SCIENTIFIC NOTE

MCOL, frontalin and ethanol: A potential operational trap lure for Douglas-fir beetle in British Columbia

B. Staffan Lingren[1,2], Daniel R. Miller[3], J. P. LaFontaine[4]

The Douglas-fir beetle, *Dendroctonus pseudotsugae* (Coleoptera: Curculionidae) is a major pest of Douglas-fir, *Pseudotsuga menziesii* (Mirb.) in British Columbia (Humphreys 1995). An operational trap lure for *D. pseudotsugae* could be useful in an integrated pest management program to minimize mortality of Douglas-fir, particularly in conjunction with anti-aggregation pheromones (Lindgren *et al.* 1988; Ross and Daterman 1995a). The principal pheromone of *D. pseudotsugae* is frontalin (1,5-dimethyl-6,8-dioxyabicyclo [3.2.1] octane), which is produced by male and female beetles and attracts both sexes of beetles (Pitman and Vité 1970; Kinzer *et al.* 1971; Rudinsky *et al.* 1976). In British Columbia, *D. pseudotsugae* prefer multiple-funnel traps baited with racemic frontalin (50:50 mix of the two enantiomers) or (S)-(–)-frontalin equally over those baited with (R)-(+)-frontalin (Lindgren 1992).

Two additional pheromones are produced by female *D. pseudotsugae* and attract both sexes of beetles, particularly when presented with host odours or frontalin: MCOL (1-methylcyclohex-2-en-1-ol) (Libbey *et al.* 1983; Lindgren *et al.* 1992; Ross and Daterman 1995b) and seudenol (3-methylcyclohex-2-en-1-ol) (Vité *et al.* 1972; Rudinsky *et al.* 1974; Pitman *et al.* 1975; Ross and Daterman 1995b). These two compounds are isomers of each other.

In 1991, we conducted a trapping experiment in British Columbia, targeting *D. pseudotsugae*. The objective of the experiment was to determine the effect of racemic frontalin and racemic MCOL, alone and in combination, on the attraction of *D. pseudotsugae* to traps baited with ethanol in British Columbia. Lindgren *et al.* (1992) found that the attraction of beetles to traps baited with the two enantiomers of MCOL seem to be additive with the highest catches in traps baited with racemic MCOL. In laboratory assays, ethanol enhanced the activity of frontalin on arrestment of male *D. pseudotsugae* (Libbey *et al.* 1983). In field assays, ethanol increased catches of beetles in traps baited with frontalin and seudenol (Pitman *et al.* 1975; Ross and Daterman 1995b).

PheroTech Inc. (now Contech, Victoria, BC) supplied all traps and lures. Chemical purities were >95% for all semiochemicals. Release rates were determined gravimetrically at 20–23 °C. Traps were suspended from a metal pole made from electrical conduit tubing such that the bottom of each trap was 0.2–0.5 m above ground level. No trap was suspended within 2 m of any tree. All lures were placed within the funnels (Lindgren 1983).

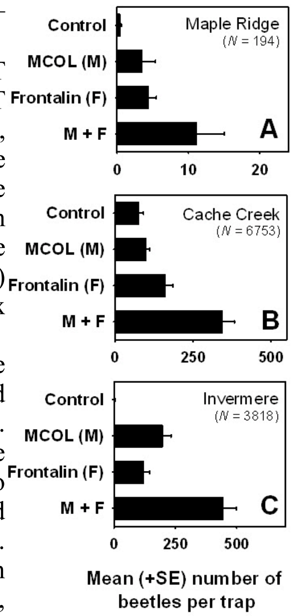
The experiment was conducted in mature stands of Douglas-fir at three locations in southern British Columbia: 1) Maple Ridge (10 April–12 May 1991); 2) Cache Creek (13–31 May 1991); and 3) Invermere (30 May–8 August 1991). We used 40 12-unit multiple-funnel traps (Lindgren 1983) with dry cups in Maple Ridge and Cache Creek, whereas 20 traps were used in Invermere. Each collecting cup contained a small piece of Vapona No-Pest Strip (Green Cross; Fisons Horticulture, Mississauga, Ontario, Canada) as a killing agent to prevent damage to the target species by predatory insects. At each location, traps were set in blocks of four traps per block resulting in 10, 10, and 5 replicate blocks per location, respectively. Blocks, and traps within

[1] Corresponding author, Staffan.Lindgren@unbc.ca
[2] Natural Resources and Environmental Studies Institute, University of Northern British Columbia, 3333 University Way, Prince George, British Columbia, Canada V2N 4Z9
[3] USDA Forest Service, Southern Research Station, 320 Green Street, Athens, GA, USA 30602-2044
[4] Contech Enterprises Inc., 7572 Progress Way, Delta, British Columbia, Canada V4G 1E9

blocks, were spaced 10–15 m apart in Maple Ridge and Cache Creek and 50m apart in Invermere. Each trap was baited with a white PVC sleeve pouch (40 cm) releasing ethanol at approximately 53 mg/d. Racemic frontalin and racemic MCOL were released from micro-centrifuge tubes (250 µL) and plastic bubblecaps, respectively, each at a rate of approximately 2–3 mg/d. One of the following four treatments was randomly assigned to each trap within a block: (1) untreated control; (2) MCOL; (3) frontalin; and (4) MCOL + frontalin.

Data were analyzed with the SYSTAT (ver. 11) statistical package (SYSTAT Software Inc., Point Richmond, California). Trap catch data were transformed by ln(y+1) to reduce heteroscedasticity. Data at each location were subjected to ANOVA using the following model: (1) replicate; (2) MCOL; (3) frontalin; and (4) MCOL x frontalin.

Trap catches of *D. pseudotsugae* were significantly affected by MCOL and frontalin at all three locations (Fig. 1). The responses were additive in Maple Ridge and Cache Creek, as there was no significant interaction with MCOL and frontalin at either location (Fig. 1A–B). There was a significant MCOL x frontalin interaction on trap catches in Invermere, resulting in a synergistic effect (Fig. 1C). The difference may be due to the relatively close spacing of treatments in the Maple Ridge and Cache Creek experiments. In contrast to our results, Ross and Daterman (1995b) found that MCOL had no effect on catches of *D. pseudotsugae* in traps baited with ethanol and frontalin in Oregon. In their study, the combination of ethanol, frontalin, and seudenol was the most effective lure combination for Douglas-fir beetles. Geographic variation in chemical ecology is known for *D. pseudotsugae,* warranting further trials of trap-lure blends over a broader range (Ryker *et al.* 1979; Stock *et al.* 1979; Ross and Daterman 1995b). Nevertheless, traps baited with frontalin, MCOL, and ethanol as described here should be used for trapping Douglas-fir beetles in British Columbia.



ANOVA (A)

Source	df	P
Replicate	9	0.140
Frontalin (F)	1	<0.001
MCOL	1	0.005
F x MCOL	1	0.899

ANOVA (B)

Source	df	P
Replicate	9	0.880
Frontalin (F)	1	<0.001
MCOL	1	0.004
F x MCOL	1	0.165

ANOVA (C)

Source	df	P
Replicate	9	0.381
Frontalin (F)	1	<0.001
MCOL	1	<0.001
F x MCOL	1	<0.001

Figure 1. Effect of MCOL and frontalin on catches of D. pseudotsugae in traps baited with ethanol in Maple Ridge (A), Cache Creek (B), and Invermere (C). Significance levels (P) for ANOVA on trap catches.

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