# Comparison of a-pinene and myrcene on attraction of mountain pine beetle, *Dendroctonus ponderosae* (Coleoptera: Scolytidae) to pheromones in stands of western white pine

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## ABSTRACT

Multiple-funnel traps baited with exo-brevicomin and a mixture of *cis*- and *trans*-verbenol were used to test the relative attractiveness of myrcene and (-)-a-pinene to the mountain pine beetle, *Dendroctonus ponderosae* Hopkins, in a stand of western white pine, *Pinus monticola* Dougl. Traps baited with myrcene caught significantly more *D. ponderosae* than traps baited with (-)-a-pinene, irrespective of the presence of *exo*-brevicomin. exo-Brevicomin was attractive to *Thanasimus undatulus* (Say) (Coleoptera: Cleridae) whereas *Trypodendron lineatum* (Olivier) (Coleoptera: Scolytidae) was attracted to (-)-a-pinene. Our results support the use of myrcene in commercial trap lures and tree baits for *D. ponderosae* in stands of western white pine in British Columbia.

Key words: Scolytidae, *Dendroctonus ponderosae*, kairomones, *Pinus monticola*, *Trypodendron lineatum*, Cleridae, *Thanasimus undatulus*

## INTRODUCTION

The mountain pine beetle, *Dendroctonus ponderosae* Hopkins (Coleoptera: Scolytidae), has killed over 500 million lodgepole, *Pinus contorta* var. *latifolia* Engehn., ponderosa, *P. ponderosa* P. Laws. and western white pines, *P. monticola* Dougl. (Pinaceae) in British Columbia over the past 80 years (Unger 1993). The current integrated pest management program for *D. ponderosae* in BC (Maclauchlan and Brooks 1994) is cost-effective, with positive economic, social and environmental impacts (Miller *et al.* 1993).

Semiochemicals play an important role in several tactics within the program (Maclauchlan and Brooks 1994). Population levels and flight periods of *D. ponderosae* are monitored with multiple-funnel traps baited with commercial lures consisting of the pheromones, exo-brevicomin and *cis*- and *tram-verbenol*, and the kairomone, myrcene (Stock 1984; Maclauchlan and Brooks 1994). The spread of infestations has been curtailed by the application of commercial tree baits consisting of the same semiochemicals (Borden and Lacey 1985; Borden *et al.* 1986) or simply the pheromones, exo-brevicomin and *cis*- and *tram-verbenol* (Borden *et al.* 1993).

Semiochemical blends for these commercial lures and baits were developed in stands of lodgepole and ponderosa pine rather than western white pine, and discrepancies exist concerning the most appropriate kairomone. The host compound a-pinene was more effective than myrcene in enhancing attraction of *D. ponderosae* to trans-verbenol in stands of western white pine in Idaho (Pitman 1971). Myrcene was more effective than α-pinene in increasing attraction of *D. ponderosae* to pheromones in stands of ponderosa

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pine (Billings *et al.* 1976) and lodgepole pine (Borden *et al.* 1983; Conn *et al.* 1983). In lodgepole pine stands, catches of ***D. ponderosae*** in pheromone-baited traps exhibited a dose-dependent increase to both myrcene and 3-carene whereas a-pinene had no effect (Miller and Borden 2000).

Our objective was to verify the effectiveness of myrcene, relative to a-pinene, in commercial lures for ***D. ponderosae*** in stands of western white pine. Specifically we attempted to compare the response of beetles to pheromones in traps baited with a-pinene to those baited with myrcene. Our expectation was that myrcene would be as effective as a-pinene in attracting ***D. ponderosae.***

## MATERIALS AND METHODS

**Semiochemical-Releasing Devices.** Phero Tech Inc. (Delta, British Columbia) supplied polyethylene bubble-cap lures containing a 13:87 mixture of ***trans-*** and *cis*-verbenol [both chemical purities 98%; both enantiomeric compositions 83:17 (-):(+)], (±)-*exo*-brevicomin polyurethane flex lures (chemical purity >98%), and separate closed, low-density polyethylene bottles (15 mL) containing either a-pinene [chemical purity >98%; enantiomeric composition > 99% (-)] or β-myrcene (chemical purity > 98%). The verbenols were released at a combined rate of approximately 1.74' mg/d at 24 °C (determined by weight loss) whereas a-pinene and myrcene were released at approximately 413 mg/d and 281 mg/d at 24-28 °, respectively (determined by weight loss). *exo*-Brevicomin was released at approximately 0.1 mg/d at 24 °C (determined by collection of volatiles) (Phero Tech Inc.).

**Experiments.** Two experiments were conducted in a mature stand of western white pine with approximately 15% of live trees infested ***by D. ponderosae*** near Barriere, British Columbia (51°10'N, 120°8'W). In both experiments, forty S-unit multiple-funnel traps (Lindgren 1983) (Phero Tech Inc.) were set 10-15 m apart, and ≥ 2m from any tree, along two parallel transect lines spaced approximately 20 m apart. Each trap was suspended between trees by rope such that the top funnel of each trap was 1.3-1.5 m above ground.

In Experiment 1, the effect of a-pinene and myrcene on the attraction of ***D. ponderosae*** to traps baited with the verbenol mix was determined, with and without exo-brevicomin. All traps, baited with the verbenol mix, were set on 1 August 1990. The following treatments were randomly assigned to 10 traps each: (1) a-pinene; (2) myrcene; (3) a-pinene and *exo*-brevicomin; and (4) myrcene and exo-brevicomin. Experiment 1 was terminated on 25 August 1990.

Experiment 2 tested the interaction between a-pinene and myrcene on the attraction of ***D. ponderosae*** to traps baited with exo-brevicomin and the verbenol mix. All traps, baited with the verbenol mix and exo-brevicomin, were set on 25 August 1990. The following treatments were randomly assigned to 10 traps each: (1) no kairomone control; (2) α-pinene; (3) myrcene; and (4) a-pinene and myrcene. Experiment 2 was terminated on 12 September 1990.

Catches of ***D. ponderosae*** and serendipitous catches of *Trypodendron* ***lineatum*** (Olivier) (Coleoptera:Scolytidae) and ***Thanasimus undatulus*** (Say) (Coleoptera: Cleridae) were tallied for each treatment. ***Sexes*** of ***D. ponderosae*** captured in Experiment 2 were determined by dissection and examination of genitalia. Voucher specimens were deposited at the Entomology Museum, Simon Fraser University, Burnaby, BC.

**Statistical Analyses.** Trap catch data were analysed by 2-way ANOVA using the SYSTAT statistical package version 8.0 (SPSS 1998). The model factors in Experiment 1 were exo-brevicomin, monoterpenes (a-pinene or myrcene), and the interaction between exo-brevicomin and monoterpenes. In Experiment 2, the model factors were a-pinene, myrcene and the interaction of a-pinene and myrcene. Catches of ***D. ponderosae*** were transformed by ln(Y) to remove heteroscedasticity whereas catches of ***Thanasimus undatulus*** and ***Trypodendron lineatum*** were transformed by ln(Y+l) due to zero catches in some treatments. Sex ratio data, expressed as percentage of males in catches, from Experiment 2 were transformed by arcsine(Y). Fisher's least significant difference (LSD) multiple range tests were performed when $P < 0.05$.

## RESULTS AND DISCUSSION

Our results clearly support the retention of myrcene in commercial lures for ***D. ponderosae*** in stands of western white pine. Catches of ***D. ponderosae*** were significantly higher in traps baited with myrcene than in traps baited with a-pinene (Figs. 1,2). *exo*-Brevicomin did not affect the preference of beetles for myrcene over a-pinene ($F_{1,36}$ = 0.605, $P$ = 0.442) in Experiment 1 nor was there any interaction between a-pinene and myrcene on catches of ***D. ponderosae*** ($F_{1,36}$ = 0.018, $P$ = 0.894) in Experiment 2. There was no significant difference in sex ratio among the treatments in Experiment 2 ($F_{3,19}$ = 2.232, $P$ = 0.12 1) with the mean (± SE) percentage of males in catches at 55 ± 3 %.

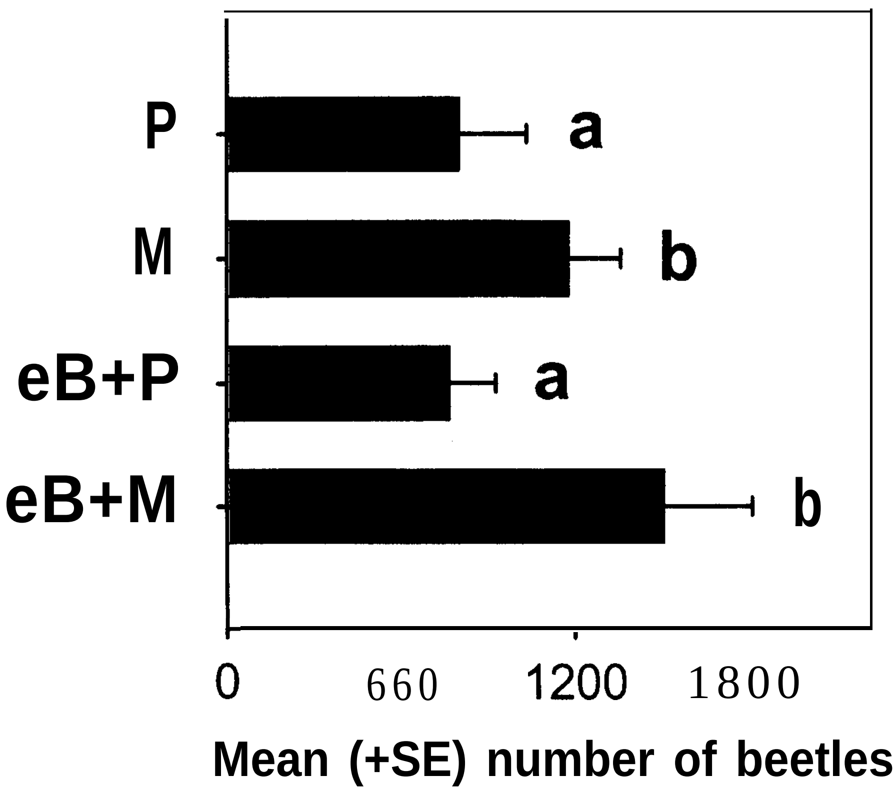


Figure 1. Effect of *exo*-brevicomin (eB), a-pinene (P) and myrcene (M) on the attraction of ***Dendroctonus ponderosae*** to verbenol-baited multiple-funnel traps from 1 August to 25 August 1990 ($n$ = 10). Means followed by different letters are significantly different at $P$ < 0.05 (LSD test).

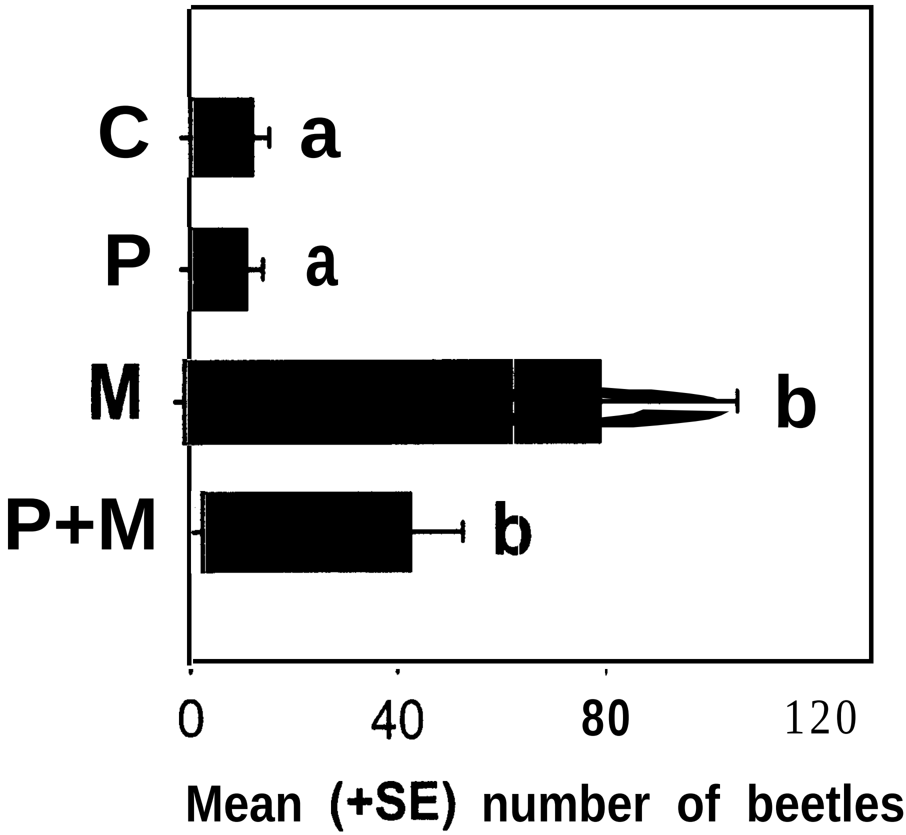


**Figure** 2. Effect of a-pinene (P) and myrcene (M) on the attraction of *ponderosae* to multiple-funnel traps baited with verbenols and exo-brevicomin from 25 August to 12 September 1990 (*n* = 10). Means followed by different letters are significantly different at $P < 0.05$ (LSD test); control (c).

Our results are inconsistent with those of Pitman (197 1) who demonstrated that α-pinene was more effective than myrcene in attracting *D. ponderosae* in stands of western white pine and are surprising since a-pinene is the most common monoterpene in the resin of western white pine, which has low amounts of myrcene (Mirov 1961). The relative proportion of myrcene is higher in the resin of' lodgepole and ponderosa pines with amounts of myrcene greater than or equal to amounts of a-pinene (Mirov 196 1; Shrimpton 1973). Geographic variation in semiochemical responses, similar to that in *Ips pini* (Say) (Miller et *al.* 1997), may explain some of these results.

Finally, research by Pitman (1971), Billings et al. (1976), Borden *et* al. (1983) and Conn et *al.* (1983) were conducted before the importance of the enantiomeric composition of a-pinene was widely recognised. It is likely, but not certain, that they used either (±)- or (-)-a-pinene due to the high costs associated with (+)-a-pinene. We used (-)-a-pinene in our trials since it is the predominant enantiomer in the resin of western white pine phloem tissue (Mirov 196 1).

In Experiment 1, catches of *Trypodendron lineatum* were lowest in traps baited with myrcene alone, and highest in traps baited with either a-pinene or exo-brevicomin (Table 1). a-Pinene significantly increases the attraction of *T. lineatum* to ethanol and the pheromone lineatin (Borden *et al.* 1982; Schroeder and Lindelöw 1989). *No T. lineatum* were caught in Experiment 2.

**Table 1**

Mean (± SE) catches of *Trypodendron lineatum* (Scolytidae) and *Thanasimus undatulus* (Cleridae) in verbenol-baited multiple-funnel traps from 1 August to 25 August 1990 [a].

| Treatment | *Trypodendron lineatum* | *Thanasimus undatulus* |
|---|---|---|
| (-)-a-Pinene | 11 ± 5 b | 1 ± 1 a |
| Myrcene | 3 ± 1 a | 1 ± 1 a |
| (-)-a-Pinene + (±)-*exo*-brevicomin | 12 ± 2 b | 28 ± 5 c |
| Myrcene + (±)-*exo*-brevicomin | 9 ± 2 b | 16 ± 3 b |

[a] Means within the same column followed by the same letter are not significantly different, $P < 0.05$ (LSD multiple comparison test).

The predator, *Thanasimus undatulus,* showed a preference for traps baited with *exo*-brevicomin in combination with myrcene or a-pinene, particularly the latter (Table 1). As might be expected for a generalist predator, similar results with *T. undatulus* have been reported with the following bark beetle pheromones: frontalin, exo- and *endo*-brevicomin, ipsdienol, ipsenol, and cis-verbenol (Kline *et al.* 1974; Dyer 1975; Chatelain and Schenk 1984; Miller *et al.* 1987; Miller and Borden 1990; Miller *et al.* 1991; Miller *et al.* 1997; Poland and Borden 1997). Usually, *T. undatulus* are not attracted to host tree compounds (Fumiss and Schmitz 1971; Miller and Borden 1990) although Macias-Samano *et al.* (1998) demonstrated attraction of *T. undatulus* to host blends from grand fir, *Abies grandis* (Dougl.) Lindl. *No T. undatulus* were caught in Experiment 2.

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