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TESTING THE EFFICACY OF VERBENONE IN REDUCING MOUNTAIN PINE BEETLE ATTACKS IN SECOND-GROWTH PONDEROSA PINE

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Abstract

"Standard" and "new," 5-gram verbenone pouches were placed in a grid throughout one-acre treatment plots in a second-growth ponderosa pine stand on the Helena National Forest (NF). Lower than anticipated mountain pine beetle (MPB) populations resulted in difficult-to-assess treatment affects; however, it appeared there were differences in the behavior of the two pouches. By replacing the standard pouch midway through beetle flight, we achieved a treatment affect different from both the new pouch and controls. Latter two treatment affects were similar. Additional testing will be required of the new pouch before we can conclude its elution period is significantly longer, and more effective, than the standard.

Introduction

Mountain pine beetle (*Dendroctonus ponderosae* Hopkins) is the most destructive bark beetle in western North America. It is capable of killing most pine species over large areas throughout its range from Canada to Mexico. In the Northern Region alone, from the 1960's to the mid-1980's about 250 million host trees were killed on more than 3 million acres. While approximately 90% of those were lodgepole pines, a significant amount of ponderosa pines were also killed.

Management options for reducing mortality caused by MPB include changing stand conditions through silvicultural practices, beetle population manipulation with commercially available attractant pheromones, and removal of infested trees (Samman and others 2000). Individual protection of high value trees with chemical treatments is not practical on a large scale or in inaccessible areas. Because many areas of varied resource concerns preclude stand manipulations to reduce MPB-caused mortality, there has long been interest in evaluating the effectiveness of anti-aggregation compounds as tree or stand protectants.

Verbenone (4,6,6-trimethylbicyclo[3.1.1]hept-3-en-2-one), a semiochemical apparently produced by both male and female beetles, has exhibited

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promising anti-aggregative effects. In early tests, it was shown to inhibit the response of MPB (Ryker and Yandell 1983). When synthetically produced verbenone was added to funnel traps baited with MPB attractants (*trans*-verbenol, *exo*-brevicomin, and myrcene), beetle catches were reduced significantly from traps with attractant alone (Borden and others 1987, Miller and others 1998, Schmitz and McGregor 1990).

Field tests conducted during the late-1980's, however, using commercially available 0.5-gram verbenone bubble capsules (Phero Tech, Inc.) in an effort to protect stands from MPB attack were inconsistent (Amman and others 1991, Amman and Lindgren 1995, Bentz and others 1989, Gibson and others 1991, Shore and others 1991). In recent years, similar studies using 5-gram verbenone pouches, which release 10 times the amount of verbenone as bubble capsules, have shown promising results (Bentz, and others, 2004; Progar 2003; Borden, and others, 2003).

Currently, MPB populations are at epidemic levels throughout the intermountain West. This is, therefore, an opportune time to test varying strategies—including new formulations of verbenone—for protecting high-value stands from MPB-caused mortality. Our objective in this test was to compare the effectiveness of a new, purportedly longer-lasting verbenone pouch (3 ml-thick membrane) with the standard (1.5 ml thickness), 5-gram pouch in protecting ponderosa pine stands from MPB attack.

Methods

The study site, a second-growth ponderosa pine stand on the Helena Ranger District (RD), Helena NF, was selected in June 2003 in an area not far from active MPB populations. Stands were predominantly ponderosa pine, with lesser amounts of Douglas-fir, aspen, and cottonwood in some plots. Although number of susceptible ponderosa pine varied somewhat from plot to plot, stocking was similar in most. Stocking varied from a low of 69 square feet per acre to high of 156; most—14 of 18 plots—were between 100 and 143 square feet per acre (Appendix, Table 1). A randomized block design, replicated 6 times, was used to test for differences among treatments. Each block consisted of three 1-acre plots separated by at least 2.5 chains (165 feet).

Each plot in a block received one of three treatments: 1) control (no pouches), 2) "standard" 5-gram verbenone pouch, and 3) "new" verbenone 5-gram pouch. Both pouches were made by Phero Tech, Inc.; but had been manufactured with differing membrane thickness, the intent being to produce different elution rates and periods. The "standard" pouch (membrane thickness 1.5 ml) was formulated to elute over a 25-40 day period. The "new" pouch (membrane thickness 3.0 ml) was anticipated to have a longer, 60-90 day, elution period. Treatments were randomly assigned to each plot within a block. For "new" verbenone treatments, 40 pouches were placed within each plot on a 0.5- x 0.5-chain (33 feet) grid. Earlier tests had concluded there was no significantly different treatment affect between 20 and 40 standard pouches per acre (Bentz, and others, 2004). Therefore, in the "standard" treatment, 20 pouches were placed in each plot on an approximate 45- x 45-feet grid. Individual pouches were stapled to the north side of the tree nearest intersecting grid point, about 6 feet from the ground.

In an attempt to assure equal beetle pressure in each plot, we placed a Lindgren funnel trap, baited with standard MPB pheromone lures (PheroTech, Inc), at the center of each plot. All compounds and baited funnel traps were installed on June 23-24, prior to beetle flight. Because of their registered elution period of 25-40 days, "standard" pouches were replaced at the end of July.

In order to evaluate elution periods of both pouches, we placed six of each on a tree outside the test area, but close enough for environmental conditions to be similar. One of each type pouch was removed at 2-week intervals, quickly placed in a freezer, then analyzed for content at the end of the season. Close by, we also installed a "Hobo" temperature-recording device to help us correlate pouch elution with daily temperatures in the area.

Following beetle flight (September 15-16), all trees equal to or greater than 5 inches diameter-at-breast-height (d.b.h.) were tallied. For each tree, we recorded d.b.h., species, and infestation status. Status categories included: 1) live tree, 2) 2003 MPB "mass" attack, 3) 2002 MPB "mass" attack, 4) 2003 MPB "strip" attack, and 5) 2003 "unsuccessful" MPB attack (Appendix, Table 2).

Data Analysis

For data analysis, trees were regarded as "attacked" (including 2003 mass attacks and 2003 strip attacks), or "not attacked" (including unattacked and unsuccessfully attacked trees). Those were variables associated with treatment (control, "standard" pouch, "new" pouch) affects. Tree d.b.h., species, and stand stocking were variables not affected by treatments.

The Univariate analysis of variance was used to detect treatment affects. The ratio of the number of successfully attacked trees to the total number of possible trees to be attacked was the criteria of these analyses. Data were transformed using the arc sin of the square root of the proportion to satisfy requirements of the test. Differences between treatments were tested using the Least Significant Difference (LSD) test.

Results and Discussion

Verbenone Effectiveness:

Individual plots within the study site represented a range of host availability and stand density (Appendix, Tables 1 and 2). MPB populations, as measured by the number of infested trees in 2002, were found in only three plots; and in hindsight, perhaps were not adequate for the purposes of our evaluation. New (2003) attack rates in all plots were low; however, despite low numbers of successful attacks; significant differences did occur between treatments.

While the "standard" verbenone treatment significantly reduced the number of beetle-attacked trees (2 [0.19%]) compared to controls (14 [1.78%]) and "new" verbenone treatment (16 [2.19%]) ($p=0.05$); MPB attacks in the "new" verbenone treatment plots were actually higher (although not significantly) than in controls. Still, numbers of new attacks in combined treatments (32 in 18 plots) were sufficiently low that we are less confident in the meaningfulness of treatment affects.

Basal area calculations (Table 1) revealed substantial differences in plot density. Plots with "standard" pouches averaged 101 square feet per acre basal area, plots with "new" pouches 124, and control plots 134. The plots with the most new attacks (5 each) were two of the more densely stocked. Plot #11 had basal area of 142 while basal area of plot #12 was 146. Had beetle populations been higher, those analyses may have been significant. As it was, all new attacks were found within about ten feet of the baited funnel trap. That would seem to negate any influence associated with stand density.

Pouch Analysis:

Pouch analysis (John Borden, Phero Tech, personal communication) showed differences in residual verbenone and elution rates over time (Table 3).

Analysis showed the standard pouch released a higher amount of verbenone per day, which appears to have resulted in a shorter elution period. In addition, pouch analysis indicated, in the field, virtually no verbenone was eluted below a residual amount of 2 grams. That does not occur in the laboratory, and is somewhat perplexing to Phero Tech chemists (John Borden, personal communication). That being the case, standard pouches would have ceased releasing verbenone by about mid-August—before beetle flight was over. That would lend credence to our supposition that standard pouches should be replaced after several weeks in the field; and might also explain why we seemed to have better results in this test with the standard pouch—which was replaced at mid-season

Table 3. Residual Verbenone and Calculated Elution Rate, June 24-August 26, 2003. (Pouches contained 4.65 grams verbenone when installed.)

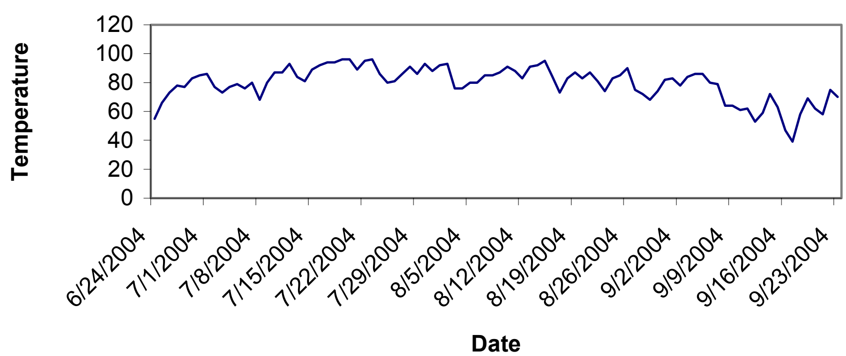
Date (placed June 24, 2003)	Residual Verb. New (gms)	Residual Verb Std (gms)	Elution rate New (mg/day)	Elution rate Std (mg/day)
8 July	4.44	4.05	15	43
22 July	3.83	2.92	43	80
5 Aug	3.44	2.39	28	38
16 Aug	3.01	1.81	39	53
26 Aug	2.93	1.90	8	0*

*Indicates pouch had ceased eluting verbenone

Temperature Recordings:

Data readings from the "Hobo" temperature recorder showed unusually high daily maximum temperatures for the test period (Figure 1). Seventeen days were 90 degrees or higher; 36 were 85 degrees or higher. We believe these atypical conditions may have been responsible for the relatively short elution period

Figure 1. Daily Maximum Temperature 24 June - 23 September



experienced by the "standard" pouch, and why we got better results with pouch replacement in those plots.

Conclusion

In hindsight, MPB populations were marginally low to conduct the 2003 test in the area we did. However, beetle response to treatments suggested the "standard" pouch, with replacement, provided better tree protection than a single application of the "new" pouch.

Temperature recordings also suggested unusually high temperatures during July and August may result in shorter than anticipated elution periods from either pouch. Presently, it appears neither pouch, in a single application during a warmer-than-normal year, can provide adequate protection for the period typically experienced for MPB flights in ponderosa pine stands in our Region (mid-July to late-August). Our data suggested for low-elevation, warmer sites, protection from MPB attacks may be achieved using the standard 5-gram verbenone pouch; but in warmer years, it would have to be replaced after 5-6 weeks in the field.

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Appendix

Table 1. Stand Characteristics of Test Plots

Plot	Pre-Test Green PP ≥ 5" d.b.h.	Average d.b.h.	Other spp. ≥ 5" d.b.h.	Live BA per Acre	Live Trees per Acre	2002 MPB Attacks
1	205	11.0	8	141	213	5
2	166	11.1	16	122	182	0
3	162	10.1	56	125	218	0
4	146	11.2	84	143	230	0
5	174	10.0	98	82	272	0
6	119	9.2	102	112	221	2
7	68	12.0	33	69	101	0
8	97	14.6	24	128	121	0
9	169	11.7	22	142	191	0
10	143	13.2	40	156	183	0
11	118	13.3	50	143	168	0
12	121	14.1	16	146	137	0
13	89	13.8	17	101	106	0
14	102	12.9	20	114	122	0
15	59	14.0	86	123	145	0
16	116	12.7	9	109	125	1
17	105	12.9	19	111	124	0
18	110	11.8	8	90	118	0

Table 2. Verbenone Test Results (All Plots)

Plot Number	Treat-ment	PP ≥ 5" Not Attacked	Mass Attack	Strip Attack	Pitchout	2002 Attack (Faders)	Percent 2003 Attack
1	Control	194	2	0	9	5	0.97
2	Standard	164	1	0	1	0	0.60
3	New	159	0	0	3	0	0
4	Control	142	1	0	3	0	0.68
5	Standard	172	1	0	1	0	0.57
6	New	111	4	0	4	2	3.36
7	Standard	68	0	0	0	0	0
8	Check	94	2	0	1	0	2.06
9	New	163	2	1	3	0	1.78
10	Control	138	4	0	1	0	2.79
11	New	111	5	0	2	2	4.23
12	Control	114	5	0	2	0	4.13
13	Standard	89	0	0	0	0	0
14	New	102	0	0	0	0	0
15	Standard	59	0	0	0	0	0
16	Standard	110	0	0	6	0	0
17	New	97	3	1	4	0	3.80
18	Control	110	0	0	0	0	0

Table 2a. Test Results: Control Plot Averages

Plot Number (C)	Green PP ≥ 5" d.b.h.	Total Trees per Acre	2003 Attacks	% 2003 Attacks
1	205	213	2	0.97
4	142	230	1	0.68
8	94	121	2	2.06
10	138	183	4	2.79
12	114	137	5	4.13
18	110	118	0	0
Average	132	167	2.33	1.78

Table 2b. Test Results: "Standard" Plot Averages

Plot Number (S)	Green PP ≥ 5" d.b.h.	Total Trees per Acre	2003 Attacks	% 2003 Attacks
2	166	182	1	0.60
5	174	272	1	0.57
7	68	101	0	0
13	89	106	0	0
15	59	145	0	0
16	116	125	0	0
Average	112	155	0.33	0.19

Table 2c. Test Results: "New" Plot Averages

Plot Number (N)	Green PP ≥ 5" d.b.h.	Total Trees per Acre	2003 Attacks	% 2003 Attacks
3	162	218	0	0
6	119	221	4	3.36
9	169	191	3	1.78
11	118	168	5	4.23
14	102	122	0	0
17	105	124	4	3.80
Average	129	174	2.67	2.19