N O T E

Sulcatol and Fuscumol Increase Catches of *Leptostylus asperatus* and *Styloleptus biustus* (Coleoptera: Cerambycidae) in Ethanol-Baited Traps[1]

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J. Entomol. Sci. 57(3): 443–446 (July 2022)

Detection programs for nonnative bark and woodboring beetles at ports of entry are critical in mitigating the potential effects of invasive species (Poland and Rassati 2019, J. Pest Sci. 92: 37–49). Complex blends of lures in a single trap can be used for detecting multiple species of Cerambycidae (Coleoptera) at the same time, providing significant cost savings in terms of trap purchases and deployment (Fan et al. 2019, J. Pest Sci. 92: 281–297; Rassati et al. 2019, J. Pest Sci. 92: 267–279; Rice et al. 2021, J. Econ. Entomol. 113: 2269–2275). Complex lure blends also can be used to assess the biodiversity of woodboring beetles in forest stands, providing opportunities to assess the effects of climate change and invasive species (Dodds et al. 2015, Agric. For. Entomol. 17: 36–47; Wickham et al. 2021, Insects 12: 277). However, managers should be aware of any possible reduction in efficacy for detecting a target species when using blends, as some lures can interrupt the attraction of some species (Miller et al. 2119, J. Econ. Entomol. 110: 2119–2128).

My goal was to determine the consequences of combining two different lures (sulcatol and fuscumol) for Cerambycidae on catches of cerambycids and associated beetle species in ethanol-baited traps in Georgia. In eastern North America, fuscumol is attractive to various species of cerambycids (Mitchell et al. 2011, Entomol. Exp. Appl. 141: 71–77; Millar et al. 2018, J. Econ. Entomol. 111: 252–259), whereas sulcatol is attractive to a different set of species (Meier et al. 2019, J. Chem. Ecol. 45: 447–454; Miller and Crowe 2020, Environ. Entomol. 49: 593–600). Additionally, sulcatol is attractive to several species of ambrosia beetles such as *Monarthrum mali* (Fitch) (Coleoptera: Curculionidae) in Georgia (Miller and Crowe 2020). Understanding the possible interactions between sulcatol and fuscumol on beetle trap catches should help managers make informed decisions about using these compounds as a stand-alone trap lure blend as well as with other lure blends in detection programs.

[1]Received 21 December 2021; accepted for publication 6 January 2022.
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A trapping study was conducted 17 June through 29 July 2021 to determine the effects of fuscumol and sulcatol on catches of forest beetles in ethanol-baited traps. Eight replicate blocks of four 10-unit black multiple-funnel traps (Synergy Semiochemicals Inc., Burnaby, British Columbia) per block were set in upland mixed-wood stands at the Scull Shoals Experimental Forest (Greene Co.) in northcentral Georgia (33.7731 °N, 83.2396 °W). The prominent tree species were *Pinus taeda* L., *Pinus echinata* Miller, *Quercus alba* L., *Quercus falcata* Michaux, *Liquidambar styraciflua* L., and *Carya tomentosa* Sargent. Traps were modified to allow lures to be hung within funnels (Miller et al. 2013, J. Econ. Entomol. 106: 206–214). Traps were hung on rope tied between trees and spaced approximately 10 m apart within blocks; blocks were spaced 100–200 m apart. Approximately 200 ml of an aqueous solution of propylene glycol (Splash RV & Marine Antifreeze, Fox Packaging Inc., St. Paul, MN) was placed in each collection cup (Miller and Duerr 2008, J. Econ. Entomol. 101: 107–113), changed after each 2-wk collection period. A piece (2.5 $\times$ 5.0 cm) of VaporTape II (Hercon Environmental Corp., Emigsville, PA) was attached under the canopy of each trap to prevent nest building by paper wasps.

Black, ethanol ultra-high release pouches were obtained from Scotts Canada Inc. (Delta, British Columbia), whereas bubble cap lures of racemic sulcatol and racemic fuscumol were obtained from Synergy Semiochemicals. Release rates for the three devices were 0.5 g/d, 5 mg/d, and 5 mg/d at 24 °C (determined by manufacturers), respectively. In a randomized complete-block design, one of the following four treatments was allocated to each of the four traps within each block: (a) ethanol lure alone, (b) ethanol lure + fuscumol lure, (c) ethanol lure + sulcatol lure, and (d) ethanol lure + fuscumol lure + sulcatol lure. Ethanol is a general attractant for woodboring beetles (Miller 2006, J. Chem. Ecol. 32: 779–794), often increasing the attraction of beetles to traps baited with cerambycid pheromones (Miller et al. 2015, J. Econ. Entomol. 108: 2354–2365). Voucher specimens were deposited in the University of Georgia Collection of Arthropods, Athens, GA.

The SYSTAT (ver. 13) and SigmaStat (ver. 3.01) statistical packages (SYSTAT Software Inc., Point Richmond, CA) were used to analyze trap catch data for species with total counts of $\geq$30. As needed, data were transformed by ln $(Y + 1)$ to attain normality and homoscedasticity, verified by the Shapiro-Wilk and Equal Variance tests, respectively. Data were analyzed by a mixed-model analysis of variance (ANOVA) with treatment as the fixed factor, followed by the Holm-Sidak multiple-comparison test for species affected by the treatments ($\alpha = 0.05$). For species affected by treatments, data were further analyzed by a mixed-model ANOVA using the following model factors: (a) fuscumol (F), (b) sulcatol (S), and (c) fuscumol $\times$ sulcatol.

Three species of Cerambycidae were detected in sufficient numbers for analyses. As in Miller and Crowe (2020), catches of *Leptostylus asperatus* (Haldeman) (Coleoptera: Cerambycidae) were affected by sulcatol (Table 1); the highest catches were in traps baited with either sulcatol or sulcatol + fuscumol (Table 2). There was no interruptive effect of fuscumol on the responses of *L. asperatus* to sulcatol (Table 1). Catches of *Styloleptus biustus* (LeConte) (Coleoptera: Cerambycidae) were affected by the treatments containing fuscumol ($F = 11.804$; df $= 2{,}14$; $P < 0.001$), consistent with results in Millar et al. (2018). The highest catches of *S. biustus* were in traps baited with fuscumol or fuscumol +

Table 1. ANOVA results for effects of fuscumol (F), sulcatol (S), and the interaction of F × S on catches of beetles in 10-unit modified multiple-funnel traps baited with ethanol.

	F		S		F × S	
Species	$F_{1,21}$	P	$F_{1,21}$	P	$F_{1,21}$	P
Cerambycidae						
Leptostylus asperatus	2.220	0.151	42.28	<**0.001**	2.800	0.109
Neoclytus acuminatus	7.872	**0.011**	0.196	0.662	2.639	0.119
Cleridae						
Madoniella dislocata	0.258	0.616	11.04	**0.003**	0.023	0.882
Curculionidae						
Xyleborinus saxesenii	9.542	**0.006**	0.843	0.369	10.60	**0.004**
Xylosandrus crassiusculus	10.63	**0.004**	0.779	0.388	0.331	0.571

Significant *P* values are presented in boldface font.

sulcatol; there was no interruptive effect of sulcatol (Table 2). Unlike Millar et al. (2018), we found no evidence of attraction of *S. biustus* to traps baited solely with ethanol (Table 2). There was an interruptive effect of fuscumol on catches of *Neoclytus acuminatus* (F.) (Coleoptera: Cerambycidae) in traps baited with sulcatol (Table 2).

As in Miller and Crowe (2020), catches of the bark and woodborer predator *Madoniella dislocata* (Say) (Coleoptera: Cleridae) were affected by sulcatol; fuscumol had no effect on catches of *M. dislocata* (Table 1). The Holm-Sidak multiple comparison test was unable to separate mean catches of *M. dislocata* by treatment (Table 2). Fuscumol affected catches of two common species of nonnative ambrosia beetles, namely, *Xyleborinus saxesenii* (Ratzeburg) and *Xylosandrus crassiusculus* (Motschulsky) (Coleoptera: Curculionidae), with a significant interaction between fuscumol and sulcatol for *Xyle. saxesenii* but not for *Xylo. crassiusculus* (Table 1). Catches of *Xyle. saxesenii* were greater in traps baited with fuscumol + sulcatol than in traps with the remaining three treatments; catches of *Xylo. crassiusculus* were greater in traps baited with fuscumol + sulcatol than in those baited solely with ethanol (Table 2). Catches of *Monarthrum mali* (Fitch) (Coleoptera: Curculionidae) were affected by the treatments containing sulcatol ($F = 6.550$; df $= 2{,}14$; $P = 0.010$), with the highest catches in traps baited with sulcatol or sulcatol + fuscumol (Table 2), consistent with results with sulcatol in Miller and Crowe (2020). There was no interruptive effect of fuscumol on catches of *M. mali* (Table 2).

Combining fuscumol and sulcatol lures in the same ethanol-baited trap did not have any adverse effect on catches of two target species of Cerambycidae. The increase in catches of three species of ambrosia beetles was a serendipitous benefit of adding the lure combination to ethanol-baited traps. The next step is to

Table 2. Effects of fuscumol (F) and sulcatol (S) on mean (±SE) catches of beetles in 10-unit modified multiple-funnel traps baited with ethanol (E).

		Mean (±SE) trap catches			
Family, Species	***n***	**E**	**E + F**	**E + S**	**E + F + S**
Cerambycidae					
Leptostylus asperatus	93	0.4 ± 0.3 a	0.4 ± 0.2 a	7.4 ± 2.5 b	3.5 ± 1.0 b
Neoclytus acuminatus	39	1.4 ± 0.4 ab	0.9 ± 0.5 ab	2.3 ± 0.6 b	0.4 ± 0.2 a
Styloleptus biustus	85	0	5.9 ± 1.3 b	0.4 ± 0.3 a	4.4 ± 0.9 b
Cleridae					
Madoniella dislocata	53	0.3 ± 0.2	0.1 ± 0.1	3.5 ± 1.7	2.8 ± 1.5
Curculionidae					
Monarthrum mali	34	0	0.3 ± 0.2 a	2.3 ± 0.6 b	1.8 ± 0.5 b
Xyleborinus saxesenii	109	3.1 ± 0.4 a	3.0 ± 0.7 a	1.4 ± 0.5 a	6.1 ± 1.2 b
Xylosandrus crassiusculus	165	2.3 ± 0.9 a	6.6 ± 3.6 ab	2.8 ± 1.2 ab	9.0 ± 2.8 b

Means for a species followed by the same letter are not significantly different at $P = 0.05$ (Holm-Sidak test). *n*, total number captured per species.

determine the benefit of adding this combination to existing complex blends for cerambycids such as ethanol + *syn*-2,3-hexanediol + 3-hydroxyhexan-2-one + 3-hydroxyoctan-2-one (Hanks and Millar 2013, Chemoecology 23: 21–44).

Acknowledgments. The use of trade names and identification of firms or corporations does not constitute an official endorsement or approval by the United States government of any product or service to the exclusion of others that may be suitable. The USDA is an equal opportunity provider, employer, and lender.