IMPACT OF INSECTS AND METHODOLOGY FOR MONITORING INSECTS IN WESTERN WHITE PINE SEED ORCHARDS

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ABSTRACT

Among other things, an integrated pest management system requires an understanding of the impact caused by insects and development and utilization of monitoring systems for those insects. Over the last several years we have evaluated the impact of insects in three producing blister rust-resistant western white pine seed orchards. Losses can exceed 90 percent with the magnitude varying greatly from year to year. Species complexes vary between orchards. Pheromone-based monitoring traps have been developed for *Eucosma recissoriana* Heinrich and have been used to time insecticide application.

Keywords: *Pinus monticola* Douglas, *Conophthorus ponderosae* Hopkins, *Dioryctria* spp., *Eucosma recissoriana* Heinrich, *Leptoglossus occidentis* Heidemann, pheromones, pest management

INTRODUCTION

Western white pine, *Pinus monticola* Douglas, reaches its greatest development in the Inland Empire Region of northern Idaho, western Montana, and eastern Washington in the United States. In this region there are approximately 1.2 X 10 6 ha of white pine habitat type. In terms of stumpage price, it is among the most valuable species in this area. The U.S. Department of Agriculture, Forest Service frequently prescribes white pine in reforestation plans, and projects an average annual need of 2.5 million seedlings. Unfortunately this projected number of seedlings has never been produced.

Management of western white pine has been complicated in the past by the introduction of the fungus, *Cronartium ribicola* Fisher, which causes the fatal disease, blister rust. The pathogen was introduced to western North America, from Europe, in 1910 on infected western white pine seedlings grown in France and planted near Vancouver, British Columbia, Canada. By 1923, the disease had spread throughout the western white pine type of the northern Rocky Mountains. After more than 20 years of research three producing blister rust-resistant western white pine seed orchards have been established in Sandpoint, Coeur D'Alene, and Moscow in northern Idaho (Hoff and Coffen 1982). These three orchards are currently the sole source of the genetically-resistant seedlings that are being used to reestablish western white pine to its former habitat.

We have initiated a program of research which has begun to provide specific data on: 1) impact of insects on production of blister rust-resistant western white pine seed, 2) techniques that may be used to monitor the presence and abundance of insect populations within seed orchards and 3) treatment strategies to prevent or reduce insect damage. Impact data are critical to orchard managers if they are to make informed decisions concerning the need for insect suppression treatments. Pheromone-based monitoring systems will be very useful for delimiting seasonal flight activity of problem insects. Resulting trap captures could also provide a means for projecting damage as well as providing critical data for the timing of suppression activities. Ultimately these data will be needed to provide seed orchard managers with an integrated pest management system.

Previous research (Jenkins 1982, Shea 1985) has shown that five species of insects from three orders and four genera cause damage to blister rust-resistant western white pine cones and seed in the three producing orchards. These are the mountain pine cone beetle, *Conophthorus ponderosae* Hopkins, one or more species of the fir coneworm group, *Dioryctria* spp., the lodgepole cone moth, *Eucosma recissoriana* Heinrich, and the western conifer seed bug, *Leptoglossus occidentalis* Heidemann. Mountain pine cone beetle damage occurs primarily in the Sandpoint Seed Orchard and has been at very low levels since 1983. Before 1983, the loss of cones to this insect has been as high as 90 percent (Jenkins 1982 and Shea et al 1984). Shea et al. (1984) and Haverty and Shea (1985) have developed insecticide treatments for reducing damage by this insect. However, we believe these low population levels are due to sanitation procedures followed by the orchard managers since that time. All infested cones are removed from the orchard at the time of harvest and burned. In addition, vegetation beneath trees is burned which scorches cones on the ground and possibly kills *C. ponderosae* brood. Significant reinvasion by the mountain pine cone beetle from the surrounding western white pine stands has not occurred to date. Perhaps these sanitation measures have reduced the impact of *C. ponderosae* below that of pest status.

In this paper we report on the impact studies conducted in the Moscow Arboretum and Coeur d'Alene Seed Orchard during the years 1984 and 1985. In addition, we summarize tests of pheromone-based trapping systems to detect _E. recissioriana_ in both orchards in 1984 and 1985.

MATERIALS AND METHODS

The Moscow Arboretum is located ca. 110 km S of Coeur d'Alene, Idaho. Beginning in 1957 this seed orchard was planted with _P. monticola_ seedlings that survived intense artificial inoculation with blister rust (Hoff & Coffen 1982). This orchard occupies ca. 9 ha and tree height ranges from 9 to 15 m. Only trees in the NW quadrant of the orchard were used since other management activities were in progress in the remainder of the orchard (Haverty et al. 1986).

The Coeur d'Alene Seed Orchard is located ca. 2.5 km N of Coeur d'Alene, Idaho. This orchard was established in 1960 and was planted with trees from the same genetic heritage as those planted in the Moscow Arboretum. It is ca. 5 ha in size with tree height ranging from 3 to 5 m. This orchard is just beginning to produce harvestable quantities of cones but still requires supplemental pollination.

Impact

In 1984 (a year of very low cone production) all trees with at least 3 cones/tree were used to assess impact of insects in the Coeur d'Alene Seed Orchard. In 1985 (a year of abundant cone production) 10 trees were randomly selected throughout the orchard for sampling. For the Moscow Arboretum 22 and 10 trees were randomly selected for impact assessment in 1984 and 1985, respectively. A hydraulic manlift was used to collect cones. At the end of the growing season and before the cones began to open, all cones were removed from each sample tree and taken to the laboratory. Infested cones were dissected to verify damage by lepidopterous species or mortality by _C. ponderosae_ and to recover larvae. The remaining undamaged cones on all sample trees were counted, put in separate, labeled burlap bags, and air dried. Seeds were extracted by tumbling the dried, open cones. The seed were kept separate by tree, put in plastic bags and shipped to Berkeley, California for analysis. Eight envelopes per tree, with 100 seed per envelope, were radiographed to determine the percentage of filled seed with viable embryo, empty seed, or seeds damaged by _L. occidentalis_.

Pheromone Studies

In 1984 and 1985 an array of pheromone blends of (Z) and (E)-9-dodecenyl acetate were tested for attractiveness to _E. recissoriana_ in the Moscow Arboretum. All candidate blends were formulated in a polyvinyl choride, controlled-release preparation according to methods described by Daterman (1974). Individual bait pellets were 3 x 5 mm and contained 0.1 percent active ingredient by weight. Pellets were suspended on insect pins, and were placed in adhesive coated Pherocon II traps. Traps were hung individually at the tip of branches 2 to 3 m above the ground. In 1984 each of the seven blends were replicated five times and assigned to sampling sites at random, one trap per tree. In 1985 the six candidate blends were replicated eight times and also assigned to sample sites at random. No sample site (tree with one trap) was closer than 30 m from another. Pheromone traps were placed on the trees in early May, remained in the orchard for ca. 1 to 2 months of each year, and were visited every 3 to 6 days.

RESULTS AND DISCUSSION

Impact

In 1985 the cone crop in both the Moscow Arboretum and the Coeur d'Alene Seed Orchard were the largest ever produced. Trees in the Moscow Arboretum averaged 309 cones/tree whereas the trees in the Coeur d'Alene Seed Orchard averaged only 48 cones/tree (Table 1). These were 6- and 9-fold increases, respectively, in cone production over 1984. The relatively small cone crop experienced in the Coeur d'Alene orchard is not unexpected since this is a fairly young orchard with small trees. The cone crop for 1987 at Coeur d'Alene as evidenced by the 1986 first-year conelet count, is expected to surpass the 1985 cone crop by a considerable amount. In addition to the large cone crop of 1985, the number of seeds/cone also increased many fold. The mean number of seeds/cone for both orchards in 1985 was also the highest ever recorded from either orchard (Table 1). The total of 147 seeds per cone recovered from trees in the Moscow Arboretum is the highest seeds/cone count ever recorded from any blister rust-resistant western white pine seed orchard.

For the last several years the primary insect pests at the Moscow Arboretum and Coeur d'Alene Seed Orchard have been _Dioryctria_ spp. and _E. recissoriana_. Both of these lepidopterous insects attack the cones of several species of conifers. Adults oviposit their eggs on the surface of developing cones. Larvae mine throughout the cone and destroy most or all of the seed. Pheromone and light trapping during 1984 and 1985 indicated adult males of _E. recissoriana_ begin flying in the orchard during the first week of May and the first _Dioryctria_ spp. adult males were captured ca. 10 days later. We have used this trap information to time insecticide treatments (Haverty et al. 1986).

We are unable to distinguish between damage caused by _Dioryctria_ spp. and _E. recissoriana_. Therefore, we report their damage as percent damage caused by lepidopterans. Damage caused by _Dioryctria_ and _E. recissioriana_ was considerably less in 1985 than in 1984 (Figure 1). In 1985 these pests were responsible for only 7.2 percent loss in the Moscow Arboretum compared to a 46.6 percent loss in 1984. The Coeur d'Alene orchard also had a low incidence of lepidopteran damage in 1985. We found only one damaged cone out of the 480 cones sampled compared to a 47.0 percent of the cones being damaged in 1984 (Figure 1).

The low incidence of damage in 1985 in both orchards may be attributable to several causes. Several applications of an insecticide were applied during the summer of 1984 at the Moscow Arboretum to control these two insect pests.

Table 1. Cone and seed production at the Moscow Arboretum and the Coeur d'Alene Seed Orchard in 1984 and 1985.

Orchard	Year	Number of Trees	Cones/Tree $\bar{X}$ (S.E.)	Seed/Cone $\bar{X}$ (S.E.)
Moscow	1984	22	56.9(6.1)	31.3(3.2)
	1985	10	309.0(58.9)	147.5(9.1)
Coeur d'Alene	1984	68	5.2(2.2)	10.2(0.7)
	1985	10	48.0(10.3)	59.9(9.1)

TABLE 2. Number of filled seed and seed damaged by *Leptoglossus occidentalis* Hiedemann from the Moscow Arboretum and the Coeur d'Alene Seed Orchard in 1985.

ORCHARD	Filled seed/cone $\bar{X}$ (S.E.)	*L. occidentalis* damaged seed/cone $\bar{X}$ (S.E.)	Empty seed/cone $\bar{X}$ (S.E.)
Moscow	133.0(7.4)	0.03(0.01)	9.49(2.4)
Coeur d'Alene	40.9(5.2)	0.03(0.02)	17.85(3.8)

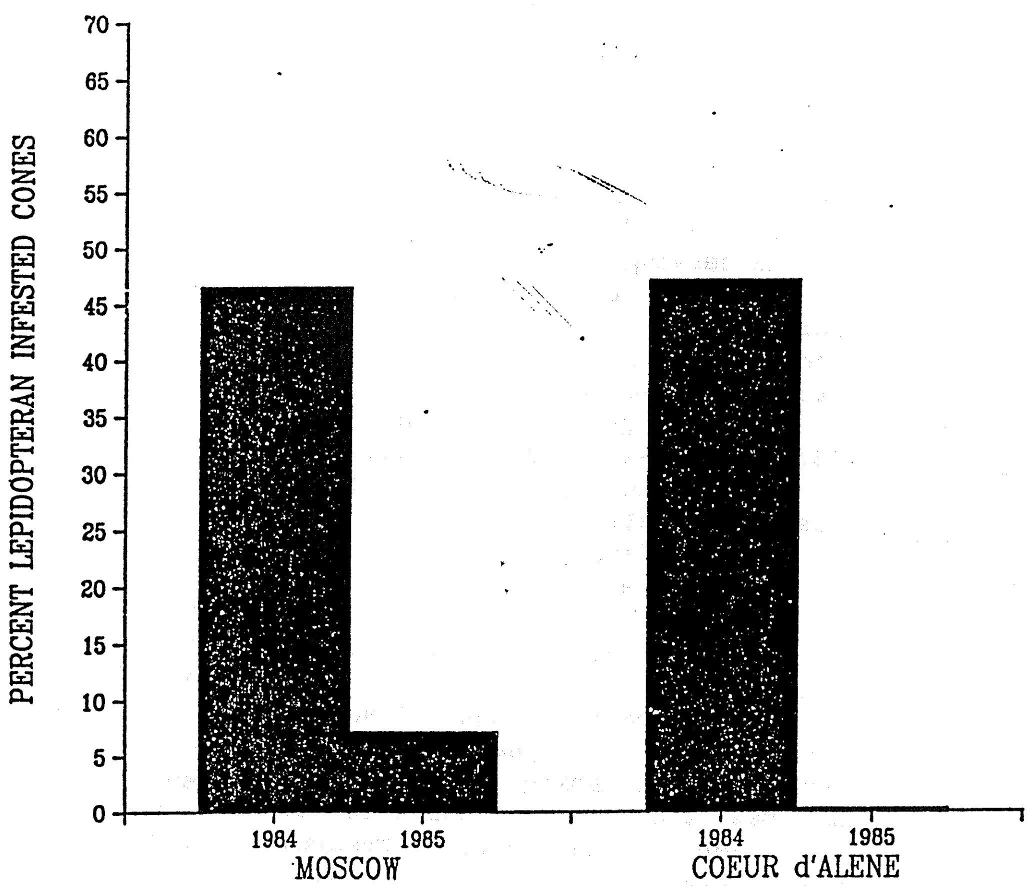

Figure 1. Percent of lepidopteran-infested cones in the Moscow Arboretum and Coeur d'Alene Orchard, 1984 and 1985.

Treatments were applied over a large portion of the orchard that was well separated from our study area. We also conducted an insecticide test in the portion of the orchard in which we evaluated impact (Haverty et al. 1986). It is possible that the effect of the control operation and the insecticide test had a profound impact on Dioryctria spp. and E. recissoriana populations, and the insect populations may have been suppressed into 1985. This does not, however, explain the low incidence of lepidopteran damage in the Coeur d'Alene orchard. The large cone crop in 1985, compared to the 1984 crop, may have overwhelmed the insect population. Even though insect populations of the same size were present in 1985 compared to 1984, the percent damage was very low. Also, Dioryctria spp. may be exhibiting extended diapause and 1985 was the diapause year. We really do not fully understand the bionomics of this Dioryctria complex. Whatever the reason(s) we have sampled both orchards again during 1986 to evaluate damage caused by these pests.

Over the years of our impact study in both orchards the managers have expressed concern over loss of seed due to the western conifer seed bug, L. occidentalis. Incidences of mass migrations of adult L. occidentalis are common for both seed orchards. However, in 1985 damage we attributed to L. occidentalis in both orchards was very low (0.03 seed/cone), even though there was a brief incursion of adults into the Coeur d'Alene Seed Orchard. We suspect the full impact of L. occidentalis on production of blister rust-resistant western white pine seed may not be fully captured by x-ray analysis of seed. There is considerable suspicion that this pest may cause conelet abortion during the first year of cone development, and may be partially responsible for the significant reduction in the number of conlets after cone harvest and before cone elongation the following season (Figure 2).

Pheromones

Several active blends of synthetic sex attractants have been found for E. recissioriana (Table 3). Further it would appear from the 1984 results that the (E)-9 isomer is serving to enhance the attractiveness of the (Z)-9 isomer since a 100 percent formulation of the (E)-9 isomer trapped no insects. Blends ranging from 80:20 to 50:50 (Z:E isomers) appear to trap the greatest number of males. Therefore, we would recommend that one or a combination of these blends serve for monitoring populations of E. recissoriana. This lack of a specific preference by males of E. recissoriana is similar to that exhibited by E. sonomana Kearfoot, a closely related species which showed little distinction among (Z):(E)-9 blends dodecenyl acetate between 95:5 and 50:50 (Sower et al. 1979). Conversely, an eastern species, E. gloriola Heinrich, was somewhat more discriminating, being optimally attracted to 90:10 and 80:20 ratios of (Z):(E)-9-dodecenyl acetate (Grant et al. 1985).

In summary, blister rust-resistant western white pine seed is in limited supply and is quite valuable. This set of circumstances emphasizes the need for improved pest management for protection of this valued resource. Additional research on impact and sex attractants will be conducted to develop an annual program that includes pheromone-based monitoring systems and sound sampling procedures for assessing and projecting damage. Determination of season activity, pest and cone population levels, and seed demand can be used by the orchard manager to make decisions regarding the need for insecticidal control of insect pests. In addition, because the Moscow Arboretum and the Coeur d'Alene Seed Orchards are relatively isolated (the nearest natural stand

TABLE 3. Total number of *E. recissoriana* male moths caught in pheromone traps with various blends of (Z)–9 and (E)–9–dodecenyl acetate in the Moscow Arboretum in 1984 and 1985.

Ratio of Z:E isomers	Number of moths 1984	Number of moths 1985
100:0	17	NT
95:5	51	4
90:10	NT[a]	8
80:20	162	16
70:30	NT	11
60:40	NT	22
50:50	99	7
20:80	25	NT
5:95	10	NT
0:100	0	NT

[a]Not tested.

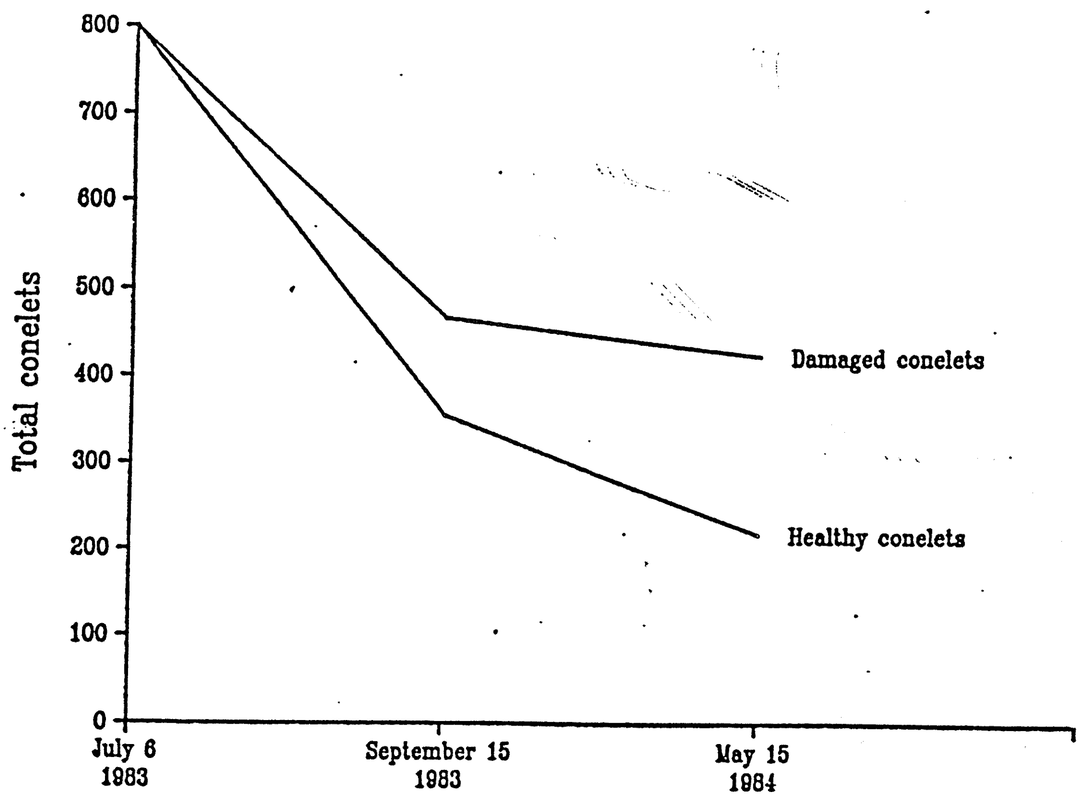

Figure 2. Conelet mortality in 12 cone analysis trees located in the Moscow Arboretum

of western white pine is several miles distant) and small in area, a mating disruption or trap-out strategy using the _E. recissoriana_ sex attractant could replace the need for insecticidal control.

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