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SPRUCE BEETLE (COLEOPTERA: SCOLYTIDAE) RESPONSE TO TRAPS BAITED WITH SELECTED SEMIOCHEMICALS IN UTAH

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Spruce beetle, *Dendroctonus rufipennis* (Kirby), populations periodically reach outbreak densities throughout the range of spruce, *Picea* spp., in western North America. During outbreaks it may kill thousands to millions of trees over vast areas, dramatically altering forest structure, composition, and ecological processes, thus impacting a variety of resource values (Schmid and Frye 1977, Veblen et al. 1991, Holsten et al. 1995, 1999, Ross et al. 2001). Current options for reducing negative impacts on resource values caused by the spruce beetle include harvesting high-risk trees, sanitation/salvage logging, insecticide applications to high-value trees, felling and removal of trap trees, lethal trap trees, burying infested material, and burning or removing bark of infested trees (Holsten et al. 1999). Resource managers have used mass trapping with semiochemical-baited traps to some extent, but further research is needed to make this treatment more effective. An attempt to mass trap spruce beetle in Alaska reduced the number of subsequent beetle-attacked trees compared with untreated control plots, but beetle catches were considered low relative to beetle populations in the area (Werner and Holsten 1995). In Utah semiochemical-baited traps were used in conjunction with felling and burning of infested trees and trap trees to effectively suppress an isolated spruce beetle population (Bentz and Munson 2000).

Initially, the standard trap lure for spruce beetle was composed of 1,5-dimethyl-6,8-dioxabiocyclo[3.2.1]octane (frontalin) and α-pinene, and this lure is still available commercially (Phero Tech, Inc., Delta, BC, Canada, and IPM Tech, Inc., Portland, OR). Subsequent studies demonstrated that the addition of 1-methyl-2-cyclohexen-1-ol (MCOL) to the 2-component lure could significantly increase number of spruce beetles captured in traps at some locations (Werner 1994, Borden et al. 1996, Setter and Borden 1999). However, in 1 of these studies, spruce beetle response to racemic MCOL and the 2 enantiomers was not consistent at 5 different locations in Alaska, British Columbia, and Alberta (Borden et al. 1996). This latter study demonstrated the need to understand the response of spruce beetles to semiochemicals throughout their range.

Recently the spruce beetle has been at outbreak densities in central and southern Utah (USDA Forest Service 2003). No published reports exist that compare different semiochemicals as trap lures for spruce beetle in the Southern Rocky Mountains. Resource managers who want to use semiochemical-baited traps to reduce the impact of the spruce beetle in this region need the most attractive lure possible to have maximum effect on spruce beetle populations. The objective of this project was to compare several different trap lures containing frontalin and 1 or 2 of the following compounds: α-pinene, MCOL, 3-methyl-2-cyclohexen-1-ol (seudenol), and ethanol. Specifically, we wanted to determine whether the spruce beetle would respond to the addition of MCOL to the standard 2-component lure of frontalin and α-pinene in the Southern Rocky Mountains. Additionally, we wanted to compare several novel 2- and 3-component lures to the standard lures. Seudenol was included in the experiment because it is known to be attractive to spruce beetles in other parts of their range (Furniss et al. 1976, Dyer and Lawko

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1978, Dyer and Hall 1980), and ethanol was included because it has been shown to induce colonization by spruce beetle when applied to host trees (Moeck 1981), and it is known to be attractive to other scolytids (Ross and Daterman 1995, Kelsey and Joseph 2001).

An experiment was installed on 23 June 1998 at the Cedar City Ranger District of the Dixie National Forest in southwestern Utah (37°39′N, 112°45′W). The study included 6 replications of 8 treatments. The treatments were 16-unit, multiple-funnel traps (Lindgren 1983) baited with frontalin combined with 1 or 2 of the other semiochemicals (Table 1). Frontalin, seudenol, and α-pinene were formulated in polyvinylchloride in our laboratory (Daterman 1974). MCOL and ethanol were formulated in bubble capsules and plastic pouches, respectively, and were purchased from Phero Tech, Inc. Chemicals with chiral centers were tested as racemates. Chemical purities of semiochemicals were as follows: frontalin, 95.0%; seudenol, 99.3%; MCOL, ≥98%; ethanol, ≥98%; α-pinene, ≥98%. Semiochemical release rates determined by weight loss at 25°C over a 2-week period in mg · day^{-1} were as follows: frontalin, 3.3; seudenol, 4.2; MCOL, 4.0; ethanol, 88; α-pinene, 1.6. Within a replicate, traps were spaced 50–100 m apart and replicates were at least 100 m apart. Traps were placed in stand openings of various sizes to keep them as far as possible from host trees to minimize potential "spillover" beetle attacks on nearby trees. All replicates were located within a 16-km^2 area that included numerous spruce beetle–infested trees. Traps were emptied on 26–29 June and 1, 3, and 16 July 1998.

Spruce beetles and an associated predator, *Thanasimus undatulus* Say (Coleoptera: Cleridae), were counted in all samples. A subsample of 100 spruce beetles or the entire sample, if it contained less than 100 spruce beetles, was separated according to gender based on characteristics of the elytral declivity (Wood 1982); percentage male composition was determined. Beetle catches for each trap were summed across all collection dates and transformed by $\ln(Y+1)$ to correct for heteroscedasticity. Transformed beetle catch and percentage male composition data were subjected to analysis of variance (ANOVA) for a randomized complete block design. Means were compared and separated by Fisher's protected LSD when $P < 0.05$. Nontransformed means are reported. All statistical analyses were performed with the SAS System for Windows Release 8.02 (SAS Institute, Inc., Cary, NC).

Due to the low number of spruce beetles collected on 26 June and the large number of missing samples on 16 July, data from those dates were excluded from the analyses. A total of 3858 spruce beetles were collected across all treatments and collection dates that were used in the analyses. The effect of trap lure composition on spruce beetle catches was highly significant ($F_{7,35} = 3.48$, $P < 0.0062$). The 2 lures that contained MCOL caught the largest numbers of spruce beetles (Table 1). The lure composed of frontalin, α-pinene, and MCOL caught significantly more beetles than any other lure except the one containing frontalin and MCOL. The lure containing frontalin and MCOL produced the 2nd highest catch, which was significantly higher than all other lures except the combinations of frontalin and seudenol; frontalin, α-pinene, and ethanol; and frontalin, ethanol, and seudenol. Only 12 *T. undatulus* were collected.

We sorted 3241 spruce beetles according to gender and determined that the effect of trap lure composition on percentage male beetles in the catches was not significant ($F_{7,35} = 1.08$, $P < 0.3972$). Mean percentage male beetles for all treatments ranged from 47% to 67 %.

A 2nd experiment was installed on 3 April 2001 at the Heber Ranger District of the Uinta National Forest in central Utah (40°32′N, 111°01′W). The study included 10 pairs of 16-unit, multiple-funnel traps spaced about 30 m apart. Traps were placed in forested sites at least 10 m from potential host trees, with pairs of traps at least 500 m apart. One trap in each pair was baited with frontalin and α-pinene and the other trap with frontalin, α-pinene, and MCOL. Trap lures were purchased from Phero Tech, Inc. All semiochemicals were ≥98% pure, and release rates in mg · day^{-1} were as follows: frontalin, 2.6 at 23°C; α-pinene, 1.5 at 20°C; MCOL, 2.0 at 20°C. Eight pairs of traps were emptied on 5, 18, and 26 June, 5, 12, 18, and 24 July, and 6 August 2001. The other 2 pairs of traps were less accessible and were emptied on 17 and 19 June, 2, 10, and 30 July 2001. We counted spruce beetles collected in each sample and summed beetle catches for each trap across all collection dates. We subjected total spruce beetle catches to ANOVA.

TABLE 1. Mean numbers (± s) of spruce beetles caught in multiple-funnel traps baited with selected semiochemicals in southern Utah.

Lure composition	Spruce beetles (number per trap)[a]
Frontalin and α-pinene	27.3 ± 6.2 c
Frontalin and ethanol	29.5 ± 11.4 c
Frontalin and seudenol	42.5 ± 20.6 bc
Frontalin and MCOL	154.8 ± 95.3 ab
Frontalin, α-pinene, and ethanol	72.8 ± 37.9 bc
Frontalin, α-pinene, and seudenol	22.8 ± 4.8 c
Frontalin, α-pinene, and MCOL	236.0 ± 85.5 a
Frontalin, ethanol, and seudenol	57.2 ± 16.5 bc

[a]Means followed by the same letter are not significantly different (Fisher's protected LSD, $P < 0.05$).

A total of 9749 spruce beetles were collected across both treatments and all collection dates. The mean (± $s_{\bar{x}}$) total number of spruce beetles collected in traps baited with frontalin, α-pinene, and MCOL was 611 ± 82 compared with 364 ± 91 in traps baited with just frontalin and α-pinene. The difference was highly significant ($F_{1,9} = 10.42$, $P < 0.0103$).

These results are consistent with those from Alaska, northwestern Alberta, and southeastern British Columbia, where racemic MCOL increased catches of spruce beetles to varying degrees (Borden et al. 1996, Setter and Borden 1999). The present study extends the range for which racemic MCOL appears to be attractive to the spruce beetle to include all sites that have been tested within and east of the Rocky Mountains. These results indicate that in the Southern Rocky Mountains, addition of racemic MCOL to spruce beetle lures containing frontalin and α-pinene will significantly increase catches. Furthermore, lures composed of frontalin and MCOL will likely be more effective in trapping spruce beetles than lures composed of frontalin and α-pinene. However, other combinations of frontalin and MCOL with seudenol or ethanol should be tested as well as different ratios of the various semiochemicals to determine if a more attractive lure can be developed.

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LITERATURE CITED

BENTZ, B.J., AND A.S. MUNSON. 2000. Spruce beetle population suppression in northern Utah. Western Journal of Applied Forestry 15:122–128.

BORDEN, J.H., G. GRIES, L.J. CHONG, R.A. WERNER, E.H. HOLSTEN, H. WIESER, E.A. DIXON, AND H.F. CEREZKE. 1996. Regionally specific bioactivity of two new pheromones for *Dendroctonus rufipennis* (Kirby) (Col., Scolytidae). Journal of Applied Entomology 120: 321–326.

DATERMAN, G.E. 1974. Synthetic sex pheromone for detection survey of European pine shoot moth. Research Paper PNW-180, Pacific Northwest Forest and Range Experiment Station, USDA Forest Service, Portland, OR.

DYER, E.D.A., AND P.M. HALL. 1980. Effect of the living host tree (*Picea*) on the response of *Dendroctonus rufipennis* (Coleoptera: Scolytidae) and a predator *Thanasimus undatulus* (Coleoptera: Cleridae) to frontalin and seudenol. Canadian Entomologist 112: 167–171.

DYER, E.D.A., AND C.M. LAWKO. 1978. Effect of seudenol on spruce beetle and Douglas-fir beetle aggregation. Fisheries and Environment Canada Forestry Service Bi-monthly Research Notes 34:30–32.

FURNISS, M.M., B.H. BAKER, AND B.B. HOSTETLER. 1976. Aggregation of spruce beetles (Coleoptera) to seudenol and repression of attraction by methylcyclohexenone in Alaska. Canadian Entomologist 108: 1297–1302.

HOLSTEN, E.H., R.W. THIER, A.S. MUNSON, AND K.E. GIBSON. 1999. The spruce beetle. Forest Insect and Disease Leaflet 127, USDA Forest Service, Washington, DC.

HOLSTEN, E.H., R.A. WERNER, AND R.L. DEVELICE. 1995. Effects of a spruce beetle (Coleoptera: Scolytidae) outbreak and fire on Lutz spruce in Alaska. Environmental Entomology 24: 1539–1547.

KELSEY, R.G., AND G. JOSEPH. 2001. Attraction of *Scolytus unispinosus* bark beetles to ethanol in water-stressed Douglas-fir branches. Forest Ecology and Management 144:229–238.

LINDGREN, B.S. 1983. A multiple funnel trap for scolytid beetles (Coleoptera). Canadian Entomologist 115: 299–302.

MOECK, H.A. 1981. Ethanol induces attack on trees by spruce beetles, *Dendroctonus rufipennis* (Coleoptera: Scolytidae). Canadian Entomologist 113:939–942.

ROSS, D.W., AND G.E. DATERMAN. 1995. Response of *Dendroctonus pseudotsugae* (Coleoptera: Scolytidae) and

Thanasimus undatulus (Coleoptera: Cleridae) to traps with different semiochemicals. Journal of Economic Entomology 88:106–111.

ROSS, D.W., G.E. DATERMAN, J.L. BOUGHTON, AND T.M. QUIGLEY. 2001. Forest health restoration in south-central Alaska: a problem analysis. General Technical Report PNW-GTR-523, USDA Forest Service, Pacific Northwest Research Station, Portland, OR.

SCHMID, J.M., AND R.H. FRYE. 1977. Spruce beetle in the Rockies. General Technical Report RM-49, USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.

SETTER, R.R., AND J.H. BORDEN. 1999. Bioactivity and efficacy of MCOL and seudenol as potential attractive bait components for *Dendroctonus rufipennis* (Coleoptera: Scolytidae). Canadian Entomologist 131:251–257.

USDA FOREST SERVICE. 2003. Forest insect and disease conditions in Utah—2001. Ogden Field Office Technical Report 03-01, USDA Forest Service, Intermountain Region, Forest Health Protection, Ogden, UT, and Utah Department of Natural Resources, Division of Forestry, Fire, and State Lands, Salt Lake City.

VEBLEN, T.T., K.S. HADLEY, M.S. REID, AND A.J. REBERTUS. 1991. The response of subalpine forests to spruce beetle outbreak in Colorado. Ecology 72:213–231.

WERNER, R.A. 1994. Research on the use of semiochemicals to manage spruce beetles in Alaska. Pages 15–21 *in* P.J. Shea, technical coordinator, Proceedings of the symposium on management of western bark beetles with pheromones: research and development. General Technical Report PSW-GTR-150, USDA Forest Service, Pacific Southwest Research Station, Albany, CA.

WERNER, R.A., AND R.H. HOLSTEN. 1995. Current status of research with the spruce beetle, *Dendroctonus rufipennis.* Pages 23–29 *in* S.M. Salom and K.R. Hobson, technical editors, Application of semiochemicals for management of bark beetle infestations—proceedings of an informal conference. General Technical Report INT-GTR-318, USDA Forest Service, Intermountain Research Station, Ogden, UT.

WOOD, S.A. 1982. The bark and ambrosia beetles of North and Central America (Coleoptera: Scolytidae), a taxonomic monograph. Great Basin Naturalist Memoirs 6. Brigham Young University, Provo, UT.

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