N O T E

Combining Lures for Conifer and Hardwood Cerambycidae in Multiple-Funnel Traps in Georgia—A Preliminary Study[1]

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J. Entomol. Sci. 60(2): 290–292 (April 2025)
DOI: 10.18474/JES24-27

Key Words ipsenol, ipsdienol, syn-2,3-hexanediol, 3-hydroxyhexan-2-one, Cerambycidae

The costs of detection programs targeting native and nonnative species of bark and woodboring beetles can be reduced by combining lures in a single trap (Fan et al. 2019, J. Pest Sci. 92: 281–297; Rice et al. 2020, J. Econ. Entomol. 113: 2269–2275). However, the effects of any interactions among semiochemicals on the attraction of beetles should be evaluated before such tactics are made operational. 3-Hydroxyhexan-2-one and *syn*-2,3-hexanediol are known pheromones and attractants for the hardwood longhorn beetles *Neoclytus acuminatus* (F.), *Neoclytus mucronatus* (F.), *Neoclytus scutellaris* (Olivier), and *Xylotrechus colonus* (F.) (Coleoptera: Cerambycidae) in Georgia, with attraction enhanced by addition of ethanol (Miller et al. 2017, J. Econ. Entomol. 110: 2119–2128). In the southeastern United States, the conifer longhorn beetles *Acanthocinus obsoletus* (LeConte) and *Monochamus titillator* (F.) (Coleoptera: Cerambycidae) are attracted by the bark beetle pheromones ipsenol and ipsdienol (Miller and Asaro 2005, J. Econ. Entomol. 98: 2033–2040), with attraction enhanced by addition of ethanol and α-pinene (Miller et al. 2011, J. Econ. Entomol. 104: 1245–1257).

My goal was to conduct a preliminary study on the effects of combining two lures for hardwood Cerambycidae with two lures for conifer Cerambycidae on catches of these six species of Cerambycidae in ethanol-baited traps. I conducted a trapping study from 5 September to 18 October 2012 in Putnam County, Georgia (33.237°N, 83.514°W) utilizing 10-unit multiple-funnel traps (Contech Enterprises Inc., Delta, British Columbia, Canada). Bubblecap lures containing racemic ipsenol and racemic ipsdienol were obtained from Synergy Semiochemicals Inc. (Burnaby, British Columbia, Canada), with release rates of ca. 0.1–0.2 mg/d at 25°C (as determined by the manufacturer). Contech Enterprises supplied the following lures: (a) black high-release-rate ethanol pouch

[1]Received 2 March 2024; accepted for publication 10 March 2024.
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Table 1. Mean (±SE) catches of longhorn beetles (Cerambycidae) in traps baited with ethanol (E), ipsenol + ipsdienol (SD), and 3-hydroxyhexan-2-one + *syn*-2,3-hexanediol (KD6).*

		Lure Treatments			
Species	***N***	**E**	**E + SD**	**E + KD6**	**E + SD + KD6**
Acanthocinus obsoletus (LeConte)	206	–	12.8 ± 4.4	–	10.1 ± 2.2
Monochamus titillator (F.)	563	–	5.1 ± 0.6	–	4.6 ± 1.3
Neoclytus acuminatus (F.)	190	0.9 ± 0.4a	1.1 ± 0.3a	8.9 ± 1.1b	10.2 ± 1.1b
Neoclytus mucronatus (F.)	563	0.3 ± 0.2a	0.6 ± 0.2a	27.4 ± 2.9b	34.2 ± 5.7b
Neoclytus scutellaris (Olivier)	175	0.2 ± 0.1a	0.3 ± 0.2a	9.1 ± 2.1b	9.8 ± 2.0b
Xylotrechus colonus (F.)	34	0.4 ± 0.2a	0.1 ± 0.1a	1.3 ± 0.4b	1.9 ± 0.4b

* Means followed by different letters are significantly different at $P < 0.05$ (Holm-Sidak test). N = total number of beetles caught. Dash indicates no beetles were captured.

lures (20 × 45 × 335 mm); (b) white pouch lures (4 × 85 × 110 mm) containing racemic *syn*-2-3-hexanediol; and (c) brown pouch lures (5 × 50 × 125 mm) containing racemic 3-hydroxyhexan-2-one. The release rates of ethanol, *syn*-2-3-hexanediol, and 3-hydroxyhexan-2-one from these lures were approximately 0.5 g/d, 1.5 mg/d, and 25 mg/d, respectively, at 20–23°C (as determined by the manufacturer).

I utilized 36 multiple-funnel traps that were modified to allow lures to be placed within funnels (Miller et al. 2013, J. Econ. Entomol. 106: 206–214). Traps were hung between trees such that collection cups were approximately 0.5 m above ground level. Nine replicate blocks of four traps/block were spaced 15–100 m apart with traps spaced 8–12 m apart within each replicate block. One of the following lure treatments was randomly assigned to traps within each block: (a) ethanol alone; (b) ethanol + ipsenol + ipsdienol; (c) ethanol + 3-hydroxyhexan-2-one + *syn*-2-3-hexanediol; and (d) all five lures. Collection cups contained 100–200 ml of a pink aqueous ethanol-free solution of propylene glycol (Splash RV & Marine Antifreeze, SPLASH Products Inc., St. Paul, MN) to kill and preserve beetles (Miller and Duerr 2008, J. Econ. Entomol. 101: 107–113). Voucher specimens were deposited in the University of Georgia Collection of Arthropods (Athens, GA).

The SigmaStat (ver. 3.01) statistical package (SYSTAT Software Inc., Point Richmond, CA) was used to analyze trap catch data for species with total counts ≥30. Data were transformed as needed by $\ln(Y + 1)$ to meet the conditions of normality and homoscedasticity, verified by the Shapiro-Wilk and equal variance tests, respectively. For species with trap catches in all four lure treatments, data were analyzed with a mixed-model analysis of variance with treatment as the fixed variable, followed by the Holm-Sidak multiple-comparison test for species affected by treatments ($\alpha = 0.05$). For species captured in only two treatments, data were analyzed with a two-tailed paired t test.

The six target species of Cerambycidae were caught in sufficient numbers for analyses (Table 1). The addition of ipsenol + ipsdienol to traps baited with *syn*-2-3-hexanediol + 3-hydroxyhexan-2-one did not affect catches of *N. acuminatus*, *N. mucronatus*, *N. scutellaris*, and *X. colonus* (Table 1). The addition

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of *syn*-2-3-hexanediol + 3-hydroxyhexan-2-one to traps baited with ipsenol + ipsdienol did not affect catches of *A. obsoletus* ($t_8 = 0.751$, $P = 0.474$) and *M. titillator* ($t_8 = 0.375$, $P = 0.718$) (Table 1).

The lack of any negative interactions between lure blends in this preliminary study provides support for conducting further trials over a broad geographic area in late spring or early summer when cerambycid diversity and abundance are greatest. Future trials should consider the inclusion of conifer volatiles, such as α-pinene (Miller 2006, J. Chem. Ecol. 32: 779-794), and other cerambycid pheromones, such as sulcatol and fuscumol (Miller 2022, J. Entomol. Sci. 57: 443–446), to broaden the diversity of detected species of Cerambycidae. In addition to enhancing detection programs for nonnative species, cost-effective lure blends could be useful for assessing biodiversity of bark and woodboring beetles and their associated predators as a measure of forest health (Dodds et al. 2015, Agric. For. Entomol. 17: 36–47). Ipsenol and ipsdienol are attractive to bark beetles (Miller et al. 2005, J. Econ. Entomol. 98: 2058–2066) and their predators (Allison et al. 2013, J. Insect Behav. 26: 321–335). Predators also are attracted to *syn*-2-3-hexanediol and 3-hydroxyhexan-2-one (Miller et al. 2023, Environ. Entomol. 52: 9–17).

Acknowledgments. This research was supported by the USDA, Forest Service. I thank Will Shepherd (USDA, Forest Service) for review of the manuscript, Chris Crowe (USDA, Forest Service) for field and laboratory assistance, and Richard Hoebeke (University of Georgia, Collection of Arthropods) for verifications of beetle identifications. The findings and conclusions in this publication are those of the author and should not be construed to represent any official USDA or U.S. Government determination or policy. The use of trade or firm names in this publication is for reader information and does not imply endorsement by the USDA of any product or service. The USDA is an equal opportunity provider, employer, and lender.

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