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Evaluation of Some Carbamate and Phosphate Insecticides Against Southern Pine Beetle[1] and *Ips* Bark Beetles[1,2]

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ABSTRACT

Six insecticides were tested on southern pine beetle, *Dendroctonus frontalis* Zimmerman, to determine effects on established brood and ability to prevent attacks of *Ips* engraver beetles. The insecticides were: lindane as a reference; 2 carbamate insecticides, propoxur and carbaryl; and 3 organophosphates, acephate, phosmet, and diazinon.

Only lindane significantly reduced established southern pine beetle broods. Phosmet caused high mortality of adult beetles within 24 h after emergence from treated pines. Lindane, propoxur, and carbaryl were effective in preventing *Ips grandicollis* Eichoff and *I. calligraphus* Germar attacks on loblolly pine logs.

The bark beetles are the most destructive forest insects, yet insecticidal controls for them have been little refined since the 1950's. Benzene hexachloride (BHC) and lindane remain the only currently recommended chemicals for control of pine bark beetles in the South. Effectiveness of the less persistent carbamate and phosphate insecticides for bark beetle control has not been adequately investigated.

Lyon (1971) tested some organophosphate and carbamate compounds against western pine beetle, *Dendroctonus brevicomis* LeConte. Tests of carbaryl against Douglas-fir beetle, *Dendroctonus pseudotsugae* Hopkins, also were made by Allen and Rudinsky (1959), Rudinsky and Terriere (1959), and Rudinsky et al. (1960). We report here tests of the effectiveness of certain carbamate and phosphate insecticides in controlling established broods of southern pine beetle, *Dendroctonus frontalis* Zimmerman, and in preventing attack of *Ips grandicollis* Eichoff and *I. calligraphus* Germar.

METHODS AND MATERIALS.—*Insecticides.*—The chemicals were phosmet 50%WP, diazinon 24%EC, acephate 75%SP, propoxur 70%WP, and carbaryl 31%FP. Lindane 17%EC was included as a reference, and a control treatment received water only. Insecticides were applied in water solutions at the following concentrations: phosmet, 0.8%; diazinon, 1.0%; acephate, 0.12%; propoxur, 1.1%; carbaryl, 2.2%; lindane, 0.25%. Insecticide concentrations were based on manufacturer suggestions, since only lindane has been used for bark beetle control.

Effects on Southern Pine Beetle Brood.—Six loblolly pines, *Pinus taeda* L., averaging 7 in. (17.8 cm) DBH, containing larvae and pupae of the southern pine beetle, were used for the brood effect experiments. Seven bolts were cut from each tree, beginning on the lower bole ca. 4 ft (1.2 m) above ground level. The lowest bolt was cut to a length of 30 in. (0.8 m) whereas the other 6 bolts were 24 in. (0.6 m) long. To provide data on brood density and stage of attack, circular bark samples 4½ in. (11.4 cm) diam were taken from each bolt. Four samples, 2 from each end, were taken from the lowest bolt, and 2 samples were taken from the top end only of the other 6 bolts. Each bolt was then cut to 18 in. (45.7 cm) by removing the sampled ends. Circular bark samples were examined using a Faxitron® model 805 X-ray unit. Radiographs were examined on an illuminator where the adults, larvae, and pupae were identified and counted. The average beetle population per ft² in sample bolts, including larvae, pupae, and adults, before chemical treatment was acephate, 301.0; carbaryl, 360.0; diazinon, 326.8; phosmet, 300.7; propoxur, 332.2; lindane, 371.5; and 316.8 for the control.

The treatments were assigned randomly to the 7 bolts from each tree. The insecticides were mixed and applied with a Hudson Clipper® 6215 sprayer until the bark was wet and the insecticide ran in rivulets. The bolts were placed upright in cylindrical rearing cages with funnel-shaped bases (Germain and Wygant 1967). Emerging insects were collected each day, identified, and counted.

Some of the emerging southern pine beetles from each treatment were randomly selected and placed in 60×15-mm plastic petri dishes lined with filter paper to measure their time of survival after emergence through the treated bark. These petri dishes were checked every 24 h for 5 days, and surviving beetles were counted.

Prevention of Attack by Ips *Engraver Beetles.*—The attack prevention phase of the study was set up in an area where recent logging debris had attracted many bark beetles. Loblolly pine trees ca. 7 in. (17.8 cm) diam were felled and cut into 8-ft (2.4 m) logs. The logs were propped at a 45° angle against a wooden stand. Two treatment blocks, consisting of 7 logs each, all oriented in the same direction, were used. Logs in each block were separated from one another by at least 10 ft (3.0 m). The 2 blocks were separated by ca. 100 ft (30.5 m). Random selection decided the treatments applied to each log in each block.

Each week, logs were checked for *Ips* attack and new attacks marked and counted. At the end of 6 wk, bark samples were removed from the logs to determine the predominant attacking *Ips* species.

RESULTS.—*Effects on Southern Pine Beetle Brood.*—Analysis of variance of the emergence data from the

[1] Coleoptera: Scolytidae.

[2] Based, in part, on a thesis submitted by the 1st author to the Grad. School, Stephen F. Austin State Univ., in partial fulfillment of the requirements for the M.F. degree. Received for publication May 30, 1974.

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Table 1.—Emergence of adult southern pine beetles from insecticide-treated pine bolts, Nacogdoches, TX 1973.

Treatment	Emergence[a] southern pine beetle
phosmet	690.9 a
carbaryl	521.0 abc
acephate	508.0 abcd
propoxur	480.3 bcde
diazinon	379.8 bcdef
lindane	223.5 f
control	554.0 ab

[a] Emergence is mean of 6 pine bolts (7 in. diam × 18 in.) for each insecticide. Means having no letter in common are significantly different at the 5% level of probability as determined by Duncan's multiple range test.

treated bolts indicated a significant F-value at the 5% level. Comparison of the mean emergence data for each insecticide showed that only in the case of lindane did emergence vary significantly from the control (Table 1). Lindane is thought to possess fumigant properties that enable it to kill beetle brood beneath the bark. These results suggest that the other 5 test insecticides had little or no fumigant effect and did not penetrate the tree bark in sufficient quantity to kill beetles.

Observations of beetle survival after emergence measured possible toxic effects of insecticide contacted or ingested during or after emergence (Fig. 1). Survival data for the control and each treatment were arrayed into a 2×5 contingency table and tested using χ^2. Survival time for all treatments except acephate differed significantly (at 5% level) from that of the control. Phosmet produced the most rapid mortality.

Prevention of Attack by Ips *Bark Beetles.*—Based on the bark samples taken at the end of the attack prevention studies, *I. grandicollis* accounted for 91% of the attacks and *I. calligraphus* for the remaining 9%. Except for acephate, all insecticides effectively prevented *Ips* beetles from successfully attacking the pine for 4 wk (Fig. 2). After that time, only carbaryl, propoxur, and lindane were effective. Duncan's multiple range test showed no significant difference at the 5% level between carbaryl, propoxur, and lindane in number of attacks.

DISCUSSION.—Although none of the test insecticides except lindane had any significant effect on the mortality of brood beneath the bark, several had a noticeable impact on the survival time of emerging adults. This may be an important consideration in bark beetle control since many of the emerging beetles may die before mating and host selection has taken place. By combining the data on adult emergence and emergent adult mortality, control of adults can be as high as 97% within 48 h after emergence (Table 2). The high mortality of emergent adults from phosmet-treated bolts after 24 and 48 h, and of adults from carbaryl-, diazinon-, and lindane-treated bolts after 48 h, suggests that these chemicals may have a significant impact on southern pine beetle populations even though some were ineffective in killing brood beneath the bark.

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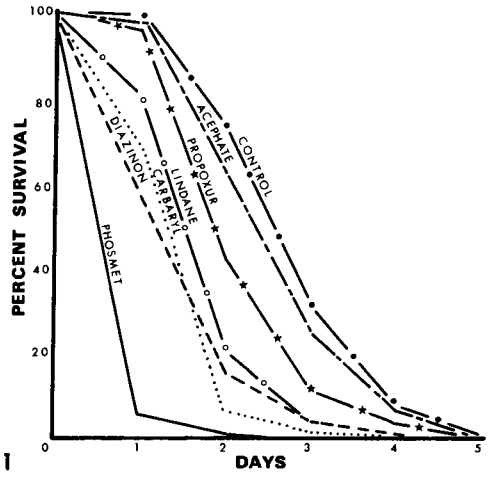

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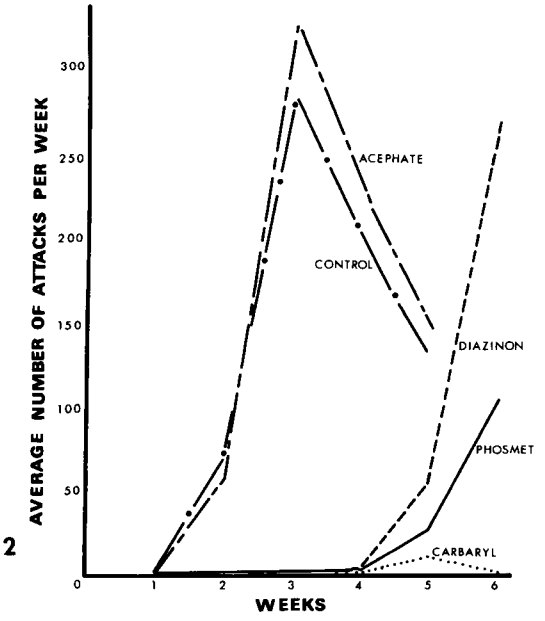

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FIG. 1.—Survival of southern pine beetles after emergence from insecticide-treated pine bolts. The initial numbers of beetles were: 193 for the control, 164 for lindane, 194 for carbaryl, 248 for propoxur, 242 for acephate, 182 for diazinon, and 197 for phosmet.

FIG. 2.—Effectiveness of treatments in prevention of attacks by *Ips* beetles. Propoxur and lindane curves are not shown since no attacks were recorded after 6 wk.

Table 2.—Estimated control of southern pine beetles by insecticides at 24 and 48 h following emergence from treated pines.

Treatment	% control based on total emergence[a]	% survival postemergence[b]		Adjusted % control based on postemergence survival	
		24 h	*48 h*	*24 h*	*48 h*
Phosmet	0	6	2	92	97
Carbaryl	6	60	7	44	91
Diazinon	31	72	16	51	86
Lindane	60	83	22	66	88
Propoxur	13	98	43	15	51
Acephate	8	99	65	9	21
Control	—	100	76	—	—

[a] Based on mean emergence (Table 1).
[b] From Fig. 1.

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