GENETIC VARIATION IN RESISTANCE OF TREES TO INSECT ATTACK

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When Ernie Schreiner asked me to discuss resistance of trees to insect attack he promised to write a speech for me. I wish that he had kept his promise for I am sure that he has much more information on the subject than I. We at New Haven have not worked on any specific project of this nature so my remarks must of necessity be a rehash of the work and deliberation of others. I would like to state at the outset that our Division is intensely interested in the problem and our Berkeley, California station is working on two specific projects at the present time.

In recent years emphasis has been placed on studies to control forest insects by direct methods. Considerable success has been attained in combatting a number of serious forest insect pests with insecticides applied by aircraft and from the ground. We are, however, running into a number of unforeseen problems in connection with insecticidal control and are now attempting to place greater emphasis on natural control studies. At least we are trying to evaluate the role of natural factors in controlling our major pests. These factors include parasites, predators, disease, climate, etc., and certainly the resistance of trees to attack by insects.

There are many forest insects which are limited in their feeding to one species of tree or to a specific group of trees. Some, however, are general feeders. Little is known regarding the underlying reasons for host, specificity of forest insects. Why does the white pine weevil, for example, prefer white pine and Norway spruce to other species of pine and spruce? Why does the gypsy moth prefer the oaks to ash and maple?

Rapidity of growth, Nigor, and age are important factors in determining susceptibility of trees to attack by certain insects, notably bark beetles and borers.

Condition *of* the foliage may sometimes result in resistance to insect attack. Black spruce is resistant to spruce budworm attack because of lack of synchronization of emergence of budworm larvae and opening of buds on black spruce.

In some instances individual trees of the same species are resistant to attack by certain insects. One of the best known examples is found in Norway and white spruce plantations infested by the spruce gall aphid. Friend and Wilford have studied this problem and they report that some trees appear to be absolutely immune to gall aphid attack, others become heavily infested, and between these groups all gradations of infestation occur. The immediate cause of immunity lies in the inability of the insect to survive and not in any particular preference shown by the winged generation for individual trees. The winged females, which fly during late summer will oviposit on immune trees, the eggs will hatch, and the nymphs will crawl to the twigs and start feeding, but such individuals die before ovipositing the following spring. These investigators failed to discover any clearly visible external characters which enabled them to predict degree of susceptibility of individual trees.

Our Berkeley station is conducting studies of resistance in pines to bark beetle attack and tests of hybrid pines for resistance to the pine reproduction weevil. These studies are conducted in cooperation with the California Forest and Range Experiment Station at the Institute of Forest Genetics, Placerville, California.

The bark beetle study, initiated in 1951 by Callaham and Miller, indicated that Jeffrey-ponderosa pine hybrids were resistant to the western pine beetle which normally attacks ponderosa pine. The work indicated that the oleoresins which exude from the tree into wounds created by the attacking beetles are very toxic to the insects. The 1952 studies showed that Monterey-knobcone hybrids are resistant to both the western pine beetle and the mountain pine beetle. Both Torrey and Digger pines are resistant to the western pine beetle. In all instances it appeared that oleoresins were toxic to the beetles. The tests provided some confirmation to the theory that qualitative oleoresin composition of different pine species determines their susceptibility or resistance to the western pine beetle.

Miller found that a hybrid of Jeffrey and Coulter pine, developed at the California Institute of Forest Genetics proved to be very resistant to the highly injurious pine reproduction weevil. This weevil causes severe damage to Jeffrey and ponderosa pine. There are, however, in the field resistant individuals of both pine species indicating that resistant varieties of either species may be obtained by natural selection.

Miller discovered that resistance is apparently accomplished in part by walling off the attacked areas in the bark before the larvae reach the cambium and in part by the production of large quantities of resin. The former reaction is indicated by a thick layer of cork cells surrounding the necrotic areas. The latter is evidenced by a great concentration of resin ducts inside the cambium and also by the flow of the resin from these ducts into the bark. **A** similar condition is evident in resistant individuals of both Jeffrey and ponderosa pine.

Callahan tells me that backcross progenies (between Jeffrey and Coulter and Jeffrey) are now being produced at the Institute of Forest Genetics in large numbers for interplanting with Jeffrey and ponderosa pine on California National Forests.

We are very anxious to see work started in this region toward the development of a white pine hybrid that would be resistant to white pine weevil attack. We have or will have at the end of this season some 250 quarter acre plots which have been established in cooperation with the New England States, New York, New Jersey and Pennsylvania where annual records of weeviling will be taken. These plots should be helpful in detecting the presence of individual resistant trees.

There are a number of plantations in one area in New York which are relatively free from weevil attack. Some of these weevil-free plantations are located within two or three miles of severely attacked plantations. Of course natural enemies of the insect could be responsible for the control of the weevil in these plantations but it is conceivable that the trees themselves may be resistant to attack.

Kriebel has recently conducted a study to determine if bark thickness may be a factor in resistance to white pine weevil attack. He summarizes his study as follows!

"Five pure, evenaged stands of eastern white pine were examined in a study of the relationship between bark thickness and susceptibility to white pine weevil injury. The number of weevil injuries per tree was taken as a measure of susceptibility.

In all stands bark thickness at breast height was found to be significantly related to susceptibility to weevil injury, more so than d.b.h. Trees with thin bark were less susceptible than trees with thick bark, although there was considerable variation due to other factors.

Bark thickness is considered to be important because of the relation of thickness of phloem in the terminal shoot to weevil attraction, oviposition and larval development. Bark thickness at breast height is a cumulative measure of annual phloem production over the period of exposure of the tree to weevil injury.

In evenaged stands, among trees of equal diameter and height, those with the thinnest bark may be expected to be least injured by the white pine weevil. In forest genetics research, this may be a guide in the selection of trees to be tested for inherited resistance to weevil injury."

In conclusion I would like to say that our New Haven station would welcome the opportunity of working with forest geneticists on the white pine weevil problem or any other forest insect problem designed to develop trees resistant to insect attack.