Evaluation of disease resistance in a breeding program

Parents *E. grandis* × Parents *E. urophylla*

Progeny test

hybrid

Evaluation

Selection

Clonal trial

Selection

Enlarged Clonal trial

Selection

Commercial Plantation

Evaluation of parents and commercial clones for disease resistance

Fonseca et al. (2010)
Genetic Variation in Lodgepole Pine Physical and Chemical Defenses Associated with Host Selection Behaviors of Mountain Pine Beetles

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Acknowledgments

Forest Ecosystem Health Group: Dan Ott (MS), Sarah Pears (MS), Steve Oster (PhD), Dan Comerford (MS) and Dr. Paul Schaberg, Josh Halman, Tom Sallalie, and Gary Hawley

Field and lab crews: John Murphy, John Murphy, Dr. Mike Carlson, Bonnie Lee, Bonnie Hooge, Marco Hernandez, Andrea Singh, Erin Clark, Dr. Clive Dawson, Dave Dunn, Jeff Selesnic, Alan Howard, Chris McEvoy

Funding sources: BC-Ministry of Forest, USDA Forest Service - Research Branch and Forest Health Protection, McIntire-Stennis, National Science Foundation, USDA National Research Initiative
Three Stages of Bark Beetle Life History

• 1) Host Selection and Colonization
  – Habitat location
  – Host location
  – Host use

• 2) Brood Development

• 3) Dispersal
Host Defenses At Each Stage

• 1) Primary Defenses
  – Outer Bark
  – Resin Flow
  – Constitutive Terpenes

• 2) Secondary Defenses
  – Compartmentalization of associated fungi
  – Induced Terpenes
    – Halt Reproduction
Eggs are deposited in niches along the egg gallery

- Adults may die in the gallery prior to oviposition
Bark beetles carry a variety of microorganisms (fungi, yeasts, and bacteria)

• **Blue-stain fungi** (Ophiostoma) are common
  – Aid in tree killing
  – Serve a nutritional role
2. Brood Development

- Larvae mine at right angles to the egg gallery
  - 3-4 larval instars and late instars stay in phloem or move into outer bark
- Pupate at end of larval mines
3. Dispersal

- Emerge to locate another suitable host
- Strong fliers – can disperse over long distances
- Dispersal is a small fraction of the generation time
Objectives

Examine an important open pollinated family trial using simulated and ‘optimum’ mountain pine beetle attack for discerning genetic variation

Examine variation in ‘choice’ by mountain pine beetle and resistance / tolerance among families

Estimate genetic parameters for these traits

Examine mechanisms of resistance, to better understand host / bark beetle interactions

Ott, Yanchuk, and Wallin
• Quantify host resistance traits thought to be linked to MPB attack and successful colonization
• 2 sites with randomized complete block design
• 45 families of interest identified based on preliminary findings
• 8-12 individuals per family per site
• Estimate $h^2$ defensive responses

Ott, Yanchuk, and Wallin
Randomized complete block design – 8 reps with the same families, but individually randomized. Each family placed with 4 individuals in a row.
Simulated attack: 1º and 2º Defenses

Resin Flow: 1800+

*O. clavigerum* – cultivated & inoculated

Tree chemistry – 2800+ samples
Constitutive – phloem collected when resin flow
Induced - phloem during lesion measuring
Actual Mountain Pine Beetle Attack

Host Location: Landed or not landed upon
Host Selection: Landed upon and attacked or not attacked

Brood Development: Ovipositional placement density, including eggs deposited and offspring development

Dispersal: Adults emerging density
Beetle lands on a tree

Ott, Yanchuk, and Wallin
Beetle lands on a tree

Does not enter

Enters

Smooth → Rough
Beetle lands on a tree

- Does not enter
- Enters

Bark texture $h^2=0.65$

Ott, Yanchuk, and Wallin
Beetle lands on a tree

- Does not enter
- Enters
- Dies

Tree defenses
Primary: Resin flow
Secondary: Terpenes

Bark texture $h^2 = 0.65$

Ott, Yanchuk, and Wallin
Beetle lands on a tree

Does not enter

Enters

Dies

Resin volume $h^2=0.05$
Total terpenes $h^2=0.5$
3-carene $h^2=0.6$

Bark texture $h^2=0.65$

Blue stain lesion $h^2=0.24$

Ott, Yanchuk, and Wallin
Beetle lands on a tree

Does not enter

Dies
Resin volume $h^2=0.05$
Total terpenes $h^2=0.5$
3-carene $h^2=0.6$

Enters

Bark texture $h^2=0.65$

Blue stain lesion $h^2=0.24$

Survives

Ott, Yanchuk, and Wallin

Recruits conspecifics
Beetle lands on a tree

Does not enter

Dies
- Resin = $h^2=0.05$
- Total terpenes $h^2=0.5$
- 3-carene $h^2=0.6$

Enters

Bark Texture $h^2=0.65$

Blue stain lesion = $h^2=0.24$

Survives

Terpinolene = $h^2=0.35$

Recruits conspecifics

Success

Ott, Yanchuk, and Wallin
Results

• All estimates of heritability for differential attack of MPB on lodgepole pine were generally in the range of the heritability of height at age 10 (i.e., $h^2 = 0.45$) indicating there are moderate to high levels of genetic variation for resistance related traits to MPB.

• Resin volume was not a good predictor of insect mortality.

• Total terpenes had higher than the general range of heritability.

• High levels of δ-3-carene at day 0 significantly correlated with insect mortality and tree survival.
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