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EFFICACY AND ECONOMICS OF SELECTED SYSTEMIC INSECTICIDES FOR CONTROL OF EUCALYPTUS BORER

Phoracantha semipunctata (F.)

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Figure 1- Adult Eucalyptus Longhorn Borer 2 - 3.5 cm. long

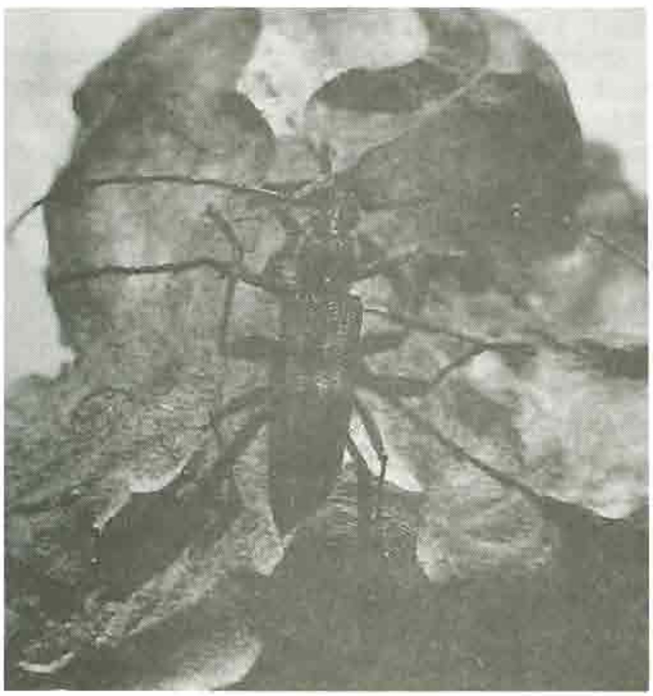

Figure 2- Mature larva of E. semipunctata

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ABSTRACT

A Eucalyptus longhorned borer (ELHB), Phoracantha semipunctata (F.), was first found infesting Eucalyptus trees in southern California late in 1984. Studies were conducted for two years to determine the efficacy and economics of soil and trunk-injected systemic insecticides for managing this pest. Both studies (Summer/Fall 1986 and Winter/Spring 1987) were conducted on woodlot (WL) and windbreak (WB) settings. None of the materials investigated (acephate, carbofuran, disulfoton, and oxydemetonmethyl) provided acceptable control. In addition, the relatively high application costs per tree (1986, \$7.74 WL and \$11.09 WB; 1987, \$6.03 WL and \$7.63 WB) render this approach impractical. Therefore, cultural and biological tactics must be used for short- and long-term ELHB management.

INTRODUCTION

The tree genus Eucalyptus, which is native to Australia, Tasmania, New Guinea, and Timor, contains up to 600 species, of which almost 200 can be found in California (6). Since its introduction to California in the 1850's, the genus has been extensively planted and can presently be found growing in Arizona and Florida, as well as Hawaii (4).

Eucalyptus has been growing in North America for over a century in a relatively pest-free status. This, however, was changes in October 1984 with the discovery of a Eucalyptus longhorned borer (ELHB), Phoracantha semipunctata (F.), in Orange County, California. ELHB infestations have spread to an area 26,000 km^2 covering six counties in southern California. ELHB also can be found in most countries where Eucalyptus is grown.

ELHB adult beetles are 2 to 3.5 cm long with a dark brown coloration. The elytra have two distinctive yellow zig-zag markings proximally and two yellow oval dots distally. Two small spines protrude postriorly from the distal end of each elytron. Males resemble females except for their antennae, which are longer than their bodies and armed with more prominent spines. Adults are nocturnal, usually hiding under loose bark in the daytime.

Mated females lay their creamy-colored, spindle-shaped eggs in clusters of 10 to 100 under loose bark. Eggs hatch in 10 to 14 days and the first instars either penetrate directly or feed superficially on the bark, leaving dark trails 1 to 2 cm long. As they increase in size, they penetrate the bark and feed in the cambium layer, creating galleries tightly-packed with frass. When larvae mature, they tunnel to the surface and leave a thin protective layer in the bark. They then tunnel in the opposite direction and pupate in chambers 6 to 10 cm deep in the trunk. Adults emerge through the pre-made tunnel and repeat the cycle (7,10). In the spring and summer, the life cycle can be completed in three to four months, but in the fall and winter up to nine months may be required for development (10).

Trees under physiological stress due to lack of moisture are more susceptible to damage by this pest. Healthy, vigorously growing trees can fend off the attack by exuding kino (dark, gummy fluid) which drowns and kills the penetrating larvae. When limbs are attacked, damage appears as flagging and dieback of branches. However, under heavy infestations the tree may die and exhibit the characteristic dry, brown marcescent leaves which may be retained for four or more weeks.

OBJECTIVES

Control of this pest with foliar-applied insecticides seems impractical due to its peculiar etiology. Adults are nocturnal fliers that hide and lay their egg masses under loose bark. Both larvae and pupae are protected inside the bole. In addition to the difficulty of insecticide contact with any of these states, thoroughly spraying the tree presents a logistical problem. Some of the older, established windbreak trees may reach heights greater than 35 meters.

In Spain, a solution of lindane was used to treat freshly-cut logs (5). As the beetles were attracted to the log to lay their eggs, they came in contact with the insecticide and died. This strategy has apparently provided acceptable overall population reductions overseas; however, it has not yet been adopted in this country. Our studies were done to determine the efficacy and economics of the use of systemic soil and truck injections of insecticides for ELHB control.

MATERIALS AND METHODS

The studies were conducted on Eucalyptus plantings in Irvine, California, in two years, Summer/Fall of 1986 and Winter/Spring of 1987. For each year, two settings were selected: a woodlot (WL) and a windbreak (WB). River red gum, *Eucalyptus camaldulensis* Dehnhardt, was the WL species, white blue gum *E. globulus* was the WB species. ELHB infestations in that location were moderate to heavy, with approximately 40% of the trees dead and displaying extensive cambium mining activity. Experimental design was a randomized complete block with four WL and five WB replications in 1986 and four replications in both settings in 1987. Each plot receiving a treatment contained four trees. The treatments were acephate (Orthene) (Creative Sales Inc., Fremont, NB), granular carbofuran (Furandan 10G) (FMC Corp., Fresno, CA), emulsifiable disulfoton (Di-Syston 8E), and emulsifiable oxydemeton-methyl (MetaSystox-R 2E) (Mobay Chemical Co., St. Louis, MO), and an untreated control. Average tree diameter at breast height (dbh [cm]± SEM 0) in 1986, WB: 46.9 ± 3.5; in 1987, WL: 29.1 ± 3.5 and WB: 44.6 ± 5.1.

Acephate, formulated in 2.54-cm capsules (97% technical insecticide), was inserted in 0.75-cm-diameter by 3-cm-deep holes spiral spaced at 15-cm intervals, starting at 30 cm aboveground. Carbofuran was applied in 20-cm-deep circular, trunk-concentric trenches 1.8 m away from the trunk, at 14.2 g per 2.54 cm trunk circumference (breast height). Disulfoton and oxydemeton-methyl were applied with a Kioritz soil injector (Wilbur-Ellis Co., Kent, WA) 15 cm deep at the tree's drip line at the rates of 11 and 30 ml per 2.54 cm trunk, trunk diameter, respectively, mixed with equal amounts of water.

During 1986, an irrigation system was installed for each setting. The system included 38 WL and 77 WB sprinklers, each with an output of 98 liters per hour. The plots were irrigated for 24 hours once a month from June through October to facilitate movement of insecticides in the soil and up the trees. precipitation during this period totaled 3.48 cm.

The trees in 1987 were irrigated with natural rainfall, which totaled 9.93 cm. Trees were ranked according to ELHB damage by a team of two observers using a scale of 1 = healthy to 10 = dead according to a method modified from Matteoni & Sinclair (8). In 1986, trees were ranked before treatment, treatments were applied on June 26, and evaluations after treatment were made on October 31. Similarly in 1987, trees were ranked before treatment, treatments applied on January 15, and pest treatment evaluations were made on May 19. An addition evaluation after treatment was made on the 1986 trees on May 18, 1987. Data were subjected to a two-way analysis of variance (11).

A phytotoxicity study was conducted on four additional *Eucalyptus* species: lemon gum, *E. sideroxylon* A. Cunn ex Wolls; and desert gum, *E. rudis* Endl. nurserystock trees growing in 24-gallon containers were selected for the study. The randomized complete block design with three replications of each treatment was used. Average tree diameter was 3.81 cm. Trees were irrigated daily with 9.5 liters of water. Insecticide treatments (as outlined above) were applied on April 23, 1987, and trees evaluated on May 22, 1987. No fertilization or pruning took place during this study.

RESULTS AND DISCUSSION

No phytotoxicity was observed during 1986 or 1987 in the WL and WB trees. Similarly, no phytotoxicity was observed in the nurserystock trees. Treatment effects on ELHB infestations and tree health are shown in Table 1 for the WL. In 1986, acephate resulted in a 25% and disulfoton in a 23% improvement in tree health 12 months after the initial application. In 1987, however, 2 and 15% tree health deteriorations were observed in the acephate and disulfoton treatments, respectively, possibly as the result of reduced amounts of irrigation water which is necessary to move the material into the trees.

Table 1. Influence of selected systemic insecticides on Eucalyptus longhorned borer infestations in woodlot plantings, Irvine, CA, 1986-87.

Year/Treatment	June 1986	Oct. 1986	Jan. 1987	May 1987
1986 Acephate	4.09±0.68[1]	3.69±0.61		3.09±0.31
Carbofuran	3.50±0.92	4.22±1.15		3.69±1.12
Disulfoton	4.91±0.46	4.66±0.58		3.78±0.21
Oxydemeton-methyl	4.13±0.66	4.00±0.75		3.69±0.44
Untreated	4.19±0.58	4.00±0.42		3.81±0.32
1987 Acephate			2.47±0.85	2.53±0.57
Carbofuran			1.78±0.51	1.81±0.27
Disulfoton			1.44±0.11	1.66±0.29
Oxydemeton-methyl			2.56±0.44	2.56±0.23
Untreated			1.81±0.37	1.97±0.38

[1]Values represent an average vigor ranking of 16 trees using a scale of 1, healthy, to 10, dead.

Table 2 illustrates the effects of the systemic insecticides on ELHB infestations in WB trees. During 1986, acephate and carbofuran resulted in the greatest health improvement (12 and 14%, respectively) four months after treatment. In 1987, all treatments resulted in tree health improvement, with disulfoton (20%) and carbofuran (14%) providing the greatest impact. Reduced irrigation water during 1987 was not crucial to WB trees as it appeared to be for WL trees. This was likely due to the more extensive root system (a consequence of their age and larger trunks) in WB trees. Analysis of variance did not reveal significant differences among treatments. Consequently, no further means separation tests were conducted.

Table 2. Influence of selected systemic insecticides on Eucalyptus longhorned borer infestations in woodlot plantings, Irvine, CA, 1986-87.

Year/Treatment		June 1986	Oct. 1986	Jan. 1987	May 1987
1986[1]	Acephate	1.65±0.38[1]	1.45±0.24		1.90±0.43
	Carbofuran	1.55±0.23	1.33±0.12		1.53±0.21
	Disulfoton	2.23±0.22	2.35±0.44		2.68±0.39
	Oxydemeton-methyl	2.88±0.71	2.60±0.56		2.88±0.62
	Untreated	1.50±0.29	1.38±0.24		1.75±0.42
1987[2]	Acephate			1.31±0.12	1.28±0.11
	Carbofuran			1.56±0.23	1.34±0.06
	Disulfoton			2.41±1.03	1.94±0.70
	Oxydemeton-methyl			1.50±0.27	1.41±0.23
	Untreated			2.00±0.47	1.44±0.18

[1]Values represent an average vigor ranking of 20 trees using a scale of 1, healthy, to 10, dead.

[2]Values represent an average vigor ranking of 16 trees using a scale of 1, healthy, to 10 dead.

The economics of ELHB control during 1986 are outlined in Table 3. Insecticide application labor costs were based on $12.39 per hour for a supervisor and $10.80 per hour for a worker including wages and benefits. Total hours of labor required for applying the insecticides were based on actual field time, excluding travel to or from the site. Insecticide costs were based on average retail values as follows: acephate at $375 per 300-cartridge pack, carbofuran at $3.66 per kg, disulfoton at $9.10 per liter, and oxydemeton-methyl at $12.57 per liter. The only equipment needed for insecticide applications was a standard shovel, a 0.85-cm drill, and a soil injector (Kioritz injector at $175.00 retail).

The capital investment for the irrigation system installation and equipment was $120.60 (WL) and $244.85 (WB). These costs were not included in Table 3 based on the following assumptions. First, irrigation systems already exist alongside California's freeways, as well as public parks, thus they are readily available when needed. Second, capital investments by public agencies, such as state departments of transportation or forestry (or both), do not have to be calculated on an annual depreciation schedule. Thus, the only cash costs considered in Table 3 were insecticide application labor and material, irrigation labor ($9.00 per hour including wage rate and benefits), and water costs (at 15 cents per 1,000 liter). The final cost per tree was $7.74 for WL and $11.09 for WB. Similarly, the cost analysis for ELHB control during 1987 is shown in Table 4. Treatment costs per tree were higher in 1986 due to the associated irrigation expenses.

Table 3. Cost analysis for Eucalyptus longhorned borer control with systemic insecticides, Irvine, CA, Summer/Fall 1986[1]

	Woodlot (64 trees)	Windbreak (80 trees)
Insecticide application:		
labor, 1 supervisor[1]	$ 82.52	$ 82.52
labor, 2 workers[2]	144.07	144.07
material[3]	171.95	464.91
Irrigation:		
labor[4]	30.00	60.00
water (15 cents per 1,000 liters)	67.03	135.83
Total cost	$495.57	$887.33
Cost per tree	$ 7.74	$ 11.09

[1]Assuming an irrigation system is installed and readily available. Capital for such a system is excluded, since such investments by public agencies do not have to be calculated on an annual depreciation schedule.

[2]Based on actual field time for insecticide applications, excluding travel to or from the site. Labor rates were $12.39/hour for a supervisor and $10.80/hour for a worker, including wage rate and benefits; total hours of labor required, 20 (WL) and 20 (WB).

[3]See text for details.

[4]Based on ca. 3 h (WL) and 7 h (WB); labor rate was $9.00/hr. including wage rate and benefits.

Table 4. Cost analysis for Eucalyptus longhorned borer control with systemic insecticides, Irvine, CA, Winter/Spring 1987

	Woodlot (64 trees)	Windbreak (80 trees)
Insecticide application:		
labor, 1 supervisor[1]	$ 66.04	$ 66.04
labor, 2 workers[1]	115.24	115.24
material	204.67	307.01
Total cost	$385.95	$488.29
Cost per tree	$ 6.03	$ 7.63

[1]Based on actual field time for insecticide applications, available excluding travel to or from the site. Labor rates were $12.39/hr. for a supervisor and $10.80/hr. for a worker, including wage rate and benefits; total hours of labor required, 16 (WL) and 16 (WB).

CONCLUSION

The greatest magnitude of tree health improvement achieved with any of the materials was only 25%, far lower than a desired improvement of 90 to 100%. This, together with the prohibitively-high treatment costs per tree during either phase, leads us to conclude that the use of these systemic insecticides is impractical for managing ELHB populations. Use of any systemic insecticide will likely result in unacceptable ELHB control.

Systemic insecticides, in general, are xylem-mobile, and thus move acropetally in the tree to reach their sink-the leaves (1,2). This fact makes the use of systemically-injected insecticides attractive for controlling foliar-feeding insects, such as pine needleminers (Coleotechnites near milleri [Busck] and C. ponderosae Hodges and Stevens) (3, 12) and the western spruce budworm (Choristoneura occidentals Freeman) (9). Unfortunately, this same fact renders this strategy ineffective against woodboring pests such as ELHB due to the absence of phloem-mobility and basipetal movement.

Apparently, future ELHB control efforts must rely on cultural or biological strategies, or both. Appropriate irrigation and fertilization during periods of hot, dry weather may enable trees to withstand attacks by this pest. In addition, studies are under way by members of the Department of Entomology at UC Riverside to investigate the importation and use of two Australian braconid parasites: Syngaster lepidus Brulle and Iphiaulax rubricepsis Von Achterberg and Shenfelt. If successful, the parasites together with cultural practices may provide the only line of defense against this new pest in North America.

References Cited

1. Ahmed, M. K., L.D. Newsom, J.S. Roussel & R.B. Emerson. 1954. Translocation of systox in the cotton plant. J. Econ. Entomol. 47: 684-691.

2. Bollard, E. G. 1969. Transport in the xylem. Ann. Rev. Plt. Physiol. 11: 141-166.

3. Brown, L. R., C.O. Eads, C.E. Crisp and M. Page. 1979. Control of a Jeffrey pin needleminer by spraying and trunk implantation and resultant acephate residues. J. Econ. Entomol. 72: 51-54.

4. Food and Agriculture Organization. 1979. Eucalyptus for planting. FAO Forestry Ser. No. 11. pp. 138.

5. Gonzalez, L. T. 1984. Luch contra Phoracantha semipunctata Fab. en el suroeste espanol. Min. Agric., Bol. Serv. Plagas. 10: 185-204.

6. Groenendaal, G. M. 1985. California's first fuel crises and eucalyptus plantings. M. S. thesis, California State University, Northridge. 232 p.

7. Loyttyniemi, K. 1980. Life history and harmfulness of the eucalyptus longhorn beetle, Phoracantha semipunctata (Fabricius) in Zambia. XI Commonwealth For. Conf. 6 pp.

8. Matteoni, J. A. & W.A. Sinclair. 1985. Role of the mycoplasmal disease, ash yellows, in decline of white ash in New York state. Phytopathol. 75: 355-360.

9. Reardon, R. C. 1984. Two consecutive yearly applications of Orthene medicaps increase protection of grand fir against western spruce budworm. For. Ecol. Manage. 7: 183-190.

10. Scriven, G. T., E. L. Reeves & R.F. Luck. 1986. Beetle from Australia threatens eucalyptus. Cal. Ag. 40: 4-6.

11. Snedecor, G. W. & W.G. Cochran. 1980. Statistical methods. 7th ed. Iowa State Univ. Press. 507 p.

12. Stevens, R. E. & D.A. Leatherman. 1982. Implants and sprays for control of Ponderosa pine needleminer in foliage of individual trees. U.S.D.A. For. Serv. Rocky Mtn. For. Range Exp. Stn. Res. Note RM-420. 4 p.