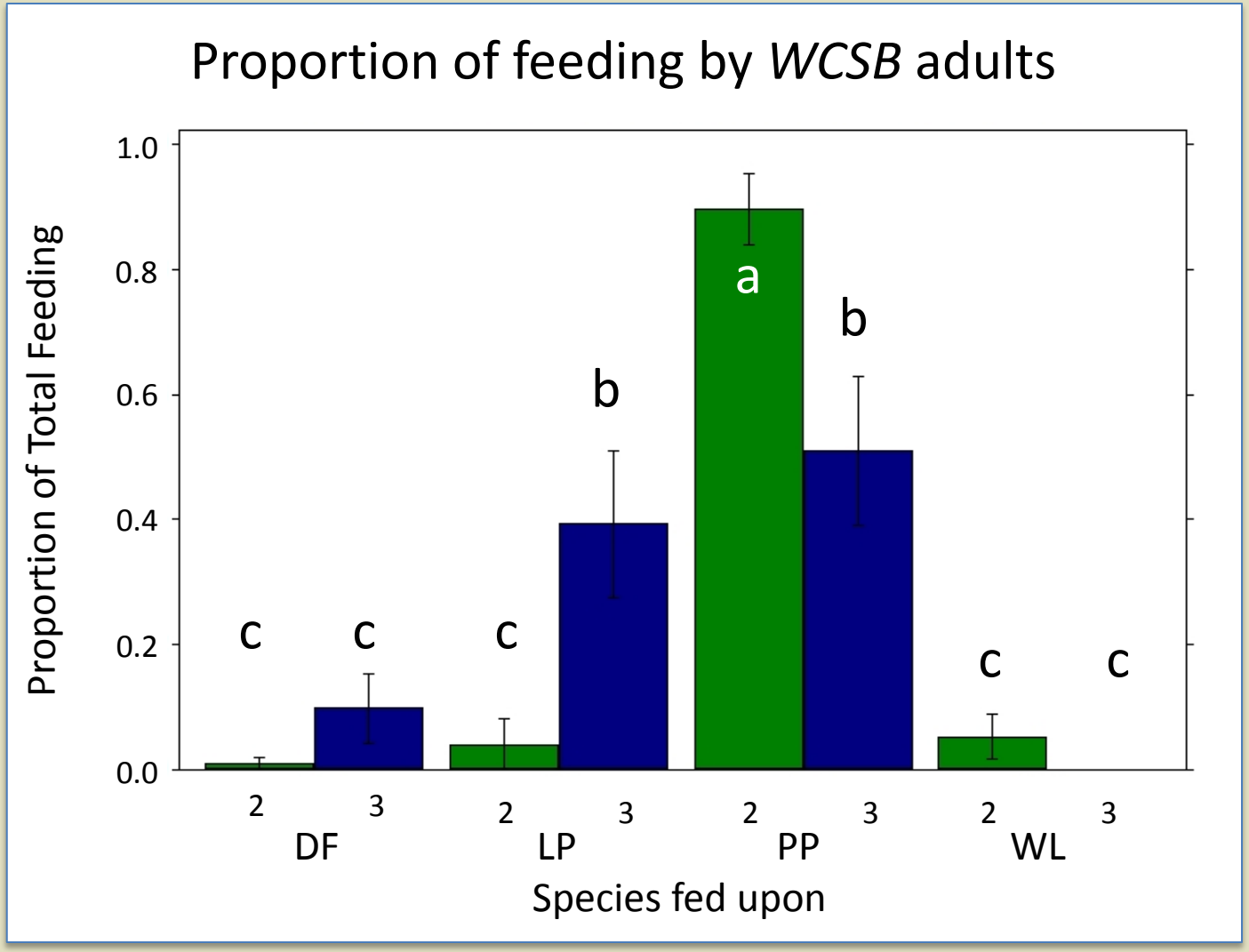
- Summer 2010
- Four hosts: Douglas-fir, lodgepole pine, ponderosa pine, western larch
- Arranged in BugDorm-1 1’x1’x1’ mesh enclosure
- N = 6 male, 6 female per trial, one insect per enclosure
- First trial monitored once per day (trial 1), or every two hours (trials 2,3) for three days
- Egg number and location recorded at end of each trial



Host Preference by Adults

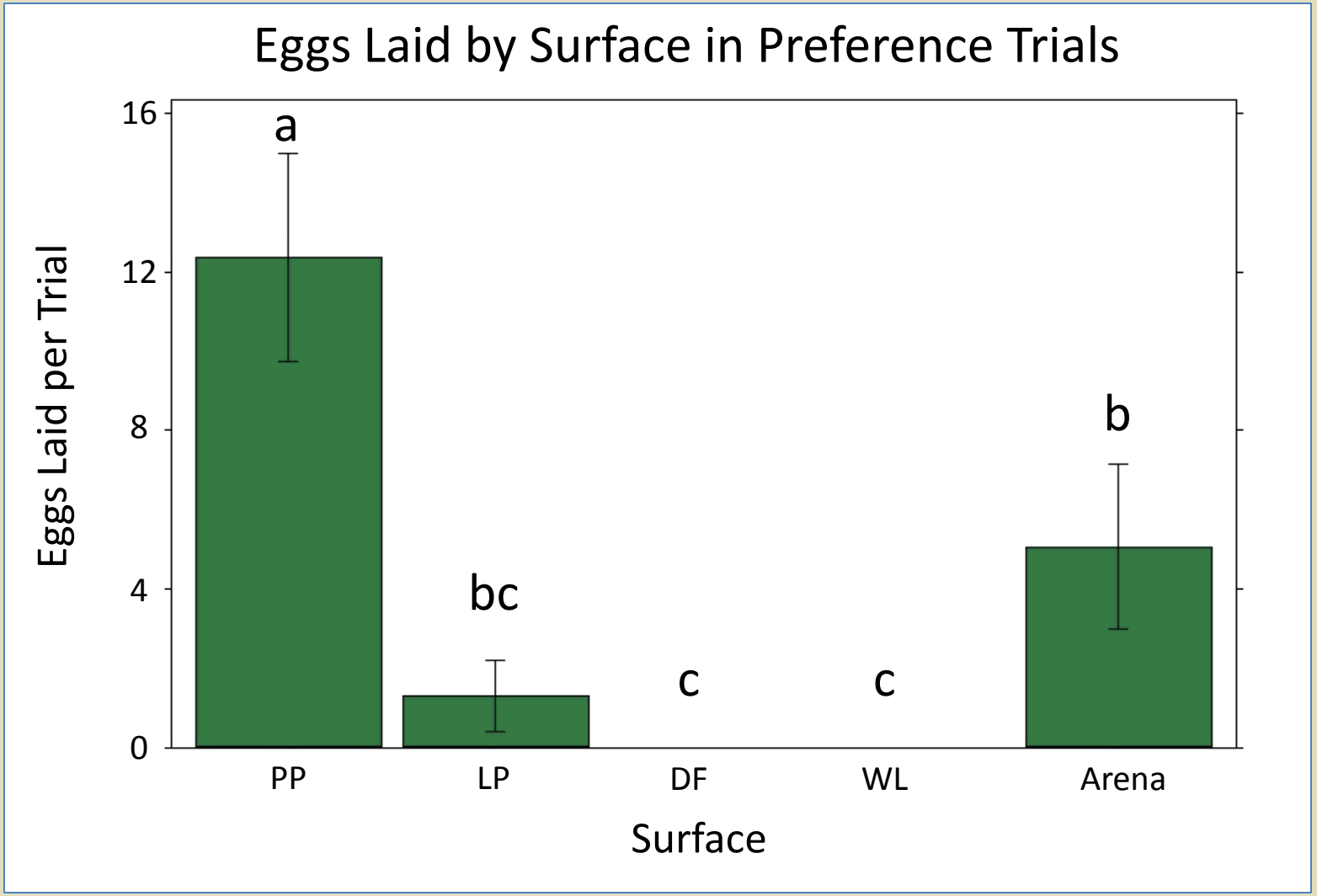
Feeding Results

Colors represent separate experiments
Green: 6/28 to 6/30
Blue: 7/8 to 7/10



Host Preference by Adults

Oviposition Results

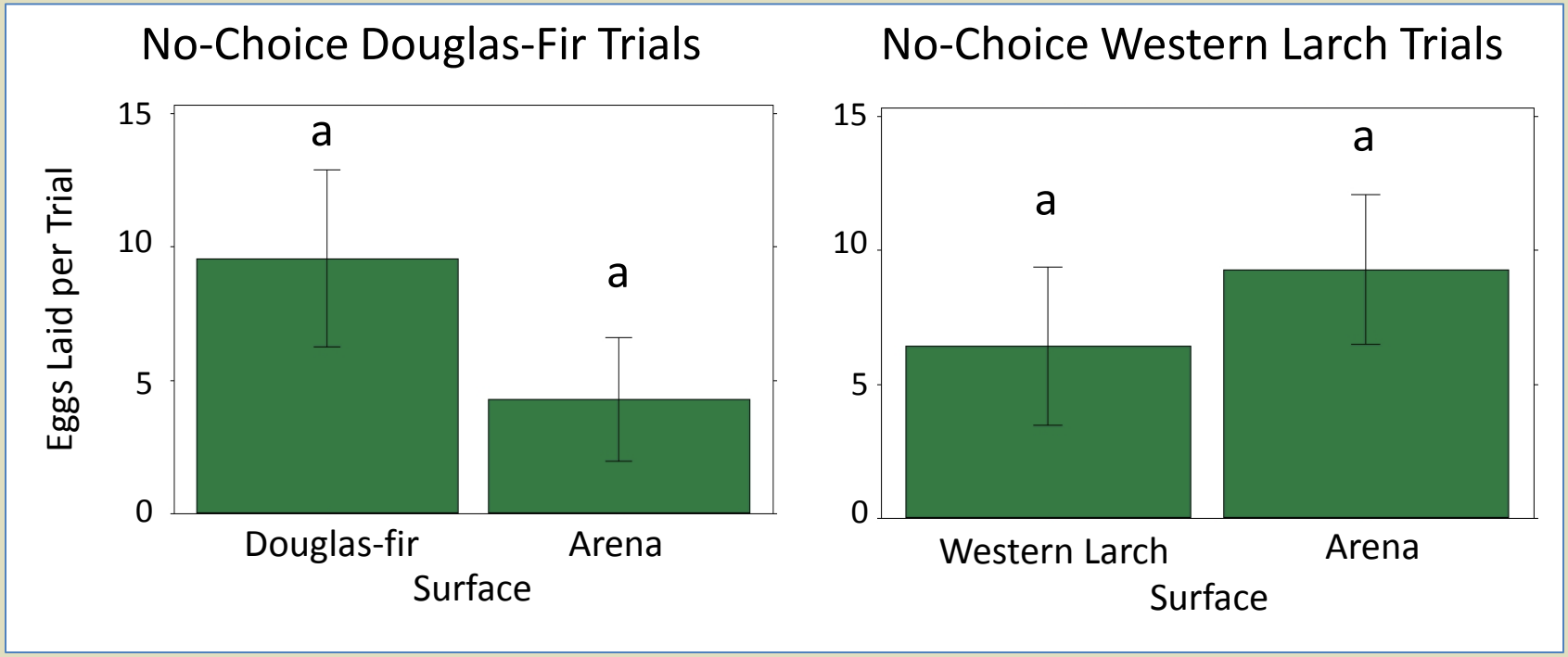


Host Preference by Adults
No-Choice Oviposition

- Objective: Determine preferred oviposition location when presented with only one, less-preferred host
- Summer 2010
- Hosts: either Douglas-fir or western larch
- BugDorm-1 1’x1’x1’ mesh enclosure, one insect per enclosure
- N = 7 females per host species
- Egg number and location recorded at end of the trial

Host Preference by Adults

No-Choice Oviposition Results



Host Preference by Adults

No-Choice Oviposition Results

Host Preference by Adults
Summary of Experimental Results

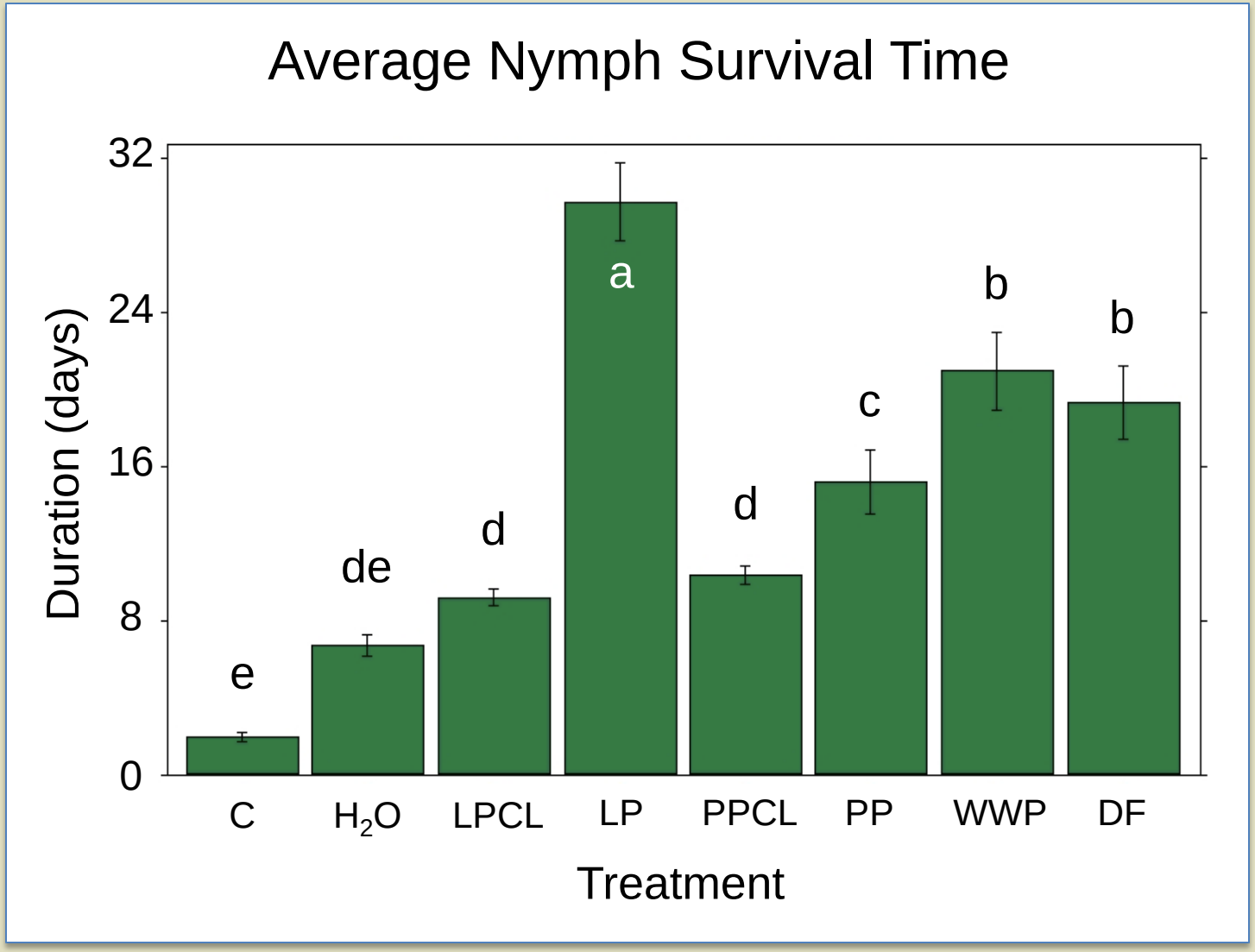
- Pines preferred over non-pines in both feeding and oviposition
- Ponderosa pine fed upon most during both experiments
- Shift in feeding with increases recorded in lodgepole pine
- Ponderosa pine most preferred choice for oviposition
- Douglas-fir and western larch no more attractive for oviposition than the enclosure

Suitability of Hosts for Nymphs
Experimental Description

- Treatments: Control, water only, lodgepole pine conelets, lodgepole pine cones, ponderosa pine conelets, ponderosa pine cones, Douglas-fir cones, western white pine cones
- One liter glass jars with mesh caps
- N = 5 for control and water only; N = 10 for all others; 5 nymphs per replicate
- Monitored for survival and development every 2-3 days
- Adults weighed and sexed

Suitability of Hosts for Nymphs

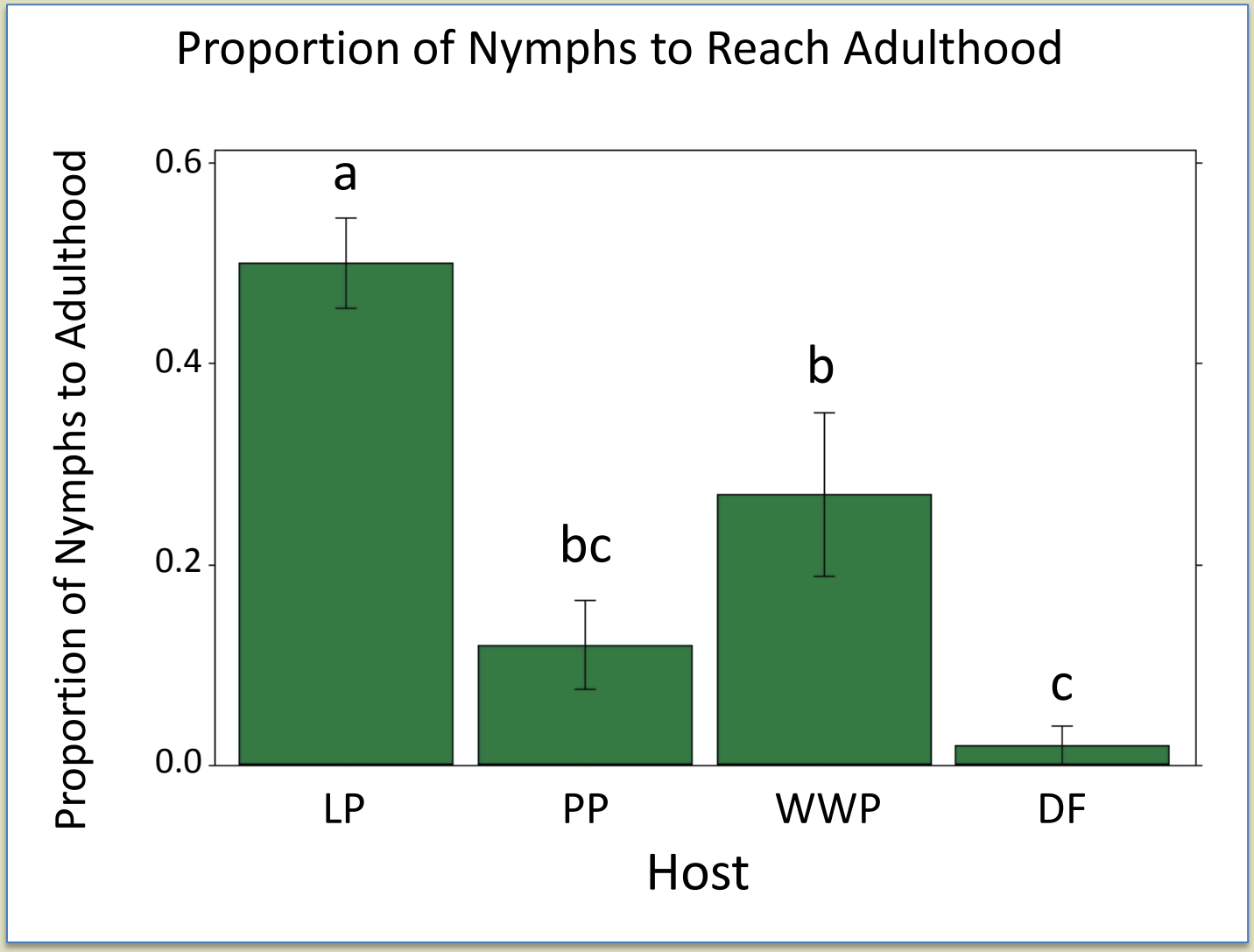
Nymph Longevity



C: Control
H_2O: water alone
LPCL: 1st-year lodgepole cones
LP: 2nd-year lodgepole cones
PPCL: 1st-year ponderosa cones
PP: 2nd-year ponderosa cones
WWP: 2nd year western white pine cones
DF: 1st-year Douglas-fir cones

Suitability of Hosts for Nymphs

Nymph Maturation



Suitability of Hosts for Nymphs
Summary of Experimental Results

- Conelets were not sufficient for development to adulthood
- Lodgepole pine was most suitable in terms of both survival and development to adulthood
- Only one nymph on Douglas-fir matured completely, but average survival on Douglas fir was similar to western white pine and greater than ponderosa pine
- Western white pine and ponderosa pine were intermediate in both nymph survival time and development to adulthood
- There were no differences between hosts for adult weight, sex ratio or time to adulthood

Host Preference and Suitability
Implications

- Pines are generally favored as hosts for adults and nymphs, suggesting pines may be more vulnerable to WCSB feeding than Douglas-fir and western larch
- Adults fed on Douglas-fir infrequently, and adult females laid eggs on Douglas-fir only when no other host was available.
- Nymphs developed poorly on Douglas-fir, but they survived (and presumably fed) for a significant period of time.

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- Adults fed on Douglas-fir infrequently, and adult females laid eggs on Douglas-fir only when no other host was available.
- Nymphs developed poorly on Douglas-fir, but they survived (and presumably fed) for a significant period of time.
- Is Douglas-fir in the intermountain west at risk of significant losses to WCSB feeding?

Host Preference and Suitability
Douglas-fir and WCSB

- Previous work suggesting WCSB as a major Douglas-fir pest were in the coast subspecies
- Coast and Rocky Mountain subspecies diverged roughly 2 Million years ago and may have a very different susceptibility to WCSB.[3]
- Our selection experiments were in a 1'x1'x1' space, while seed orchards cover at least several acres – how do these results scale up?
- How much damage can a nymph do in the time it has on Douglas-fir?

3) Gugger *et al.* 2010

WCSB and Systemic Insecticides

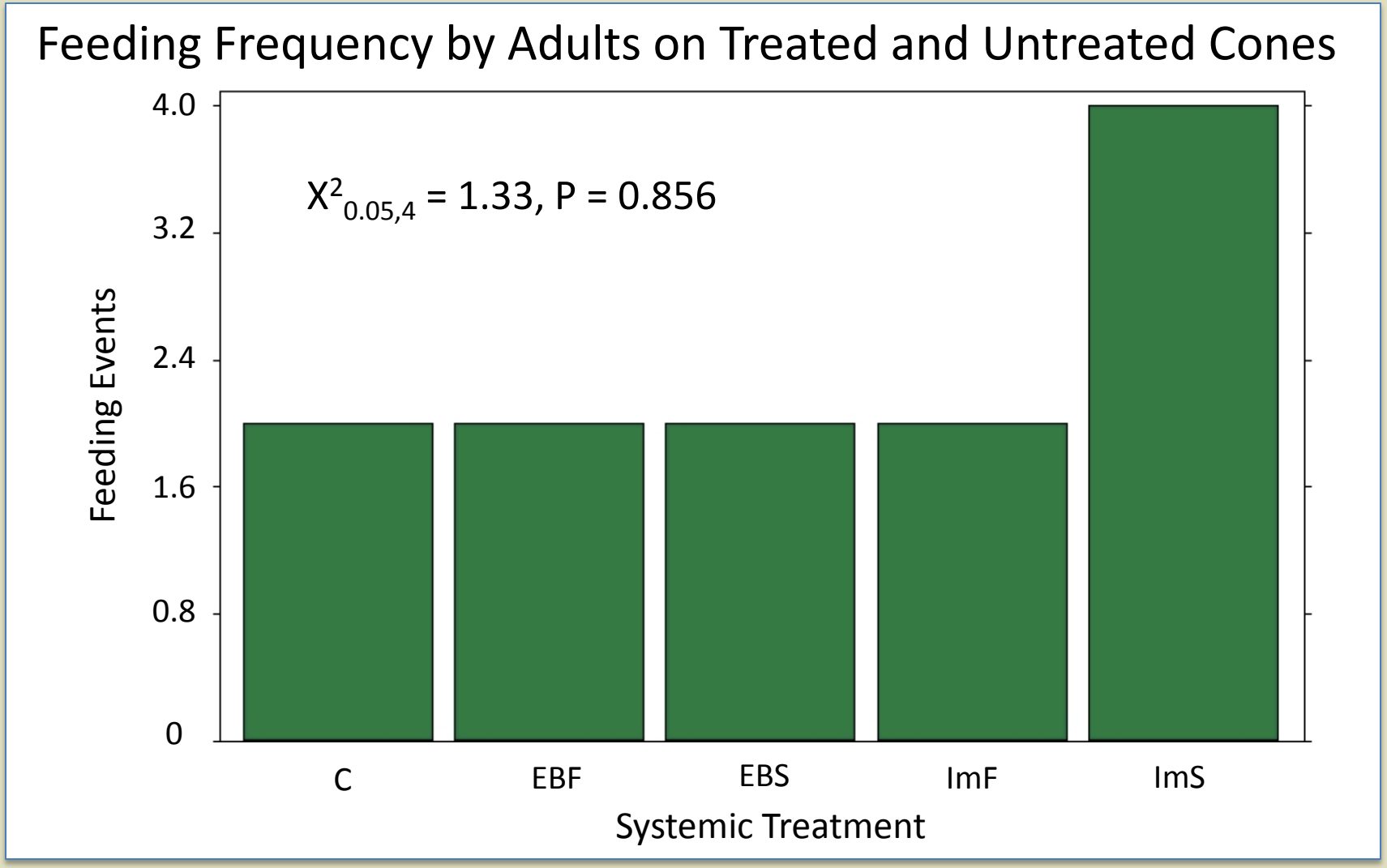
- Objectives: Determine if systemic insecticides influence feeding preference by adults and survival in nymphs
- Ponderosa pine cones harvested in late July 2011
- Great Lepto Drought of 2011

WCSB and Systemic Insecticides
Adult Preference Experimental Setup

- Summer 2011
- Objective: Determine preference by adult male WCSB among ponderosa pine cones from trees undergoing different systemic insecticide treatments
- Five treatments: Control; Imidacloprid treated fall 2010 or spring 2011; Emamectin Benzoate treated fall 2010 or spring 2011
- BugDorm-1 1’x1’x1’ mesh enclosure
- N = 8 males, hatched during 2011 season, one insect per enclosure
- Trials observed every two hours for three days

WCSB and Systemic Insecticides

Adult Preference Results

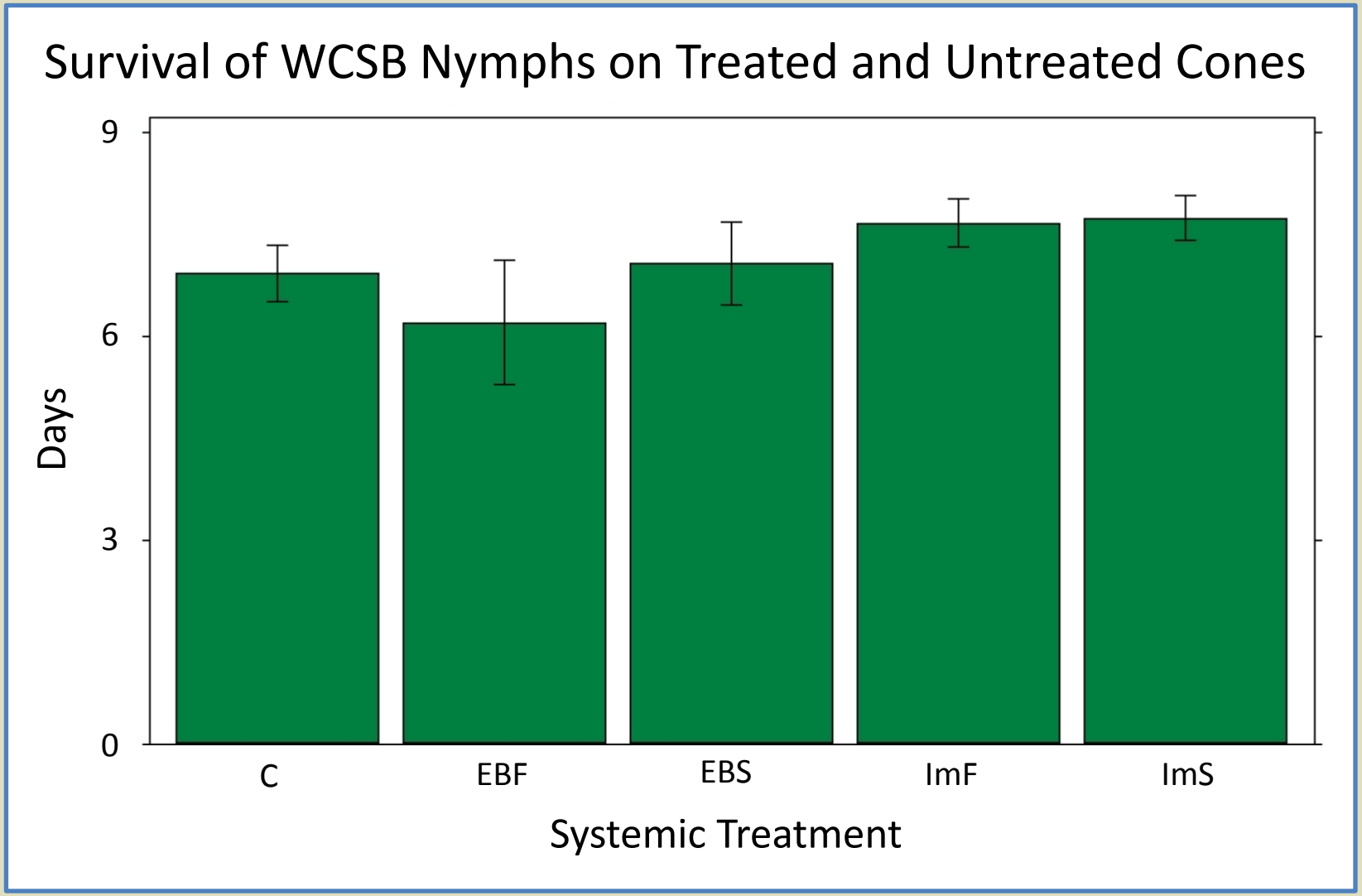


WCSB and Systemic Insecticides
Nymph Suitability Experimental Setup

- Treatments: Control; Imidacloprid treated fall 2010 or spring 2011; Emamectin Benzoate treated fall 2010 or spring 2011
- One liter glass jars with mesh caps
- N = 4; 5 nymphs per replicate
- Monitored for survival and development daily

WCSB and Systemic Insecticides

Nymph Suitability Results



WCSB and Systemic Insecticides
Summary

- Adult WCSB showed no preference among systemic treatments and controls, and no mortality was observed.
- Nymphs showed no difference in survival on cones of different systemic treatments.
- There appears to be no significant impact due to systemic insecticide treatment on WCSB survival or feeding in a laboratory setting.
- Limited data set with limited replicates – to be repeated on Douglas-fir from Paradise Valley systemic trials

Conclusions

- In laboratory settings Ponderosa pine, lodgepole pine and possibly western white pine were superior hosts for WCSB.
- Adults feed and oviposit infrequently on Douglas-fir and western larch, suggesting reduced susceptibility to WCSB.
- There may be shifts in feeding preference over the course of a season.
- Laboratory results do not suggest any significant impact on WCSB by either of the insecticides tested.

Scrambled Eggs

Gryon pennsylvanicum:
Possible international biocontrol?

Frank Merickel

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Systemic Insecticide Trials

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•USDA-FS – Grouse Creek (Western White Pine, Ponderosa Pine)
•IDL – Paradise Valley (Douglas-fir)

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Questions?

Erica Simek