EFFECT OF HIGH DENSITY FRONTALIN BAITING ON ATTACK DISTRIBUTION OF *DENDROCTONUS RUFIPENNIS* IN SPRUCE PLOTS

E. D. A. DYER[1] AND P. M. HALL[2]
Environment Canada
Canadian Forestry Service
Pacific Forest Research Centre
506 West Burnside Road
Victoria, B.C. V8Z 1M5

ABSTRACT

Intensive baiting with frontalure (33% frontalin and 66% alpha-pinene) was found to affect the distribution of spruce beetles, *Dendroctonus rufipennis* (Kirby), among available hosts. In treated plots 23 to 63% of the beetle attacks were found in standing trees potentially capable of resisting gallery establishment, compared with less than 1% in check plots. All suitable freshly downed trees were attacked in treated and check plots but the attack densities were significantly lower in two of the three treated plots as compared with their checks. Frontalure capsules placed on the ground at various distances from standing trees failed to induce attack.

RESUME

Les auteurs ont constaté qu'un appâtement intensif à l'aide de frontalure (33% frontaline et 66% alpha-pinène) influait sur la répartition des dendroctones de l'épinette, *Dendroctonus rufipennis* (Kirby), entre les hôtes disponibles. Dans les parcelles traitées, de 23 a 63% des attaques ont été observées dans les arbres sur pied potentiellement en mesure de résister a l'etablissement de galeries, comparativement à moins de 1% dans les parcelles témoins. Tous les bois récemment abattus ont été attaqués dans les parcelles traitees et témoins, mais la densité des attaques est significativement plus faible dans deux des trois parcelles traiteés par rapport à leurs témoins. Les capsules de frontalure posées sur le sol à diverses distances d'arbres sur pied n'ont pas induit d'attaques.

INTRODUCTION

The spruce beetle, *Dendroctonus rufipennis* (Kirby), periodically kills large volumes of mature spruce (*Picea glauca* Moench) Voss, *P. engelmannii* Parry) in western North America (Massey and Wygant 1954; Wood 1963). This bark beetle aggregates at spruce billets in response to pheromones produced by the first females entering the bark (Dyer and Taylor 1968). Synthetic frontalin, a pheromone of the southern pine beetle, *D. frontalis* Zimm. (Kinzer *et al.* 1969), was shown to induce spruce beetle attack on spruce trees (Dyer and Chapman 1971).

Windthrown trees are nearly always infested by spruce beetle in spruce stands with endemic beetle populations but standing trees are seldomly attacked. However, in such stands, frontalin baiting of standing trees will induce beetle attack even though tree resistance usually cannot be overcome (Dyer and Safranyik 1977). Baited trees, then, usually become lethal traps for beetles which would otherwise seek out windthrown trees for attack and successful brood production. Under epidemic conditions baited trees are attacked, often successfully, although tree resistance is variable (Dyer 1973, 1975).

Spruce forests contain varying amounts of susceptible windthrown material which is the preferred host of spruce beetle. Thus, in considering the use of pheromone-baited trees for beetle population management, it is necessary to know what percentage of the population is caught in the lethal traps.

About 4% of an endemic spruce beetle population was estimated to have attacked pheromone-baited trees while about 96% infested windthrown trees in an experiment using 100 randomly selected, frontalin-baited spruce trees scattered throughout a 766 ha spruce forest. Although the attack density was similar in standing baited trees and windthrown trees, the beetles attacked only the lower boles of the standing trees, but infested the entire surface of the more numerous fallen trees (Dyer and Safranyik 1977). From the same study, it was estimated that 34 baited trees per windthrown tree would capture 90% of the population in the baited trees in which the beetles could not reproduce.

[1]Research Scientist, Retired.

[2]Present Address: British Columbia Ministry of Forests, Protection Branch, 1450 Government St., Victoria, B.C. V8W 3E7.

The present paper reports the distribution of attacks by endemic spruce beetle populations in windthrown and standing trees when stands were baited with pheromone at a higher density than was used by Dyer and Safranyik in 1977.

METHODS

In 1975, paired plots of 4.05 ha, 100 m apart in mature spruce stands were replicated three times in different parts of the Naver Forest near Prince George, British Columbia. Most of the six plots contained one or more uninfested winter-windthrown spruce trees but, where required, other trees were felled to provide each pair of plots with similar bark-surface areas of downed trees (Table 1). Stand composition data are also shown in Table 1. One plot, selected at random from each pair served as a check and the other was treated by attaching pheromone capsules at breast height on one hundred spruce trees at grid intervals of 20 m throughout the plot. Additionally, one capsule was placed on the ground at the centre of each grid, approximately 14.1 m from each baited tree. The capsules were polyethylene tubing, 1 cm (OD) x 6.5 cm, sealed at both ends, containing ½ ml frontalure (33% frontalin, 67% alpha-pinene).

After beetle flight and attack, the plots were cruised and beetle entrances were counted on all standing trees. The attacks on windfall trees were estimated by counting entrance holes in 20.3 x 25.4 cm samples of bark selected randomly on the bark surface of the tree. Depending on the length of the windfall, 8 or 12 samples per tree were taken. Population estimates are presented (Table 2 and 3) as numbers of females since they are based on estimates of entrance holes. Infested bark surface area was calculated for each of the infested standing trees and windfalls (to a 15 cm top diameter) by the following method:

1) infested standing trees:
   π x dbh x maximum infested height

TABLE 1. Plot description data for 3 pairs of Plots. One plot of each pair treated with frontalure[a] capsules at 20 m grid intervals.

		Standing Spruce ≥ 19.3 cm dbh			Downed spruce	
			dbh (cm)			Surface area
	Plot	No. trees	Mean	SE[b]	No. trees	(m^2)
1	Treated	966	47.1	1.5	4	59.5
	Check	911	45.8	4.57	5	70.4
2	Treated	881	42.7	1.14	2	32.8
	Check	707	42.2	1.85	2	29.1
3	Treated	724	43.4	0.81	3	50.2
	Check	940	36.8	0.90	5	49.1

a. Capsules of frontalure (33% frontalin, 67% alpha-pinene) attached to spruce tree boles.

b. Standard error.

TABLE 2. Spruce beetle attack distribution in pheromone treated and untreated plots.

Plot		Attacked standing trees				Downed trees	
		Number		Attacks/tree		Attack density/m^2	
		Baited	Unbaited	Mean	SD[a]	Mean	S E[b]
1	Treated	29	8	21.2	30.3	44.8	3.52
	Check	–	2	5.0	2.8	48.1	3.92
2	Treated	29	11	32.8	44.5	38.8[c]	3.62
	Check	–	1	5.0	–	75.9	5.92
3	Treated	49	23	21.1	28.4	18.3[c]	3.02
	Check	–	1	1.0	–	34.2	3.49

a. Standard Deviation

b. Standard Error

c. Treated and check differ at 0.05 level of significance (Mann-Whitney U Test.)

2) windfall:

$$\pi \times \frac{(\text{base diam} + \text{top diam (15 cm)})}{2} \times \text{length.}$$

The Mann-Whitney U test (Siegal, 1956) was used to determine differences in attack densities (Table 2).

A second experiment was carried out to determine whether or not pheromone capsules on the ground at various distances from spruce trees would induce beetle attack. Four replicates were established. Four trees with similar diameters and 20 m or more apart were selected in each replicate. In each group, a pheromone capsule was placed on the first tree 1.4 m above ground, on the ground within 1.5 m of the second tree, on the ground at 3.7 m from the third tree and no capsule near the check tree. After beetle flight, the trees were examined and all attack entrances were counted.

RESULTS

All windthrown and felled trees were attacked over the entire bole in both treated and untreated plots. However, in two of the three replicates the attack density in the treated plots was about half that in the check plots (Table 2).

Not all of the baited trees in the treated plots were attacked. Of the 100 baited trees in each treated plot, 29, 29 and 49 trees, respectively, were attacked. An additional 8, 11 and 23 unbaited trees also became attacked in the three treated plots (Table 2 and Fig. 1). The infested trees were attacked from near the base to a maximum height of 4 m. The attacks were occasionally dense but averaged from 21 to 33 per tree in various plots. In the check plots an average of only about four attacks per tree occurred on a total of four attacked standing trees (Table 2).

The distribution of the female beetle population based on the number of attack entrances is shown in Table 3. Female population totals within the plots were estimated by adding the attacks counted on standing trees and the calculated total attacks on windfall or felled trees. The estimated female population totals were similar in each pair of plots but more than 99% of the population in the check plots was in the felled trees, whereas in the treated plots from 37 to 77% of the beetles were in downed trees. Most of the rest of the attacks in the treated plots were on pheromone baited trees. The distribu-

TABLE 3. Estimated population levels of female spruce beetles in spruce forest plots of 4.05 ha (one plot of each pair treated[a] at 20 m intervals).

Plot		Female beetle population	% of population in felled trees
1	Treated	3450	77.3
	Check	3396	99.7
2	Treated	2585	49.2[b]
	Check	2214	99.8
3	Treated	2438	36.7[b]
	Check	1680	99.9

a. Capsules of frontalure (33% frontalin 67% alpha-pinene) attached to spruce tree boles.

b. Significantly ($p=0.05$) fewer attacks than in check plots.

TABLE 4. Beetle attacks per tree on four replicated groups each of 4 trees baited with pheromone capsules[a] placed on the boles and at various distances on the ground.

Position of capsule	Attacks per tree in each replicate			
On bole 1.4 m above ground	137	31	7	196
On ground 1.5 m from tree base	0	5	0	0
On ground 3.7 m from tree base	0	0	0	0
Control tree - unbaited	0	0	0	0

a. 33% frontalin 67% alpha-pinene in polyethylene capsules.

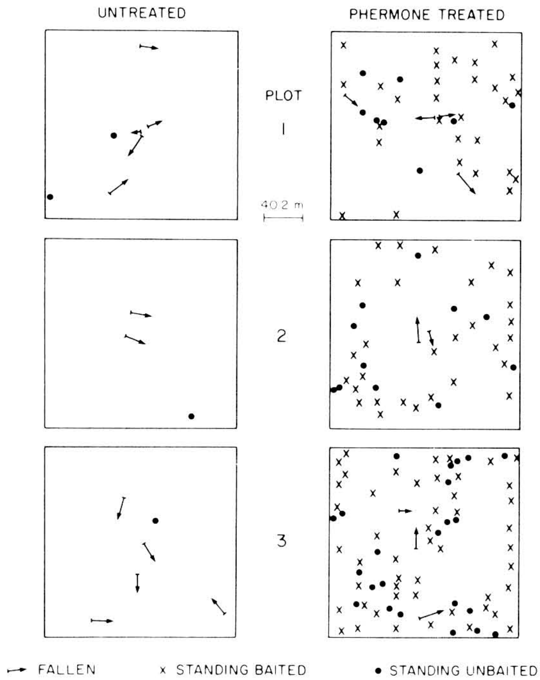

Fig. 1. Distribution of infested fallen and standing trees in check and pheromone-treated plot pairs.

tion of the infested standing and felled trees in the pairs of plots is shown in Figure 1.

Pheromone capsules placed on the ground in the treated plots were intended to increase the level of pheromone in the plots and aid in confusion such that naturally attractive downed trees would not be found by the attacking beetles. The effect of pheromone placed on the ground between baited trees in the treated plots could not be determined from the attack distribution. However, as shown by the results of the second experiment (Table 4) only capsules attached to the boles of trees induced any significant attack. When unbaited trees were infested, they were usually adjacent to densely attacked baited trees where naturally produced pheromones could also affect attack behavior. The poor attractiveness of the ground-based pheromone may be due to the absence of necessary host-produced volatiles which would act as synergists to the synthetic frontalin mixture. The host volatiles would be in addition to the alpha-pinene included with the frontalin in the capsules.

DISCUSSION

Frontalure capsules, attached to spruce trees on a 20-m grid in forest plots, attracted part of the endemic spruce beetle population into potentially resistant standing trees. However, the remaining population in suitable hosts such as windthrown and felled trees would provide a continuing beetle hazard for future years.

Dispensing larger amounts of attractant in the forest might confuse the beetles so that they could not find scattered hosts such as windthrown trees. However, in the treated plots from 37 to 77% of the beetles found and infested the felled trees despite the density of pheromone capsules used in this experiment. Baiting at even greater densities would be costly over large areas and would be impractical to apply to large numbers of individual trees. Aerial application of pheromone dispensers is likely to be ineffective, at present, as indicated by the poor beetle response to ground-based pheromone release. An improved pheromone complex, incorporating the required host tree volatiles, may make this strategy practical for spruce beetle. Currently, however, the precise pheromone complex for spruce beetle is not known.

It should be emphasized that baited standing trees cannot always be expected to show a high degree of resistance to beetle attack and thus may not cause brood failure. This could, in some circumstances, increase a beetle problem. If this technique is used, treated stands should be harvested and processed prior to the next beetle attack period. For the present, it would be best to look for more efficient methods of attracting beetles to insecticide-treated, pheromone baited trap trees and to practise better forest management to reduce or remove windthrown trees in which the beetles breed so abundantly.

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