ENTOMOLOGY

Field Tests with Semiochemicals for the Mountain Pine Beetle in the Cypress Hills, Alberta

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Following the discovery of the mountain pine beetle, *Dendroctonus ponderosae* Hopk., in the Cypress Hills of southeastern Alberta in 1979 (Hiratsuka et al., Can. Dep. Environ., North. For. Res. Cent., Inf. Rep. NOR-X-225, 1980), a control program of sanitation cutting and burning of beetle-infested trees was initiated in 1980 to prevent spread and intensification of this infestation. This program has been continuing since and has proven both costly and labor-intensive because of the difficulty in locating all of the widely distributed "pocket infestations" for the control treatment (Moody and Cerezke, Can. Dep. Environ., North. For. Res. Cent., Inf. Rep. NOR-X-248, 1983).

Recent field tests with semiochemicals (behavior-modifying chemicals) for the mountain pine beetle in British Columbia have resulted in the identification of chemical components that induce strong aggregation behavior of the beetle to its host tree, lodgepole pine, *Pinus contorta* Dougl. var. *latifolia* Engel. (Borden et al., Can. J. For. Res. 13:325–333, 1983a; Borden et al., For. Chron. 59:235–239, 1983b; Borden et al., J. Econ. Entomol. 76:1428–1432, 1983c; Conn et al., Can. J. For. Res. 13:320–324, 1983). In 1982, extension of these tests were conducted in Cypress Hills Provincial Park in Alberta to take advantage of the isolated populations of the mountain pine beetle in this area which uniquely represented the most easterly distribution of both the beetle and its host, lodgepole pine in Canada. These investigations provided data for evaluation of semiochemicals for control of the beetle, and for comparative attractiveness of two semiochemical blends.

The two semiochemical blends were placed as bait on "trap trees" and in multiple funnel traps (Lindgren, Can. Entomol. 115:299–302, 1983) located within two sites where most of the bark beetle population had been removed by sanitation cutting, and in another site that received little control but contained a resident beetle population.

One bait (M/tV/eB) consisted of the host tree monoterpene, myrcene (M), and two beetle-produced compounds, *trans*-verbenol (tV) and *exo*-brevicomin (eB), released at laboratory-determined rates of 17,1, and 0.5 mg/day, respectively (Conn et al. ibid). The second bait consisted only of myrcene and *trans*-verbenol (M/tV), but with the same release rates.

Ten plot sites with dominant mature lodgepole pine trees were selected. Plots 1 to 3 were within the general area where control treatment (by cutting and burning of infested trees) was considered nearly complete. Plots 4 and 5 were in a second control area, from which most infested trees were removed. Plots 6 to 10 were located in a separate valley where little control work had been done.

At each site the positions for three multiple funnel traps and three lodgepole pines of above-average diameter (Table 1) were approximately 50 m apart in a rectangular pattern. The choice of bait for each trap or tree and baited trap and tree positions along a transect were decided randomly so that each plot site contained:

- three traps, one baited with M/tV, one with M/tV/eB, and the other an unbaited control
- three trees, one baited with M/tV, one with M/tV/eB, and the other an unbaited control

TABLE 1

Diameters and *Dendroctonus ponderosae* attack densities on baited and adjacent unbaited lodgepole pine trees.

	M/tV-baited	M/tV/eB-baited	Control (unbaited)
Avg. diameter (cm)	34.3(10)[a]	36.9(10)	36.4(10)
Proportion of trees attacked in 1982	6/10	10/10[b]	0/10
Avg. attack density (m^2/tree)	39.6	51.6[c]	—
No. attacked trees within 10 m of baited trees	17	23	0
Avg. diameter (cm) of attacked trees adjacent to baited trees	28.5(14)	29.7(9)	0
Avg. attack density/m^2/tree of trees adjacent to baited trees	32.8(14)	35.0[d](9)	0

[a] Numbers in brackets indicate number of trees used in computing average or in t–test comparisons.
[b] Difference in proportion attacked significant; Chi-square test, $p < 0.05$.
[c] Means significantly different at $p < 0.01$.
[d] Means not significantly different, $p > 0.05$.

Baits were suspended at mid-height within the funnel traps. Each trap hung freely from a 1.5 m stake driven into the ground. On all trees baits were placed on the north aspect of stems, about 1.5 m above ground and within small aluminum envelopes nailed to the tree (Borden et al., 1983a, ibid).

The experiment was initiated July 16 and terminated August 31, 1982, when all beetles caught in the traps were counted and preserved for sex determination. All baited trees were examined at the end of August for new (1982) mountain pine beetle attacks. Attack density was counted within two 20 × 40 cm areas of bark surface, centered at bait-attachment height on north and south aspects of the tree, and expressed as number of beetle strikes/m^2 of bark surface per tree. In addition, the numbers of 1982 beetle-attacked trees, mostly within a 10-m radius of each baited tree and trap, were also tallied, and attack densities on trees within a 5-m radius were estimated as on baited trees.

All 10 trees baited with M/tV/eB and 6 of the 10 trees baited with M/tV were attacked by *D. ponderosae*, while no attack was observed on any of the 10 control trees. One of the M/tV-baited trees had only one new attack. Mean attack density of the six attacked M/tV-baited trees was 39.6/m^2, significantly less (t−test; $p < 0.01$) than the 51.6/m^2 recorded on M/tV/eB-baited trees (Table 1). These results indicate that beetles were more strongly attracted to M/tV/eB-baited trees than to M/tV-baited trees, similar to those results obtained from British Columbia (Borden et al. 1983a, ibid.).

Average density of beetle attacks on trees adjacent to each of the two bait formulations was tallied separately. The densities on trees adjacent to the two bait formulations were not statistically different from each other, but were both less than densities on the respective baited trees (Table 1). However, densities on those trees adjacent to the M/tV baits and those adjacent to M/tV/eB baits did not differ significantly ($p > 0.20$ and $p > 0.10$, respectively) from the respective densities on M/tV-baited and M/tV/eB-baited trees.

Twenty-three trees, attacked in 1982 were observed within a 10-m radius of the M/tV/eB-baited trees and 17 around the M/tV-baited trees. Thus both types of baits influenced immigration and colonization by the beetles. Elsewhere in the vicinity of plots, 1982 attacks were observed on one recently fire-scorched tree near an M/tV/eB-baited tree in Plot 1, on two wind-blown trees some 15 m from an M/tV-baited tree in Plot 3, and on two trees 12−15 m from an M/tV-baited trap in Plot 6. Beetle attraction to these trees may have been influenced by factors other than the nearby baits. Within all plot areas there is evidence that the two bait formulations on trees influenced mass attacks (i.e., >31.2/m^2 of bark) on at least 50 trees, including both baited and adjacent unbaited trees. This result suggests that semiochemical baits could be used effectively within the park to help contain infestations (Borden et al. 1983b, ibid). Comparison between controlled and uncontrolled areas indicates that the average number of trees per plot apparently influenced by baited trees was 1.3, 1.0, and 9.2, respectively, for plots 1 to 3, 4 and 5, and 6 to 10. These data correlate well with the relative population levels within the three general areas, and corroborate the results of Borden et al. (1983c, ibid), that demonstrated that baited trees can be used to assess the effectiveness of silvicultural controls and to mop up residual infestations.

In comparison to the baited trees, baited traps collected relatively few mountain pine beetles (Table 2), and variability between plots and bait formulations was considerable. One explanation is that the baited trees, with subsequent enhancement from mass attacks, provided a stronger attraction than baited traps and attracted beetles away from the traps. Additionally, the concentration of chemicals on attacked baited trees may have varied from that in baited traps because of natural release of host odors; the beetles may also have oriented more strongly to the tree silhouettes.

TABLE 2

Numbers and sex of *Dendroctonus ponderosae* captured in funnel traps baited with two semiochemical formulations.

	No. beetles captured	
Treatment	Males	Females
M/tV	83	31
M/tV/eB	17[a]	24
Control	0	0

[a] Number of males attracted to M/tV/eB significantly less (t−test, $p = 0.05$) than to M/tV.

The numbers of female beetles caught with the two bait formulations are similar (Table 2) while the numbers of males caught in M/tV/eB-baited traps were significantly less (t−test; $p < 0.05$) than the numbers caught in M/tV-baited traps. This reduction in numbers of males may have resulted from an inhibitory effect of *exo*-brevicomin (Ryker and Rudinsky, J. Chem. Ecol. 8:701−707, 1982; H. Wieser, E.A. Dixon, and H.F. Cerezke, 1982, unpublished report). The data, however, are somewhat contradictory to those of Conn et al. (1983 ibid), which indicated that *exo*-brevicomin had no apparent affect on males but rather enhanced the response of females.

The results of this study demonstrated that the M/tV/eB bait formulation influenced a greater number of attacked "trap trees", each with higher (about 30% more) average attack densities than did the M/tV bait formulation. Thus the trap trees, in addition to the large numbers of attacked adjacent unbaited trees, suggest a useful method to focus large numbers of beetles within designated areas for efficient subsequent sanitation control. The M/tV/eB bait shows the best potential to maximize the numbers of attracted beetles and should therefore be used in any future mountain pine beetle control programs.

FOREST DESCRIPTION AND MENSURATION

Dimensional Relationships for Several Tree Species from the Spruce-fir Forest Types of Northwestern Ontario

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Over 3 million hectares of Ontario's productive forest lands are classified in the spruce-fir forest types. A spruce-fir forest stand is at least 60% coniferous by volume (mainly white spruce (*Picea glauca* (Moench) Voss), black spruce (*P. mariana* [Mill.] B.S.P.), and balsam fir (*Abies balsamea* [L.] Mill.). Forty percent or less is hardwood, essentially white birch (*Betula papyrifera* L.), balsam poplar (*Populus balsamifera* L.), trembling aspen (*Populus tremuloides* Michx.), and other species. The gross volume of these cover types is estimated at about 700 million m^3. At present, the annual harvest is below the calculated allowable cut for these forest types. However, as wood supplies diminish in Canada and as forests are used more and more for recreational purposes, greater demands will be placed on the spruce-fir forest types in Ontario.

Because of the complexity of the spruce-fir forest types and a lack of research resources, very little information is available about the extent, species composition, growth, yield, and other mensurational characteristics of these types. Such information is essential in the determination of management potential; hence, a preliminary assessment was undertaken to provide basic mensurational information. This note presents dimensional relationships for the principal tree species of the spruce-fir forest types of northwestern Ontario. Knowledge of such relationships is essential for growth and yield studies and simulation modelling.

Measurements were taken from 526 trees on 193 semipermanent growth plots established from 1970 to 1974 at three main locations: the Black Sturgeon Lake area northeast of Thunder Bay, the Beardmore area north of Nipigon, and the Searchmont area north of Sault Ste. Marie. All plots were located within stands 2 ha in area or larger without significant gaps in the canopy. The plots covered a wide range of stand ages, species composition, densities, and site indexes. Most of the sample trees were dominants and codominants. A few trees were from the intermediate crown class. It is believed that all trees were of natural origin.

Tree diameter (DBH) was measured to the nearest 2.5 mm with a diameter tape. Total tree height (HT) was measured to the nearest 30 cm with sectional measuring poles for trees less than 10 m and a Spiegal relascope for taller trees. Crown diameter (CD) was estimated to the nearest 30 cm. Crown length (CL), the distance from the tip of the tree to the general level of live branches, was also measured to the nearest 30 cm, with either a height-measuring pole or a Spiegal relascope. Tree age (A) was determined from increment borings taken at 30 cm stump height. Total (TV) and merchantable (MV) tree volumes were calculated according to Honer's (Can. Dep. For. Rur. Devel., Ottawa, Ont. Inf. Rep. FMR-X-5, 1967) tree volume equations. Merchantable volume was based on a stump height of 15 cm and a minimum top diameter of 7.5 cm. Plot site indexes were calculated on the basis of existing site index equations (Payandeh, Can. For. Serv. Bi-mon. Res. Notes 33:37 – 39, 1977) for important Canadian timber species. When a site index equation for a species was not available, an equation for another species similar in growth pattern was employed, for example, the site index equation for balsam poplar was used for both trembling aspen and balsam poplar. The site index for an average plot was calculated and assigned to each of the two or three trees within that plot used for dimensional relationships.

Table 1 provides a statistical summary of species for which data on 30 or more trees were available. Nonlinear regression analysis was employed to establish dimensional relationships for white spruce, black spruce, balsam fir, balsam poplar, and white birch. Model forms were similar to those employed earlier (Payandeh, Can. For. Serv. Bi-mon. Res. Notes 34:11, 1978) for peatland black spruce (Table 2). Inclusion of site index in the later models improved the fits significantly in nearly all cases. In each case plotting of residuals against predicted and independent variable(s) was examined carefully to detect unexpected trends, outliers, and variance heterogeneity. In a few cases, weighting would have improved the fit slightly, but not significantly, and hence was not employed to maintain model uniformity across the species. The final equations were chosen on the basis of their values of R^2, standard errors, % bias, and functional forms. Table 2 gives the regression models used for various dimensional relationships. The resulting parameter estimates along with values of R^2, standard error, and % bias for different species and dimensional relationships are given in Table 3. These equations will provide preliminary but essential mensurational information for further growth and yield studies of the spruce-fir forest type in Ontario.

I would like to thank G. Kubik for his patience in doing the numerous regression runs required for this analysis.

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research notes

Calibration for the Spray System on a Four-Engine DC-4G Aircraft for Dispersing *Bacillus thuringiensis*

* Field Tests with Semiochemicals for the Mountain Pine Beetle in the Cypress Hills, Alberta CEREZKE, BORDEN [illegible]

Dimensional Relationships for Several Tree Species from the Spruce-fir Forest Types of Northwestern Ontario

Temperature Effects on Pilodyn Pin Penetration

Individual Rearing of Spruce Budworm Larvae

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