the preceding year. They have not been found in any plantings of potatoes, before introductions were started, in each of the years 1964 to 1969, inclusive. However, results of our hibernation cage studies suggest that this introduced coccinellid may be capable of surviving the winter in grassland, in cages, at Presque Isle, at least as well as the native *C. transversoguttata*, and possibly better that *H. tredecimpunctata*. Considering the results in Table 1, grassland may not be the most suitable hibernation habitat for *H. tredecimpunctata* (and *H. convergens*, possibly). However, it and *C. transversoguttata* are ordinarily the most abundant of the coccinellids occurring there on potatoes. Apparently, minimum winter temperature at Presque Isle will not be a deterrent to successful establishment of *C. septempuctata*, as the range of −30.0 to −33.5°C occurring there during our cage studies does not differ markedly from that of −41°C in southeastern Kazakstan where the beetle occurs naturally (Savoiskya 1965).

According to Bonnemaison (1964) and Hodek (1965), our population of *C. septempunctata*, which was obtained from the Paris district, is rather heterogeneous in that it contains univoltine individuals, polyvoltine individuals, and crosses of the 2 races. Our observations lead us to think that if or when *C. septempunctata* becomes established in northeastern Maine, it probably will have 1 generation/year and a partial 2nd one, as does the native *C. transversoguttata*. Adults of the 2nd generation may survive the winter poorly because of inadequate food and length of feeding periods for developing the necessary reserves of fats and glycogen before entering hibernation.

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Attraction of Mountain Pine Beetles[1] to Small-Diameter Lodgepole Pines Baited with *Trans*-Verbenol and Alpha-Pinene[2,3]

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ABSTRACT

Lodgepole pines, *Pinus contorta* Douglas, 8.9 in. diameter at breast height (DBH) or less, were baited with the pheromone *trans*-verbenol and the terpene alpha-pinene to determine if populations of *Dendroctonus ponderosae* Hopkins could be attracted to these trees of small diameter. Even though the beetles in most cases did not successfully attack baited trees, such trees were usually the first to be attacked. This phenomenon indicated that these chemicals might be used to attract beetles into areas with baited trees but not to baited trees exclusively. This indication was supported by the fact that the beetles successfully attacked larger unbaited trees.

Infestations of mountain pine beetle, *Dendroctonus ponderosae* Hopkins, in lodgepole pine, *Pinus contorta* Douglas, have occurred in Idaho, Montana, and Utah at rather frequent intervals. The mountain pine beetle kills most of the large lodgepole pine trees in a forest before the beetle population subsides, and it probably is the most aggressive *Dendroctonus* bark beetle in the western United States.

Amman (1969) reported that brood survival, as measured by emergence holes, was correlated closely with bark depth but varied with stand density and plot elevation. The greatest proportion of thick-barked trees was in the large-diameter classes. He hypothesized that phloem thickness was the critical

[1] Coleoptera: Scolytidae.
[2] Received for publication Oct. 13, 1971.
[3] Mr. Walter E. Cole endorses and communicates.
[4] Biological Technician.

factor. Cole and Amman (1969) indicated that large infestations of mountain pine beetle depend on the presence of large-diameter trees within a stand of lodgepole pine, and they concluded that growth of the beetle population is food-limited, i.e., survival and population size are correlated highly with the quantity of phloem within the infested tree. Therefore, if materials such as the pheromone *trans*-verbenol and the terpene alpha-pinene could be used to attract beetles to small-diameter thin-phloem trees, population reduction might be attained.

The occurrence of pheromones in *Dendroctonus* species is well known (McMullen and Atkins 1962, Vité 1962). Pheromones are the means of communication that cause mass attack and probably function to maintain the species integrity of bark beetles inhabitating the same host tree. Pitman et al. (1968) reported that *trans*-verbenol, a terpene alcohol isolated from the hindgut of the female, is the principal attractant for *D. ponderosae*. According to Pitman (1971), the effectiveness of *trans*-verbenol depended upon the terpene alpha-pinene produced by the host tree.

Even though the ability of *trans*-verbenol to attract the mountain pine beetle to white pine is substantiated, the question still remains whether *trans*-verbenol can be used to manipulate and manage populations of this beetle in lodgepole pine forests.

METHODS.—Two lodgepole pine stands in southeastern Idaho were selected in the spring of 1970. Each stand had a fairly uniform representation of 8- to 16-in.-diam trees and contained scattered groups of mountain pine beetle infestations. Nine groups of infested trees were designated as test plots; 8 were circular and 1 was rectangular.

Two plot designs were used. The 1st plot design consisted of 8 circular plots. For each of the circular plots, pairs of uninfested trees were selected around a group of infested trees at a radial distance of 198 ft (3 chains); the uninfested trees were so selected that they were a minimum of 66 ft (1 chain) apart. Each pair consisted of 1 tree 7- to 8.9-in. DBH with thin phloem (0.10 in. or less) and a 2nd tree 12 in. or larger DBH with thick phloem (0.11 in. or greater). The smaller was baited with *trans*-verbenol and alpha-pinene, whereas the larger tree was used as a check. The number of these pairs on the 8 circular plots ranged from 3 to 8, depending upon the availability of trees having desired characteristics. Each of the circular plots contained ca. 2.8 acres; thus, the total acreage involved was ca. 22.4 acres.

The 2nd plot design consisted of 1 rectangular plot. In this plot, 4 cruise lines were established 132 ft (2 chains) apart, and 45 baited trees alternating with 45 check trees were marked along these lines at 66-ft intervals. The size and phloem thickness requirements for baited and check trees were the same as those for the circular plots. This plot covered ca. 19 acres and contained 82 trees that had been infested by the beetle.

Using a method similar to that of Pitman (1971), 4-ft lengths of polyethylene catheter tubing (0.038 in. ID), charged with a mixture of *trans*-verbenol and alpha-pinene at a ratio of 9:1, were attached to each experimental tree. A polyethylene Boston bottle containing 10 ml of alpha-pinene also was attached to each of these trees to compensate for the higher evaporative rate of alpha-pinene from the mixture.

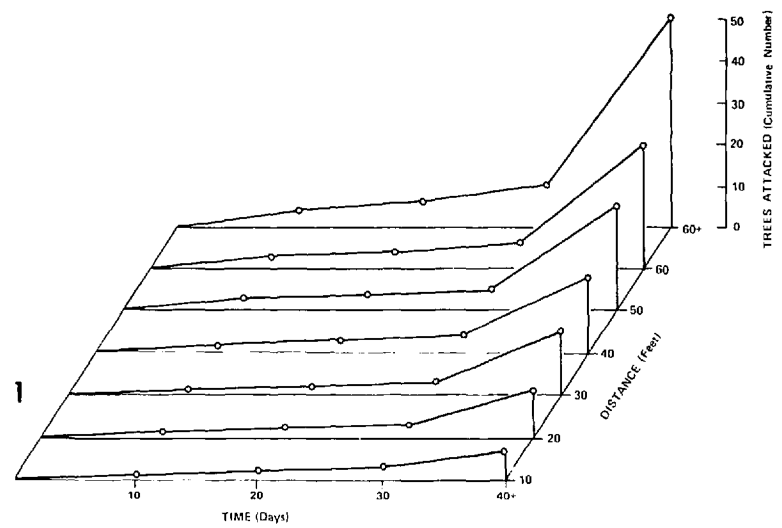
Daily observations were made to detect timing, sequence, and severity of beetle attacks. Also, attacks were recorded on nonexperimental trees within 66 ft of each baited tree in both types of plots.

RESULTS AND DISCUSSION.—The effectiveness of *trans*-verbenol and alpha-pinene in attracting mountain pine beetles is indicated by the relative proportions of trees attacked. Of the 64 trees that were attacked by the mountain pine beetle in the circular plots, 17% were baited, 5% were checks, and 78% were nonexperimental trees. Of the 84 trees that were attacked in the rectangular plot, 23% were baited, 2% were checks, and 75% were nonexperimentals (Table 1). When only the baited and check trees were compared, the effectiveness of the attractants is indicated by the percentages of trees attacked: i.e., 22 and 6%, respectively, for the 8 circular plots; 42 and 4%, respectively, for the rectangular plot (Table 1).

Eleven of the 50 baited trees were attacked by the mountain pine beetle in the circular plots. However, only 6 (54%) of these were successfully mass attacked; the other 5 trees were considered to be attacked unsuccessfully because they either experienced only one to a few scattered attacks or the beetles were pitched out by the tree. Three of the 50 check trees were attacked; on 2 (66%) the attacks were successful. Fifty nonexperimental trees also were at-

Table 1.—Comparison of lodgepole pine trees attacked by the mountain pine beetle in circular and rectangular plots.

	No. trees attacked			% trees attacked			% experimental trees attacked	
Plot	Baited	Check	Non-experimental	Baited	Check	Non-experimental	Baited	Check
Circular								
1	1	1	11	8	8	84	14	14
2	1	0	4	20	0	80	17	0
3	1	0	6	14	0	86	33	0
4	2	0	12	14	0	86	29	0
5	3	1	9	23	8	69	43	14
6	0	0	2	0	0	100	0	0
7	2	1	5	25	12.5	62.5	33	17
8	1	0	1	50	0	50	14	0
Total	11	3	50	17	5	78	22	6
Rectangular	19	2	63	23	2	75	42	4



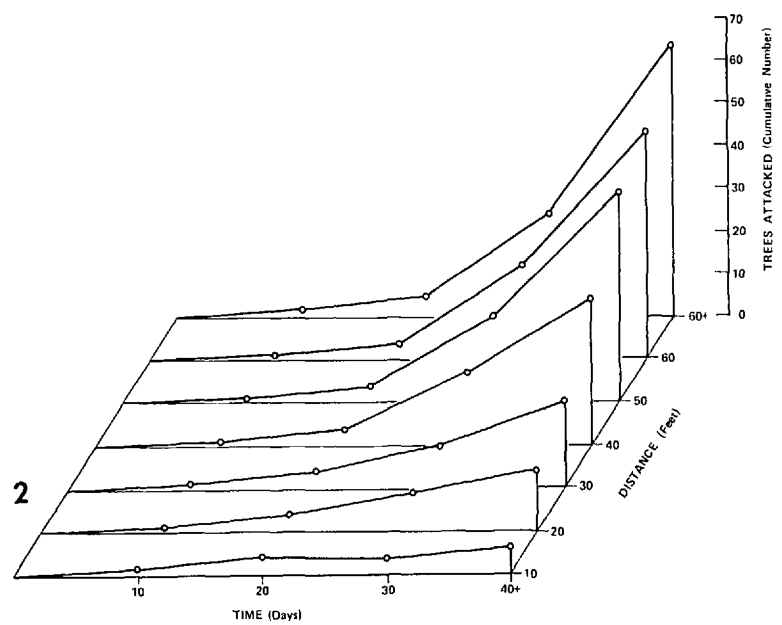


FIG. 1, 2.—Relationship of number of trees attacked by mountain pine beetle to time and distance from the nearest baited tree that was attacked. Fig. 1.—In the circular plots. Fig. 2.—In the rectangular plot.

tacked within these plots; on 46 trees (92%) the attacks were successful.

In the rectangular plot, 19 of the 45 baited trees were attacked but only 11 (58%) of these were attacked successfully. Two of the 45 check trees were attacked; on only 1 (50%) was the attack successful. Fifty-nine (94%) of 63 nonexperimental trees were attacked successfully.

In each of 5 circular plots, 1 baited tree was attacked first by the mountain pine beetle. In 1 circular plot, 1 baited, 1 check, and 1 nonexperimental tree were attacked at the same time; there was no way to distinguish which was attacked first. In 2 of the circular plots, nonexperimental trees were attacked first.

In the rectangular plot, 8 baited trees were attacked before any other tree. After 28 days of observation, 15 baited trees were attacked in contrast to 1 check tree and 9 nonexperimental trees. Thereafter, the number of nonexperimental trees being attacked rapidly increased until the beetle flight period was over.

In both the circular (Fig. 1) and rectangular (Fig. 2) plots, most of the attacked trees were in close proximity to the baited trees during the early part of the attack period. However, as the attack period progressed and the number of attacked trees increased, the proximal distance also increased.

A greater number of smaller trees, most of which were baited, were attacked and killed during the 1970 attractant test than had been killed in the previous year. In the 1970 attractant test, 20% of all the trees attacked within the circular plots and 32% within the rectangular plot were 8.9 in. DBH or smaller (Table 2).

In the circular plots, the number of lodgepole

Table 2.—Comparison of lodgepole pine trees killed by the mountain pine beetle per year.

Plot	No. trees attacked	No. attacked 8.9 in. or less	% attacked 8.9 in. or less	Avg. DBH of trees attacked
Circular 1969	38	3	8	13.3
Circular 1970	64	13	20	13.0
Rectangular 1969	82	1	1	13.7
Rectangular 1970	84	27	32	11.8

pine trees attacked in 1970 was nearly double the number attacked in 1969, whereas in the rectangular plot the number remained almost equal for the 2 years (Table 2). A possible reason is that the general area of the circular plots contained a number of groups of trees infested by mountain pine beetles. Large numbers of the emerging beetles probably were attracted into the circular plots by the bait mixture and the newly attacked trees. However, in the rectangular plot, all the trees infested in 1969 were situated within the plot boundaries, and no supplemental source of beetles outside the plot was observed. Therefore, the number of trees attacked in 1970 more closely approximated the number attacked in 1969.

This study indicates the use of *trans*-verbenol and alpha-pinene to regulate mountain pine beetle populations by attracting beetles to small lodgepole pine where brood production is low does not appear possible at this time.

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Control of Four Species of Caterpillars on Cabbage with *Bacillus thuringiensis* var. *alesti*, 1969–70[1,2]

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ABSTRACT

An experimental wettable powder formulation of *Bacillus thuringiensis* var. *alesti* Berliner applied as a spray in field tests at Charleston, South Carolina, gave control of the populations of cabbage looper, *Trichoplusia ni* (Hübner), on spring and fall cabbage. Also, it was as effective in producing marketable cabbage heads as sprays containing endosulfan (1 lb), methomyl (0.4 lb), or endosulfan (1 lb) + parathion (0.5 lb), whether it was used at 0.1 or 0.5 lb/acre. However, applications of bacillus at 1 lb/acre were necessary to produce as many plants with completely uninjured heads as were produced by the spray mixture of endosulfan + parathion. Mixtures of bacillus + endosulfan or methomyl sometimes gave more effective control of the loopers than the same doses of the same materials used alone, and no synergism or antagonism was observed between the bacillus and the chemicals.

As little as 0.1 lb/acre of the bacillus formulated as a spray gave good control of the diamondback moth, *Plutella xylostella* (L.); the imported cabbageworm, *Pieris rapae* (L.); and the fall armyworm, *Spodoptera frugiperda* (J. E. Smith).

A bacillus dust tested only one season was not so effective as the spray in controlling the cabbage looper. However, it was moderately effective against the diamondback moth and highly effective against the imported cabbageworm.

Formulations of *Bacillus thuringiensis* var. *thuringiensis* Berliner and var. *galleriae* Berliner have been tested extensively for several years against lepidopterous larvae that damage head and wrapper leaves of cabbage and edible portions of other cole crops, primarily the cabbage looper, *Trichoplusia ni* (Hübner); the imported cabbageworm, *Pieris rapae* (L.); the diamondback moth, *Plutella xylostella* (L.); and the fall armyworm, *Spodoptera frugiperda* (J. E. Smith). In these tests, the bacillus proved effective against the imported cabbageworm (Tanada 1956, McEwen and Hervey 1959, McEwen et al. 1960, Creighton et al. 1964, 1970), the diamondback moth (Chalfant 1969, Creighton et al. 1970), and the fall armyworm (Creighton et al. 1970). However, against the cabbage looper, the most difficult of these insect species to control, the bacillus has varied greatly in effectiveness (Hall et al. 1961, Shorey and Hall 1962, Chalfant and Brett 1965, Creighton et al. 1964, 1970). Commercial formulations appeared promising

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[2] Mention of pesticide or a proprietary product does not constitute recommendation or endorsement by the USDA.