American plum borer damage to the crotch of a young almond tree. The tree responds to larval feeding by exuding large amounts of gummy sap.

Borer control in young almond trees

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Female borers lay eggs in cracks and crevices of the bark. The larva (below) feeds within the cambium tissue of the tree. Only a few larvae can cause severe damage.

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The almond borer complex, consisting mainly of the American plum borer and prune limb borer, can cause serious damage to almond trees in the first through fourth growing seasons in all districts north of Madera County, in California, particularly Merced, Stanislaus, and Sacramento counties.

Borer larvae usually attack young, injured or weakened trees where callous tissue has formed, particularly at graft unions and at junctions of major scaffold limbs and the trunk or injured areas. Feeding at the junction of the major scaffold limbs and trunk of young trees may weaken the limbs to such an extent that they break from the tree during high winds or at the first heavy crop set. If the scaffolds break, the trees must be removed.

The borers overwinter as mature larvae within silken cocoons in protected places on the tree. In the spring, overwintering larvae pupate, and adults of both species emerge in April and May. The females lay eggs either singly or in small clusters in cracks and crevices of the bark. The larvae feed within the cambium tissue of the tree and produce a characteristic orangish-red frass. The tree responds to this feeding by exuding copious amounts of sap. After the larvae complete development, they pupate in protected places on the tree. The almond borer complex has multiple overlapping generations each year.

We conducted research to find safe and effective means of controlling these insects. All experiments took place in Merced County almond orchards.

Borers found in trees

In 1984, we determined the species composition of the almond borer complex by extracting larvae from active feeding sites. The survey was conducted for a two-hour search period on May 22 and at approximately weekly intervals from June 6 through September 7. The predominant species present were the prune limb borer and American plum borer. The various larvae found and their numbers and percent of total were:

	No.	%
Prune limb borer (*Bondia comonana*)	32	58.2
American plum borer (*Euzophera semifuneralis*)	14	25.5
Peach twig borer (*Anarsia lineatella*)	7	12.7
Carpenterworm (*Prionoxystus robinae*)	2	3.6

All four species fed predominantly at the junction of the trunk and major scaffold limbs. Prune limb borer and American plum borer were frequently found also in callous tissue at the graft union; peach twig borer was frequently found on major or secondary scaffold limbs. The peach twig borer fed much less extensively than did either prune limb borer or American plum borer and it appeared not to cause widespread damage to young almond trees.

Insecticides and paint

In 1983 and 1984, we evaluated various insecticides in combination with white latex paint for almond borer complex control by periodically counting the number of active feeding sites per tree, indicated by frass piles, after treatment. After each count, we removed the frass piles so that we could determine fresh feeding on the next counting date. We did not dig into the trees to find the larvae. Replicates consisted of individual trees.

In 1983, we tested five insecticides, each mixed with interior white latex paint, as well as paint alone in a third-season Nonpareil, Carmel, and Price almond orchard. We sprayed the entire trunk up to the branching of the secondary scaffolds on March 31, May 31, and July 19 and counted the number of frass piles on the trees on nine dates from May 3 through September 28. We conducted a second trial in the same manner in a second-season Nonpareil, Carmel, and Peerless almond orchard.

All insecticides tested in combination with interior white latex paint in both trials gave nearly complete control of almond borer complex, even though the borer population was extremely large in trial

1 from May 31 through June 29 (table 1). The paint alone had some effects on borers, but it did not provide adequate control.

In 1984, we applied diazinon (Diazinon) and two rates of carbaryl (Sevin) in combination with 1:4 or 1:6 interior white latex paint:water to third-season Carmel and Price almond varieties. We inspected the trees before the application and included only those with active feeding sites in the study. We treated the entire trunk up to the branching of the secondary scaffolds on June 6, then counted the number of frass piles at weekly intervals from June 12 through September 7.

All insecticides and rates of paint tested in 1984 immediately suppressed feeding activity, as evidenced by the large reduction in frass piles on June 12 to 26 (table 2). Since materials killed the larvae within the cambium, preventive applications do not appear to be necessary. The suppression continued throughout the study (September 7), but the length of time may have been due to lack of movement of adult moths from untreated areas to the treated trees rather than to the insecticides.

When the seasonal total of larvae found was considered, either diazinon or carbaryl at 3 pounds active ingredient per acre in either 1:4 or 1:6 paint:water gave excellent results (table 2). Carbaryl at 1.5 pounds active ingredient per acre with 1:6 paint:water showed some breakdown in control, but differences among the various treatments were not significant.

Effect and longevity

In 1983, we tested five treatments in a Carmel almond orchard: three rates of carbaryl with paint, one rate of carbaryl without paint, and paint alone. We sprayed the entire trunk up to the branching of the secondary scaffolds on June 29, and counted the number of frass piles per tree on four dates.

Carbaryl without paint at the highest rate gave good control for one month after treatment; the inclusion of paint extended control for three months (table 3). Control with the two lower rates of carbaryl with paint began to break down two months after application, and paint alone gave no control.

Conclusions

Of the almond borer complex, only American plum borer, prune limb borer, and possibly carpenterworm do extensive damage. All almond varieties may become infested to some degree. Carmel and Price have been reported throughout the state to be more seriously affected and to have higher borer populations than other varieties.

Borer infestation may begin during the fall of the first growing season. The boring is generally confined to the graft union and trunk. Infestation during the second to fourth growing seasons usually is confined to the junction of the trunk and main scaffold limbs. Control during the second growing season is critical, since only a few larvae may cause serious tree damage, and heavy infestation may lead to loss of limbs. The number of larvae needed to cause damage increases with tree age, and after the fourth growing season, the trees can withstand substantial infestation without apparent damage.

Topworked trees — those grafted over to another variety — are also very susceptible to almond borer infestation.

A high level of mallet wound canker (*Ceratocystis*) has been associated with infestation by the almond borer complex. American plum borer has been reported as a vector of this disease.

We found that a number of insecticides in combination with interior white latex paint at 1:4 to 1:6 (paint:water) controlled the almond borer complex. Two of the insecticides tested, carbaryl and diazinon, are currently registered for use on almonds, reasonably safe to handle, and inexpensive, and they provided excellent control for three months when combined with paint.

Insecticides without paint provided some control, but it was not long lasting. Dilution of the paint depends on quality; higher quality paints may be diluted to a greater degree than those of lower quality. Paint without insecticide provides little or no control.

Our studies indicated that insecticide and paint combinations do not have to be applied in a preventive manner but can be applied once borer feeding activity is observed. Usually one to two applications should be adequate for seasonal control.

TABLE 1. Control of almond borer complex with various insecticides combined with white paint, Merced County, 1983

Material	Lb ai/ac*	Mean season total Trial 1†	Trial 2‡
Carbaryl (Sevin) 80S + paint	3.2	0.1 a	0.0 a
Chlorpyrifos (Lorsban) 2EC + paint	1.0	0.1 a	0.0 a
Permethrin (Pounce) 3.2EC + paint	0.4	0.2 a	0.1 a
Endosulfan (Thiodan) 50WP + paint	2.5	0.2 a	0.1 a
Methidathion (Supracide) 2EC + paint	3.0	0.3 a	0.0 a
Paint only	—	13.0 b	9.4 b
Untreated	—	39.2 b	12.8 b

NOTE: Treatments were replicated 10 times in a randomized complete block design. Means followed by the same letter in a vertical column are not significantly different by Duncan's Multiple Range Test ($P \leq 0.05$).

* Pounds active ingredient of insecticide per acre.

† For the March 31 treatment, the paint mixture was 1:3 paint:water at 1.6 pints per tree, or 4 gallons paint per acre. For the May 31 and July 19 treatments, the paint mixture was 1:4 paint:water applied at 1.2 pints per tree, or 2.4 gallons paint per acre.

‡ The paint mixture was 1:4 paint:water applied at 0.8 pint per tree for all applications.

TABLE 2. Control of almond borer complex with various insecticides and paint concentrations, Merced County, 1984

Material* Insecticide and lb ai/ac	Paint: water	Mean number of frass piles per tree during period 6/12-6/26	7/3-7/17	7/27-8/9	8/23-9/7	Season total
Carbaryl 80S, 3.0	1:4	0.2 a	0.7 a	0.2 a	0.0 a	1.1 a
Carbaryl 80S, 3.0	1:6	0.3 a	0.0 a	0.2 a	0.5 a	1.0 a
Carbaryl 80S, 1.5	1:4	0.3 a	0.2 a	0.6 a	0.6 a	1.7 a
Carbaryl 80S, 1.5	1:6	1.3 a	1.1 a	1.1 a	1.1 a	4.6 a
Diazinon 50WP, 3.0	1:4	0.3 a	0.1 a	0.3 a	0.0 a	0.7 a
Diazinon 50WP, 3.0	1:6	0.1 a	0.2 a	0.1 a	0.2 a	0.6 a
Untreated	—	7.0 b	8.5 b	3.2 b	4.0 b	22.7 b

NOTE: See table 1 NOTE.

* The paint:water mixture was applied at 1 pint per tree, or 2 gallons paint per acre and 1.4 gallons paint per acre in the 1:4 and 1:6 combinations, respectively.

TABLE 3. Effect of carbaryl with and without paint on the control of almond borer complex. Merced Co., 1983

Material*	Lb ai/ac	Mean number of frass piles per tree on 7/19	8/4	8/30	9/21	Season total
Carbaryl	3.0	0.3 a	0.3 a	2.5 bcd	2.0 a	5.1 a
Carbaryl + paint	3.0	0 a	0 a	0.1 a	0.4 a	0.5 a
Carbaryl + paint	1.5	0 a	0.3 a	1.4 abc	1.9 a	3.6 a
Carbaryl + paint	0.75	0 a	0 a	0.7 ab	1.5 a	2.2 a
Paint	—	2.1 b	2.2 b	3.8 d	4.9 b	13.0 b
Untreated	—	1.9 b	3.1 b	3.4 cd	5.7 b	14.1 b

NOTE: See table 1 NOTE.

*The paint mixture was 1:4 paint:water applied at 1 pint per tree, or 1.9 gallons paint per acre.

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