Final Report for FGC Adelgid Project

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Background:

Adelgids are minute insects that have proven to be costly pests in Western Canadian seed orchards. Adelgids have a complex life history, and cycle between primary and secondary conifer hosts. Spruce is considered the primary host because it includes the only sexual generation whereas the secondary host is of another conifer genus (*Pseudotsuga, Larix, Pinus, Tsuga,* or *Abies*) that differs among adelgid species. On the secondary host all life stages are parthenogenetic. Adelgids insert their stylets intra-cellularly and feed on solutes from the phloem of spruce and on the cortical parenchyma or ray parenchyma cells. Feeding on spruce induces galling and can limit branch development. Galling of reproductive buds directly reduces seed yields and galling of vegetative buds decreases the potential number of future cone sites. On secondary hosts adelgids feed on the needles and cones. Feeding on the needles of secondary hosts can cause twisting and yellowing, hence reducing tree vigour, whereas feeding on the cones reduces seed yields and impairs seed extraction efficiency.

Adelgids have proven to be a serious pest at the Ministry of Forests and Range Kalamalka Forestry Centre (KFC), located in the north Okanagan of BC. Seed losses as a result of pest activity can be very costly considering reforestation depends on the seed supplied from seed orchards. By 2013 British Columbia (BC) would like to have 75% of forestry seed supplied by seed orchards. To maintain a supply, orchards are managed for frequent and abundant seed production to minimize losses incurred by seed and cone pests, such as adelgids.

Our research explores questions regarding their biology and their impact in the Kalamalka Research Orchard. Information gathered will be used to design a rational pest management plan to reduce adelgid impacts in BC seed orchards.

Project objectives:

1. To determine species, abundance, and seasonality of adelgids at KFC.
2. To relate the different gall morphologies with the adelgid species that induces them.
3. To determine if there is genetic control over adelgid galling incidence in interior spruce.
4. To determine the influence of adelgid fundatrices and nymphs in gall induction and formation.
5. To describe morphological changes in gall development using histological techniques.

Project descriptions and findings:

1. Determining species, abundance, and seasonality of adelgids at KFC

In the summer of 2007 we trapped adelgids within the Kalamalka Research Orchard to ascertain an approximate population size, identify flight times, determine species present and general abundances, and to characterize movement of adelgids between orchards. Adelgid abundance was much lower than was observed in a 1996 trapping program. Species diversity remained the same. The dominant species observed were *Adelges cooleyi* and *A. lariciatus*. We did observe a shorter flight period for alates in 2007 compared to the 1996 flight period, which extended later into the fall. In 1996 a second peak in alate flight was observed in mid-August but this was absent in our 2007 trap catches. Movement of adelgids between orchards can be a contributing factor to population build-ups, however we observed a mix of species in all of our traps, which were located in different areas. Adelgids are poor flyers and their movement depends on the timing, direction, and strength of winds in the area. Proximity of secondary hosts to spruce does pose a threat, yet there are other contributing factors that influence adelgid populations that need to be considered.

2. Relating gall characteristics to the inducing adelgid species.

We attempted to characterize galls according to the adelgid species that induced them. In the summer of 2007 we photographed and bagged a variety of galls within the Kalamalka Research Orchard. Emerging alates were collected in the bags and identified to species. We were only able to characterize galls induced by *A. cooleyi, A. lariciatus, A. abietis,* and *Pineus floccus*. For each species there was a slight variation in the galls they induced although galls were still distinguishable according to species. Identifying adelgid species from galls allows for quick and easy species identification opposed to collecting adelgids and performing a lengthy procedure of fixing them onto slides for identification under a microscope. Understanding what species are present, based on galls, can aid in characterizing adelgid movement between orchards and indicate if particular neighbouring orchards represent a risk.

3. Determining if there is genetic control over adelgid galling incidence in interior spruce.

We used an interior spruce plantation in the Kalamalka Research Orchard, which was previously screened for weevil resistance, to assess if there was any genetic control over adelgid infestations. The plantation is a 13-parent, partial diallel, replicated progeny test with 42 full-sib families. There are approximately 1450 trees in this plantation and we sampled two branches from each tree for adelgid galling incidence in the summer of 2007. We found strong evidence of genetic control of susceptibility/resistance with modest individual, and high half- and full-sib family narrow sense hertibalitities. We also found that parental susceptibility/resistance to adelgid galling could be selected for as was determined by the obtained breeding values for each spruce parent. The benefits of screening for resistance to adelgid attack could be used as a screening criterion for parental inclusion into future establishment of seed orchards.

4. To determine the influence of adelgid fundatrices and nymphs in gall induction and formation.

It has not been determined what adelgid life stages are responsible for gall initiation and formation. In the summer of 2007 we attempted to determine if adelgid fundatrices (adelgid mothers that overwinter on spruce) and their offspring (nymphs/gallicolae) were both required to form a gall on the shoots of spruce trees. Our initial findings determined that fundatrices without nymphs, and nymphs without fundatrices were not able to induce a gall. We found that fundatrices and nymphs together could form a gall, and that they did not need to be related. Our treatment of fundatrices without offspring was contaminated with "escaped" nymphs and therefore we will replicate this study.

Future work:

4. To determine the influence of adelgid fundatrices and nymphs in gall induction and formation.

Project 4 will is currently being replicated in an attempt to rigorously determine the role of fundatrices and nymphs in gall induction.

5. To describe morphological changes in gall development using histological techniques.

We will further clarify the role of fundatrices and nymphs in gall formation using histological sections of spruce branches, at different stages of fundatrix and nymph development. This work will be done in collaboration with Dr. Joe Shorthouse from Laurentian University in Sudbury, Ontario. Babita Bains will travel to Joe's lab in July to do the histological work. We will attempt to determine the steps involved as adelgids gain control of a bud, leading to gall induction and development. Describing gall formation and identifying the life stages responsible will further clarify the critical pest stage in gall induction, leading to more accurate pest management decision making such as timing of sprays or more precisely estimating future gall densities.

Conclusion:

Increasing our depth of knowledge of adelgids will enhance current pest management and will lead to new insights in adelgid biology, host response, and possibly provide new avenues for monitoring and pest control.