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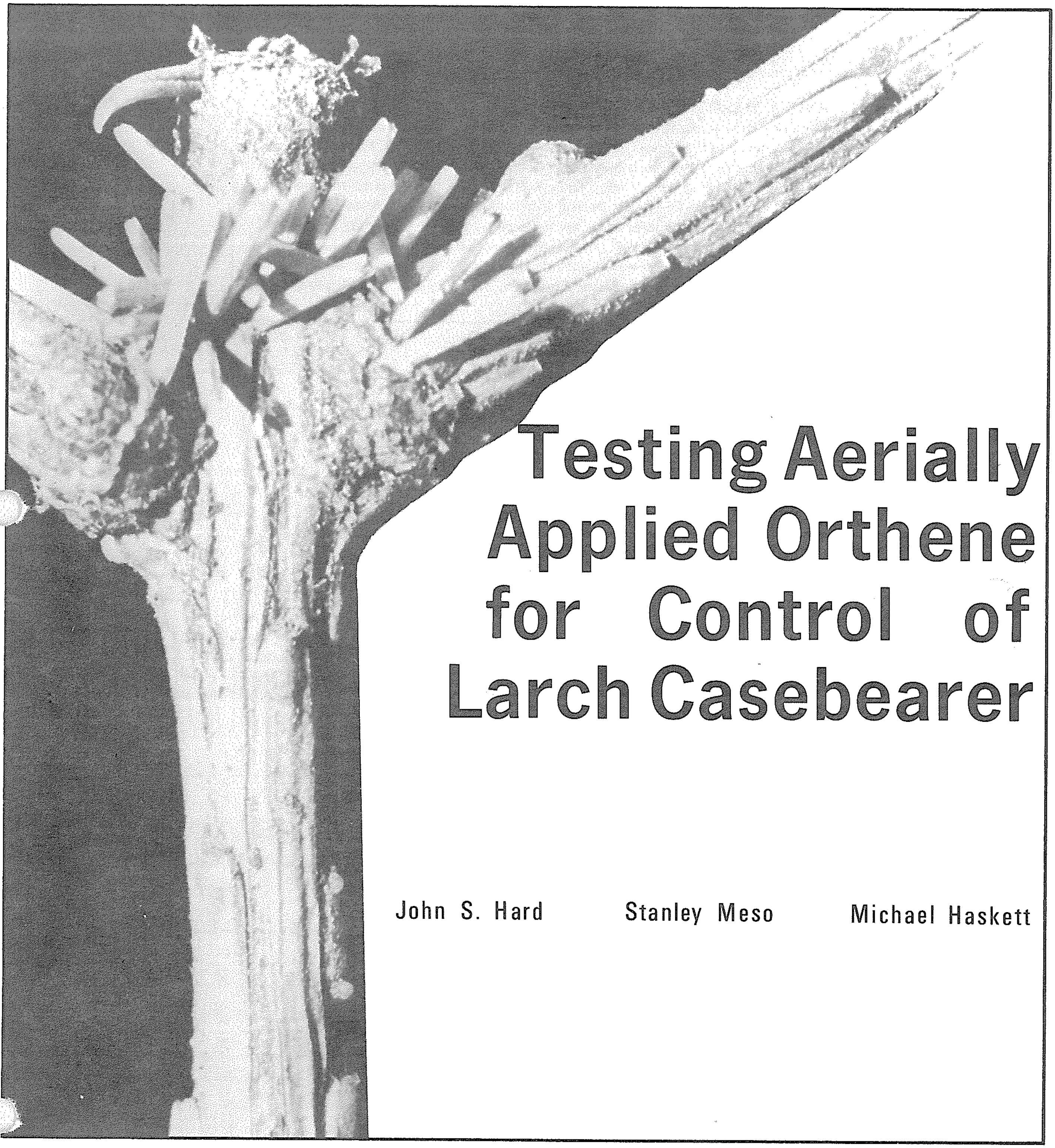

Testing Aerially Applied Orthene for Control of Larch Casebearer

John S. Hard Stanley Meso Michael Haskett

RESEARCH PAPER PSW- 138

The Authors

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ACKNOWLEDGMENTS

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IN BRIEF ...

Hard, John S., Stanley Meso, and Michael Haskett.
1979. **Testing aerially applied Orthene for control of larcn casebearer.** Res. Paper PSW-138, 6 p., illus. Pacific Southwest Forest and Range Exp. Stn., Forest Serv., U.S. Dep. Agric., Berkeley, Calif.

Retrieval Terms: insecticides; field tests; aerial spraying; Orthene; larch casebearer; *Coleophora laricella (Hbn.).*

Orthene was applied by helicopter to larch casebearer *Coleophora laricella* (Hbn.) near LaGrande, Oregon, in September 1976. The object of the experiment was to test whether Orthene, applied at a rate of 0.5 lb/gal water/acre (560 g/9.3 1/ha) would reduce, but not annihilate larch casebearer larval populations, and would protect host trees from heavy defoliation the following spring.

A randomized block design with one 50-acre replicate of each of four treatments in each block was used. Spray deposit was sampled with Kromekote cards. Casebearer larval populations were sampled 1 day prespray and 6 weeks postspray, but parasitoid populations were not assessed until the following spring.

Spray deposits were uniform among spray treatments and there was a close relationship between postspray casebearer populations and spray deposits. Larval populations were reduced an average of 92.1 percent in treated plots and an average of 40.5 percent in check plots. There were no significant differences in casebearer population reduction among the three treatment strategies. Defoliation index averaged light on treated plots and heavy on check plots the following spring; percent parasitization averaged 4.0 percent on treated plots and 1.3 percent on check plots.

We concluded that aerial application of 0.5 lb a.i./gal water/acre (560 g a.i./9.3 1/ha) to larch casebearer larvae provides adequate population reduction in young western larch stands and prevents heavy defoliation of trees the next spring. We recommend that no operational spraying be done in areas where parasitoids, such as *Agathis pumila* and *Chrysocharis laricinellae*, have been introduced until further research determines whether fall spraying of Orthene is detrimental to them.

Variances of larch casebearer percent population reductions and cost estimates of the various treatment and sampling tasks were analyzed for optimal experimental design in future larch casebearer insecticide field experiments.

Orthene *(O,S,*-Dimethyl acetylphosphoramidothioate) is a cholinesterase-inhibiting insecticide whose common name is acephate. It effectively controls forest defoliators such as the Douglas-fir tussock moth *Orgyia pseudotsugata* (McDunnough) (Neisess and others 1976) and the western spruce budworm, *Choristoneura occidentalis* Freeman (Markin 1977). Orthene is a systemic insecticide[1] which shows some phloem mobility and is transported through plant tissues to internal feeding sites of insects such as needlemining larch casebearer *Coleophora laricella*(Hbn.).[2] Orthene aerially applied at a rate of 1 lb a.i. (active ingredient) in 1 gal of water per acre (1120 g a.i./9.3 1/ha) reduced needlemining casebearer populations in Idaho almost 100 percent (Washburn and others 1977).

We experimented to determine whether Orthene applied aerially at a rate of 0.5 lb a.i./gal/acre (560 g/9.3 1/ha) near LaGrande, Oregon would reduce, but not annihilate larch casebearer larval populations, and would protect host trees from heavy defoliation the following spring. Low casebearer populations surviving the treatment were desired to support (1) native parasitoids and (2) introduced parasitoid species released in nearby areas (Ryan and others 1977).

This paper describes experimental procedures in detail and includes cost and variance data analyses to show optimum experimental design for future chemical field tests and pilot projects.

MATERIALS AND METHODS

Four rectangular 50-acre (20-ha) plots 1000 ft by 2178 ft (305 m by 664 m) were established in each of three areas at elevations ranging from 4000 to 4800 ft (1300 to 1600 m) approximately 24 km east of La Grande, Oregon. A total of 180 young western larch (*Larix occidentalis* Nutt.) were selected, 15 per plot, for casebearer larval and pupal population sampling and subsequent defoliation estimates. These trees were larch casebearer infested and open grown. Sample tree diameters, heights, and live crowns averaged, respectively, 5 inches (12.7 cm), 35 ft (10.7 m), and 90 percent of total height.

We used a randomized block experimental design with one replicate of each of four treatments in each block. Treatments were aerially applied Orthene 75S[3] (75 percent soluble powder) water solutions of 0.5 lb a.i./gal/acre (560 g a.i./9.3 1/ha) on three plots in each block and one randomly assigned untreated check. Spray sequence in each block was randomly assigned. The spray formulation contained 10 percent (by volume) ethylene glycol to reduce evaporation and to improve spray atomization, and 3.78 g/gal (1 g/l) of Rhodamine B Extra S (GAF) dye to aid in spray deposit assessment.

We sprayed all treated plots within a block on the same morning, but treated each block on a separate date—block 3 on September 9, block 1 on September 12, and block 2 on September 13, 1976. Crews monitored and recorded temperature, relative humidity, and windspeed in each plot during spray application. Spray conditions were generally good, with cool temperatures, high humidities, and little

[1]Lyon, R. L. 1973. *Reports from the Insectide Evaluation Project, PSW-2203.* USDA Forest Serv., Pacific Southwest Forest and Range Exp. Stn., Berkeley, Calif. 5 p.

[2]Page, Marion, Richard I. Washburn, and Nicholas L. Crookston. **Systemic effect of acephate on specific densities of needlemining larch casebearer in the laboratory.** (Manuscript in preparation.)

[3]Trade names and commercial products and enterprises are mentioned solely for necessary information. No endorsement by the U.S. Department of Agriculture is implied. This publication reports research involving pesticides. It neither contains recommendations for their use, nor does it imply that the uses discussed have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended.

or no wind on all 3 spray days. Light rain fell on September 12 near the end of spraying, but amounted to only a trace of precipitation.

We marked plot corners with colored treetop banners for spray pilot guidance and orientation. A Bell 206 Jet Ranger helicopter flying 60 mph (97 kph) 50 ft (15 m) above the trees applied the spray at 40 psi (2.8 kg/cm^2) in 70-ft (21-m) swaths parallel to the long axis of each plot. The spray system consisted of a detachable belly tank with conventional boom and 43 evenly-spaced flat fan T8002 tips (Spray Systems, Wheaton, Ill.).[3]

One 4- by 4-inch (10- by 10-cm) Kromekote card was placed in the open at ground level near each sample tree on treated plots to sample spray deposit. Kromekote cards were also placed near trees in untreated plots to detect spray drift from treated plots. We used a Quantimet Image Analyzer with a 32-mm objective lens to measure and count all droplets greater than 91μ in diameter in a 42-cm^2 area on each card. Spray droplet volume median diameter (VMD), mean number of droplets per cm^2, and gallons per acre (GPA) of spray deposited on each treated plot were computed by using a modified U.S. Army data processing system (ASCAS).

We sampled prespray larval populations 1 day before spray, and postspray larval populations 6 weeks later to determine effects of Orthene on casebearer, but did not assess parasitoids until the following spring. One branch from the upper crown third, two branches from the midcrown third, and one branch from the lower crown third comprised each tree sample at each sample period. We clipped six 6-inch (15-cm) twigs—minus current year's terminal shoot growth from the distal portion of each sample branch—and counted larvae on all needle fascicles of randomly selected 6-inch twigs until a total of 50 fascicles were examined on each sample branch. Each needle of each sample fascicle was examined by using transmitted light and a stereomicroscope to determine presence of live needlemining larvae during the prespray larval counts. We counted overwintering larvae, which were easily seen on postspray sample twigs through a stereomicroscope, on the first 50 fascicles of randomly selected 6-inch twigs from each sample branch.

Individual indices of sample tree defoliation were computed according to procedures described by Ciesla and Bousfield (1974) from visual defoliation estimates recorded in June 1977. In addition, aerial photographs were taken of treated plots and surrounding untreated areas by using color infrared film to detect differences in defoliation intensity.

We sampled larch casebearer pupal populations in June 1977 to assess any differences in rate of parasitization between Orthene-treated and untreated plots. We placed 100 pupae bearing fascicles from two midcrown branches of each sample tree in a 2-quart (1.89-l) ice cream carton with moistened cotton and reared larch casebearer moths and parasitoids. The parasitoids were identified as to species. Parasitoid species are vertically stratified in larch crowns (Tunnock and others 1972), but we assumed that midcrown samples would provide an index of parasitization by all species.

Mean and standard error of prespray and postspray larvae per 100 fascicles, percent mortalities, deposit indices, and tree defoliation indices for each sample plot were computed. Analyses of variance were done to detect significant differences among blocks and among treatments. We also computed pooled variances by treatment to assess to what degree the experiment was able to detect truly significant differences among treatments (Pearson and Hartley 1951).

Regression analyses were used to graph relationships of plot sample mean (1) larch casebearer larval numbers per 100 fascicles at midcrown over (a) larval numbers per 100 fascicles at all three crown levels, and over (b) spray deposit in gallons per acre; (2) percent larval mortality at midcrown over spray deposit in drops per cm^2; and (3) defoliation index over larval numbers per 100 fascicles at midcrown.

We computed regressions as if independent (X) variables had been measured without sampling error. The sample regression coefficients, therefore, may be biased estimates of the true population regression coefficients (Snedecor and Cochran 1967). The measurement errors in X are little more than 10 percent of the total range of X-values in any regression, however. We therefore consider the expressed degrees of correlation between the various X and Y variables to be realistic and the equations describing the relationships to be reasonable approximations of the true relationships (Daniel and Wood 1971).

Variances of larch casebearer percent population reductions and cost estimates of the various treatment and sampling tasks were analyzed for optimum experimental design in future larch casebearer insecticide field experiments or pilot projects.

RESULTS AND DISCUSSION

Spray deposits were uniform among spray treatments *(table 1)* and efficacies of the three spray treatments were comparable *(fig. 1)*.

We found no significant differences in prespray casebearer larval numbers among treatments, but found highly significant differences in postspray larval numbers, percent larval mortalities, and defoliation indices between sprayed and check plots *(table 2)*.

Midcrown sample larval means were representative of larval means from all three crown levels *(fig. 2)*, and the linear relationship between midcrown sample larval means and all crown level larval means *(fig. 2)* was about one-to-one and intercepted the graph near zero. Midcrown larch casebearer larval population densities were also representative of mean larval population densities in eastern larch (Webb 1953). Because of the one-to-one relationship between midcrown sample larval means and all crown level means, as well as the high degree of correspondence between midcrown population densities and mean larval population densities, midcrown sampling can be considered appropriate for efficacy tests of Orthene against larch casebearer.

Close relationships occurred between mean postspray casebearer larval numbers in midcrown samples and mean spray deposit in gallons per acre *(fig. 3)*, and mean percent larval mortality in midcrown samples and spray deposit in drops per cm^2 *(fig. 4)*. Spray deposit measured in drops per cm^2 appeared low *(table 1, fig. 4)*, but many drops smaller than 91μ were deposited but not recorded when scanned by the image analyzer.

The linear relationship between mean sample tree defoliation index and mean number of postspray larvae in midcrown samples *(fig. 5)* is steeper than the relationship reported by Ciesla and Bousfield (1974). Their samples were taken in mature untreated western larch stands, whereas ours were taken in young treated stands. On the basis of 15 sample tree estimates in each plot, we found one treated plot was undefoliated, six treated plots were lightly defoliated, two treated plots were moderately defoliated, and all three check plots were heavily defoliated the spring following treatment. We could not distinguish defoliated from undefoliated areas on the aerial photos, because the plots contained western larch mixed with true fir, Douglas-fir, ponderosa pine, and lodgepole pine and many lodgepole pines were discolored by a foliage disease.

Larch casebearer pupal parasitoids were not abundant in the experimental plots, but percent parasitism was higher in treated plots than in check areas, and species compositions were comparable among treatments *(table 3)*.

As we expected, casebearer percent mortality variances among plots were higher than mortality variances within or among trees. Because of this difference, future insecticide tests comparing two or more chemicals or two or more dosages of a single chemical will be logistically difficult and prohibitively expensive *(table 4)*, unless experimental objectives are modified. Rather than test the data to determine whether percent mortalities resulting from two treatments are statistically different, perhaps a test to show which of the treatments equalled or exceeded a prescribed level of control would be less costly.

A pilot control project to compare two treatments (chemical against chemical or chemical against check), where the expected difference in percent mortality between treatments is about 50 percent, would require only three plot pairs, and the cost would be dependent on the number of acres sprayed and the experimental power selected to detect that mortality differences were truly significant *(table 4)*. Because the difference in percent mortality between a chemical treatment and a check treatment could be less than 50 percent, we suggest that four plot pairs be used if logistically possible.

Table 1—*Sample spray deposit indices, by treatment*

Treatment	Mean deposit and standard error[1]		
	Drops/cm²	*Volume median diameter* μ	*Gal/acre*
Sprayed first	5.85 ± 0.92	306.6 ± 24.1	0.43 ± 0.09
Sprayed second	6.92 ± 2.41	343.5 ± 13.4	0.60 ± 0.10
Sprayed third	5.72 ± 0.50	363.2 ± 20.6	0.60 ± 0.09

[1] Computed from three replicate averages per treatment.

Table 2—*Significance of casebearer mean larval numbers, mean percent mortality, and mean defoliation index on Orthene field test experimental plots*[1]

Treatment	Larval numbers per 100 fascicles		Mortality	Defoliation index [2]
	Prespray	Postspray		
			Percent	
Sprayed first	157.4	10.6	93.2	16.1
Sprayed second	173.0	18.6	91.4	19.0
Sprayed third	171.1	15.4	91.8	16.3
Untreated	217.4	123.9	40.5	61.5
Range	60.0[3]	113.3	52.7	45.4

[1]Means not connected by a vertical bar are significantly different at the 99 percent level.

[2]Negligible = 0 to 8.9, light = 9.0 to 26.9, moderate = 27.0 to 44.9, heavy = 45 or greater.

[3]The experimental power—percent chance of detecting a truly significant difference as high as the ranges shown between treated and untreated plots—is as follows: For prespray range of 60.0, <20 percent chance at the 95 percent level, <20 percent chance at the 99 percent level; for postspray range of 113., >99 percent chance at the 95 percent level, 89 percent chance at the 99 percent level; for mortality range of 52.7, >99 percent at the 95 percent level, 89 percent chance at the 99 percent level; for defoliation index of 45.4, 97 percent chance at the 95 percent level, 82 percent chance at the 99 percent level.

Table 3—*Parasitoids reared from larch casebearer pupae collec*
June 1977 from experimental plots treated with Orthene in Sept
1976

Parasite species	Treatment			
	Sprayed first	Sprayed second	Sprayed third	Che
Eulophidae:				
Tetrastichus sp.	4	0	2	4
Derostenus silvia	7	9	10	0
Elachertus sp.	4	0	0	0
Dicladocerus nearcticus	1	0	1	3
Cirrospilus (?) sp.	0	1	0	0
Pteromalidae:				
Mesopolobus verditer	1	0	2	20
Habrocytus phycidis	0	1	0	12
Unknown species	0	0	1	2
Chalcididae:				
Spilochalcis albifrons	5	5	7	7
Spilochalchis leptis	2	0	0	0
Ichneumonidae:				
Itoplectis evetriae	9	3	4	0
Unknown species	0	0	0	1
Braconidae:				
Bracon pygmaeus	4	1	0	3
Total	37 (780)[1]	20 (459)	27 (978)	52 (
	Percent			
Parasitization	4.7	4.4	2.8	1.

[1] Numbers in parentheses represent numbers of casebearer pupae pl in rearing.

Table 4—*Optimum sampling requirements and estimated costs for randomized block field tests of insecticide treatments to larch casebearer needlemining populations*

Alternate hypothesis: Percent difference in average mortality between treatments[1]	Treatments	Plots per treatment	Trees per plot	Branches per tree [2]	Experimental power [3]	Costs [4]
					Percent	*Dollars*
50 percent	2	3	17	2	90	3,590
	2	3	9	2	80	2,974
	2	3	6	2	71	2,743
10 percent	2	14	19	2	80	17,474
	2	11	23	2	70	14,859
	2	10	18	2	60	12,224
20 percent between one pair and 10 percent between another pair[5]	3	8	15	2	90	13,745
	3	7	13	2	81	11,487
	3	6	13	2	71	9,845

[1]Percent difference in average mortality between treatments where differences between a number of insecticides *or* between a number of insecticides and a check, are being tested.

[2]Analysis using two, four, and six branches showed that the desired power always met minimum cost requirements with two branches.

[3]Experimental power is the percent chance of detecting a truly significant mortality difference of the magnitude stated in the alternate hypothesis.

[4] Based on temporary employee salary costs of $4.45 per hour, spray application costs of $5.00 per acre on 60-acre (24-ha) plots, and spray card reading costs of $2.00 per card; does not include salary or travel costs of permanent personnel.

[5] These percent differences are not additive. The maximum range of differences is 20 percent; therefore, the maximum difference between any two of the three treatments is 20 percent.

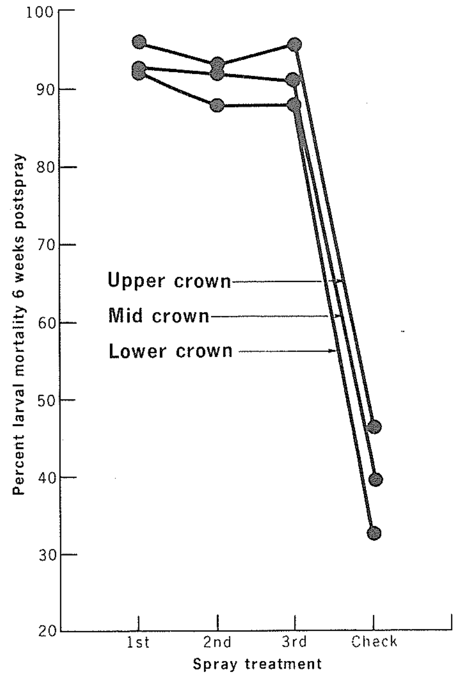

Figure 1—Percent larch casebearer larval mortalities in midcrown samples approximate percent mortalities in combined samples of all tree crown levels.

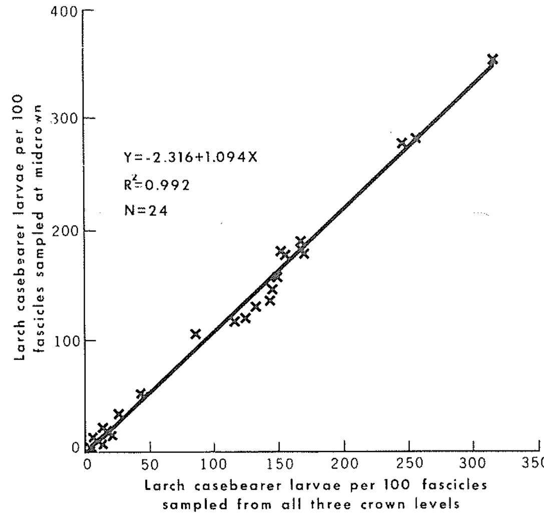

Figure 2—Midcrown sample mean larch casebearer larval numbers are approximately equal to total crown sample mean larval numbers in pre- and postspray samples.

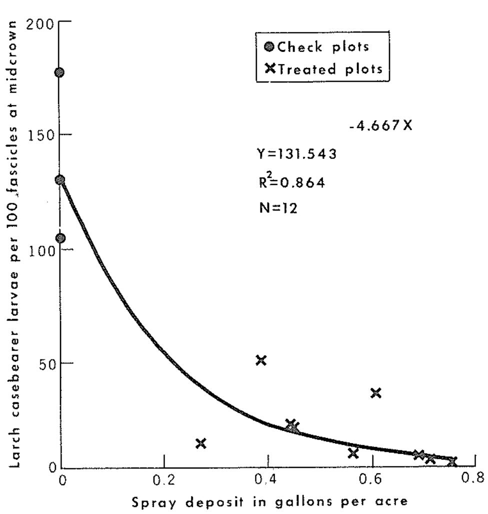

Figure 3—Midcrown sample mean larval numbers in postspray samples are closely associated with Orthene spray deposit measured in gallons per acre.

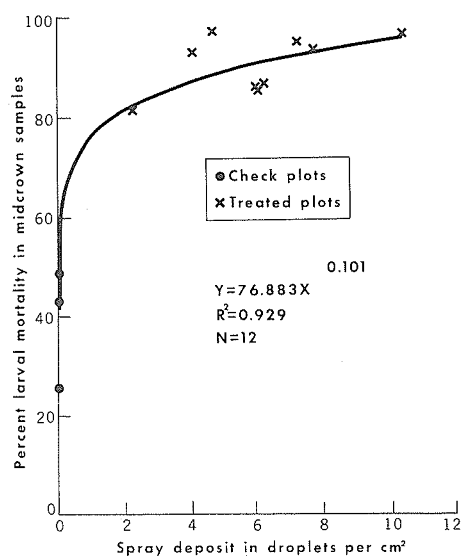

Figure 4—Percent postspray larval mortality in midcrown samples is closely related to Orthene spray deposit in drops per cm².

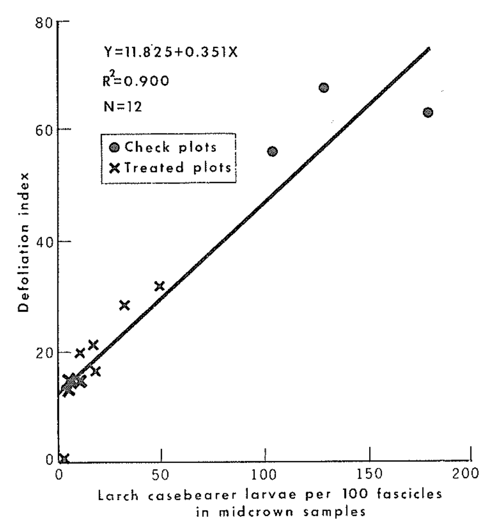

Figure 5—Sample plot defoliation index is closely related to postspray larval numbers in midcrown samples.

CONCLUSIONS

Helicopter application of 0.5 lb Orthene in 1 gallon water per acre (560 g a.i./9.3 l/ha) to needlemining larch casebearer larvae provides significant population reduction in young western larch stands and protects the trees against heavy defoliation the following spring. Native parasitoids emerging from larch casebearer pupae do not appear to be adversely affected by a fall application of 0.5 lb Orthene per acre (560 g a.i./ha).

We conclude that midcrown sampling is appropriate for casebearer larval sampling in future chemical efficacy tests. We do not know what effect Orthene spraying may have on introduced parasitoids, such as *Agathis pumila* and *Chrysocharis laricinellae.* We recommend that no operational spraying of Orthene be done in areas where these species have been released until further research determines whether fall spraying of Orthene affects them detrimentally.

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