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Should Ipsdienol and Ipsenol Lures be Retained in a Generic Trap Lure Blend for Pine Bark and Woodboring Beetles (Coleoptera) in the Southeastern United States?¹

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Abstract Trap lure blends that maximize the diversity of captured insect species help to reduce the costs of detection programs that target native and nonnative invasive species of bark and woodboring beetles. In 2007, the effects of the bark beetle pheromones ipsdienol and ipsenol on catches of beetles (Coleoptera) in multiple-funnel traps baited with ethanol + α -pinene were evaluated in a trapping study in one stand of mature loblolly pine, *Pinus taeda* L., in northcentral Georgia. Ipsenol and/or ipsdienol increased catches of *Acanthocinus obsoletus* (LeConte) and *Monochamus titillator* (F.) (Cerambycidae), *Ips avulsus* (Eichhoff), *Ips calligraphus* (Germar), *Ips grandicollis* (Eichhoff) (Curculionidae), *Temnoscheila virescens* (F.), and *Aulonium tuberculatum* (LeConte) (Zopheridae) in traps baited with ethanol and α -pinene. However, catches of most species in traps baited with ipsenol + ipsdienol were the same as those baited with either ipsenol or ipsdienol alone. Only catches of *I. avulsus* were greatest in traps baited with both ipsdienol and ipsenol. Catches of *Thanasimus dubius* (F.) (Cleridae), *Platysoma* spp. (Histeridae), and *Lasconotus* spp. (Zopheridae) increased with the addition of ipsenol but decreased with the addition of ipsdienol. In contrast, catches of *Orthotomicus caelatus* (Eichhoff) (Curculionidae) increased with the addition of ipsdienol; attraction was interrupted by the addition of ipsenol. A number of trade-offs exist in retaining ipsdienol and/or ipsenol in the multicomponent pine lure blend for detection programs in Georgia.

Key Words *Ips avulsus*, *Ips calligraphus*, *Ips grandicollis*, *Monochamus titillator*, *Temnoscheila virescens*

National programs to detect nonnative species of insects, particularly bark and woodboring beetles (Coleoptera), are common around the world due to global movement of goods (Brockerhoff et al. 2006, Brockerhoff and Liebhold 2017, Poland and Rassati 2019, Rabaglia et al. 2019, Aguirre Gil et al. 2021, Thurston et al. 2022). Combining lures for different species of bark and woodboring beetles can help reduce the costs of detection programs for nonnative species (Hanks et al. 2012, Miller et al. 2015, Fan et al. 2019, Poland and Rassati 2019, Rice et al. 2020). In the southeastern United States, adding α -pinene (a common volatile released from pines) lures to traps baited with ethanol (a known attractant for ambrosia beetles) lures results in a lure blend that is broadly attractive to bark and ambrosia

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beetles, with minimal interruption in attraction of ambrosia beetles due to the addition of α -pinene (Miller and Rabaglia 2009). The combination is also attractive to several species of longhorn beetles (Cerambycidae) and reproduction weevils (Curculionidae) (Miller 2006).

The bark beetle pheromones ipsdienol and ipsenol are used as pheromones by three common species of *Ips* in the Southeast and are attractive to all three species when used in combination (Miller et al. 2005, Allison et al. 2012a). Traps baited with ipsenol + ipsdienol are also attractive to numerous species of woodborers, predators, and fungivores (Miller and Asaro 2005, Allison et al. 2013). Adding the binary blend of ipsdienol + ipsenol to the binary blend of ethanol + α -pinene enhanced the abundance and diversity of species captured in the Southeast (Miller et al. 2011).

The benefits of retaining both ethanol and α -pinene in the quaternary blend were verified in Georgia (Miller 2020). However, the individual effects of ipsdienol and ipsenol on catches of bark and woodboring beetles to traps baited with ethanol + α -pinene are unknown. Therefore, my objective was to evaluate the benefit of retaining ipsdienol and/or ipsenol as part of a generic trap lure blend with ethanol + α -pinene to maximize the diversity and abundance of bark and woodboring beetles captured in the southeastern United States.

Materials and Methods

In 2007, I conducted a trapping study (30 May–2 August 2007) in a mature stand of loblolly pine, *Pinus taeda* (L.) (33.392°N, 83.377°W) on the Oconee National Forest near Eatonton, GA. The stand had experienced a prescribed burn in February 2007. Ethanol and α -pinene (enantiomeric purity > 95% [–]) pouch lures were obtained from Pherotech International (Delta, British Columbia, Canada). The release rates of ethanol and α -pinene from the pouch lures were 0.6 g/day and 0.1–0.6 g/day, respectively, at 25–28°C (determined by the manufacturer). Bubblecap lures containing racemic ipsdienol and racemic ipsenol were obtained from Synergy Semiochemicals Inc. (Burnaby, British Columbia, Canada). The release rates of ipsdienol and ipsenol from the bubblecap lures were 0.1–0.2 mg/day and 0.2–0.3 mg/day, respectively, at 25°C (determined by the manufacturer).

Forty, 8-unit multiple-funnel traps (Synergy Semiochemicals Inc.) were deployed in a randomized complete block design with 10 replicate blocks of four traps/block. Traps were hung on twine strung between trees such that the collection cup of each trap was approximately 0.5 m above ground level and each trap was ≥ 2 m from any tree. Traps within a block were spaced 8–12 m apart whereas blocks were spaced 10–20 m apart. In each block, one of the following four lure treatments was randomly allocated to each trap: (1) ethanol + α -pinene (EA); (2) EA + ipsdienol; (3) EA + ipsenol; and (4) EA + ipsdienol + ipsenol. Approximately 150 ml of an aqueous solution of propylene glycol (Peak RV & Marine Antifreeze, Old World Industries Inc., Northbrook, IL, USA) was added to each collection cup to kill and preserve beetles captured (Miller and Duerr 2008). Fresh propylene glycol solution was added to collection cups after each 2-wk collection event. Voucher specimens were deposited at the University of Georgia Collection of Arthropods, Athens, GA.

Trap catch data were analyzed with the SYSTAT (ver. 13) and SigmaStat (ver. 3.01) statistical packages (SYSTAT Software Inc., Point Richmond, CA) for species caught in sufficient numbers ($n \geq 30$). Data were transformed by $\ln(Y+1)$ as needed to ensure normality and homoscedasticity (Pepper et al. 1997) and verified by the Shapiro-Wilk and Equal Variance tests, respectively. In all analyses, I employed a mixed-model analysis of variance (ANOVA) ($y = \text{ipsdienol} + \text{ipsenol} + \text{ipsdienol} * \text{ipsenol} + \text{block} + \text{error}$) with block as a random factor. Comparisons of mean treatment catches were conducted with the Holm-Sidak multiple comparison test, which controls the experiment-wise error rate at 0.05 (Glantz 2005).

Results

A total of 23,531 forest-dwelling beetles were captured in the study, representing 10 families of bark and woodboring beetles and associated species of predators and fungivores (Table 1). At least one species was caught in sufficient numbers in each family for analyses. The most abundant and diverse families were Cerambycidae and Curculionidae.

Six species of Cerambycidae were captured in sufficient numbers for analyses (Table 1). Catches of *Acanthocinus obsoletus* (Olivier) and *Monochamus titillator* (F.) were affected by both ipsdienol and ipsenol, with significant interaction between the two factors (Table 2). Catches of both species in traps baited with ethanol + α -pinene were increased by the addition of either ipsdienol or ipsenol (Table 3). However, there was no significant increase in catches in traps baited with both compounds compared to traps baited with each compound individually. Catches of the woodborers *Buprestis lineata* F. (Buprestidae), *Acanthocinus nodosus* (F.), *Arhopalus rusticus* (L.), *Neoclytus scutellaris* (Olivier), *Xylotrechus sagittatus* (Germar) (Cerambycidae), and *Alaus myops* (F.) (Elateridae) were unaffected by ipsdienol and ipsenol lure treatments (Table 4).

Sufficient numbers of 16 species of Curculionidae were caught in the study for analyses (Table 1). Catches of the bark beetles *Ips avulsus* (Eichhoff), *Ips calligraphus* (Germar), and *Orthotomicus caelatus* (Eichhoff) in traps baited with ethanol + α -pinene were affected by both ipsdienol and ipsenol, whereas catches of *Ips grandicollis* (Eichhoff) were only affected by ipsenol; the interaction term was only significant for *O. caelatus* (Table 2). Traps baited with ipsdienol + ipsenol caught the most *I. avulsus*; the lowest numbers were in traps not baited with either compound (Table 3). *Ips grandicollis* was attracted equally to traps baited with ipsenol or ipsdienol + ipsenol. Catches of *I. calligraphus* were greatest in traps baited with ipsdienol or ipsenol + ipsdienol and lowest in traps not baited with either compound (Table 3). Only traps baited with ipsdienol alone caught significant numbers of *O. caelatus*; the addition of ipsenol to traps baited with ethanol + α -pinene interrupted attraction to ipsdienol (Table 3).

Ipsdienol and the interaction between ipsdienol and ipsenol affected catches of the bark beetle *Hylastes salebrosus* Eichhoff. Catches of *H. salebrosus* were lower in traps baited with both ipsdienol and ipsenol than in traps baited each compound individually (Table 3). Lure treatments had no effect on catches of the bark beetles *Dendroctonus terebrans* (Olivier) and *Hylastes tenuis* Eichhoff (Table 4). Similarly, ipsenol and ipsdienol lure treatments had no effect on catches of the ambrosia

Table 1. Total catches of beetles in traps baited with ethanol + α -pinene (EA), with or without ipsenol (S) and/or ipsdienol (D), in northcentral Georgia in 2007 ($n = 10$). (—) indicates none captured.

Family and Species	Trap Treatments				Total
	EA	EA+D	EA+S	EA+D+S	
Buprestidae					
<i>Buprestis lineata</i> F.	128	125	100	73	426
<i>Chalcophora virginiensis</i> (Drury)	3	8	1	5	17
Carabidae					
<i>Coptodera aerata</i> Dejean	93	96	73	81	343
Cerambycidae					
<i>Acanthocinus nodosus</i> (F.)	8	7	10	5	30
<i>Acanthocinus obsoletus</i> (Olivier)	7	70	70	88	235
<i>Arhopalus rusticus</i> (L.)	30	5	12	13	60
<i>Astylopsis arcuatus</i> (LeConte)	—	3	4	1	8
<i>Astylopsis sexguttata</i> (Say)	1	6	4	5	16
<i>Curius dentatus</i> Newman	—	2	3	—	5
<i>Monochamus titillator</i> (F.)	22	179	234	225	660
<i>Neoclytus acuminatus</i> (F.)	—	—	1	—	1
<i>Neoclytus mucronatus</i> (F.)	4	6	2	3	15
<i>Neoclytus scutellaris</i> (Olivier)	13	32	18	13	76
<i>Xylotrechus colonus</i> (F.)	2	2	1	1	6
<i>Xylotrechus sagittatus</i> (Germar)	77	55	82	57	271
Cleridae					
<i>Chariessa pilosa</i> (Forster)	1	2	1	1	5
<i>Enoclerus nigripes</i> (Say)	2	4	2	3	11
<i>Thanasimus dubius</i> (F.)	4	7	19	2	32
Curculionidae					
<i>Dendroctonus terebrans</i> (Olivier)	261	256	323	180	1,020
<i>Dryoxylon onoharaense</i> Murayama	805	836	757	589	2,987
<i>Dryophthorus americanus</i> Bedel	18	9	9	12	48
<i>Gnathotrichus materiarius</i> (Fitch)	2	12	8	7	29
<i>Hylastes salebrosus</i> Eichhoff	92	105	116	54	367

Table 1. Continued.

Family and Species	Trap Treatments				Total
	EA	EA+D	EA+S	EA+D+S	
<i>Hylastes tenuis</i> Eichhoff	159	161	154	105	579
<i>Hylobius pales</i> Herbst	54	62	64	57	237
<i>Ips avulsus</i> (Eichhoff)	18	101	154	441	714
<i>Ips calligraphus</i> (Germar)	7	71	21	88	187
<i>Ips grandicollis</i> (Eichhoff)	323	261	1,523	1,314	3,421
<i>Monarthrum fasciatum</i> (Say)	8	6	19	8	41
<i>Monarthrum mali</i> (Fitch)	17	31	24	23	95
<i>Orthotomicus caelatus</i> (Eichhoff)	22	98	31	42	193
<i>Pachylobius picivorus</i> (Germar)	322	378	370	289	1,359
<i>Stenoscelis brevis</i> (Boheman)	18	6	7	8	39
<i>Xyleborinus saxesenii</i> (Ratzeburg)	549	578	515	481	2,123
<i>Xyleborus</i> spp	4	9	5	6	24
<i>Xylosandrus crassiusculus</i> (Motschulsky)	270	270	220	176	936
Elateridae					
<i>Alaus myops</i> (F.)	44	32	28	34	138
Histeridae					
<i>Platysoma</i> spp.	42	165	724	483	1,414
Passandridae					
<i>Catogenus rufus</i> (F.)	15	6	14	17	52
Trogossitidae					
<i>Temnoscheila virescens</i> (F.)	231	529	546	585	1,891
<i>Tenebroides</i> spp.	17	17	15	17	66
Zopheridae					
<i>Aulonium tuberculatum</i>	—	17	97	91	205
<i>Namuria guttulata</i> (LeConte)	3	—	2	1	6
<i>Lasconotus</i> spp.	576	394	1,412	632	3,014
<i>Pycnomerus sulcicollis</i> LeConte	27	31	36	36	130
Total	4,299	5,050	7,831	6,352	23,532

Table 2. ANOVA table for effects of ipsdienol (D), ipsenol (S), and the interaction between the two treatments (D × S) on catches of beetles in traps baited with ethanol + α-pinene northcentral Georgia in 2007.

Family and Species	D		S		D × S	
	<i>F</i> _{1,27}	<i>P</i>	<i>F</i> _{1,27}	<i>P</i>	<i>F</i> _{1,27}	<i>P</i>
Cerambycidae						
<i>Acanthocinus obsoletus</i>	13.28	0.001	12.06	0.002	6.835	0.014
<i>Monochamus titillator</i>	5.732	0.024	17.418	<0.001	7.211	0.012
Cleridae						
<i>Thanasimus dubius</i>	6.375	0.018	2.084	0.160	13.01	0.001
Curculionidae						
<i>Hylastes salebrosus</i>	4.951	0.035	1.503	0.231	11.60	0.002
<i>Ips avulsus</i>	58.74	<0.001	107.8	<0.001	2.914	0.099
<i>Ips calligraphus</i>	72.25	<0.001	9.428	0.005	0.548	0.466
<i>Ips grandicollis</i>	1.194	0.264	82.55	<0.001	0.351	0.558
<i>Orthotomicus caelatus</i>	25.45	<0.001	7.427	0.011	14.20	0.001
Histeridae						
<i>Platysoma</i> spp.	3.271	0.082	235.0	<0.001	31.13	<0.001
Trogossitidae						
<i>Temnoscheila virescens</i>	15.24	0.001	18.47	<0.001	9.004	0.006
Zopheridae						
<i>Lasconotus</i> spp.	22.96	<0.001	28.62	<0.001	8.872	0.006

beetles *Dryoxylon onoharaense* Murayama, *Monarthrum fasciatum* (Say), *Monarthrum mali* (Fitch), *Xyleborinus saxesenii* (Ratzeburg), and *Xylosandrus crassiusculus* (Motschulsky), and the snout weevils *Dryophthorus americanus* Bedel, *Hylobius pales* Herbst, *Pachylobius picivorus* (Germar), and *Stenoscelis brevis* (Boheman) (Curculionidae) (Table 4).

Species in five families of predators were affected by lure treatments. Catches of *Thanasimus dubius* (F.) (Cleridae) were affected by ipsdienol and the interaction between ipsdienol and ipsenol (Table 2). Catches in traps baited with ipsdienol caught the most *T. dubius* with the addition of ipsenol interrupting attraction (Table 3). In contrast, ipsenol and the interaction between ipsdienol and ipsenol affected catches of *Platysoma* spp. (Histeridae) (Table 2) with catches greatest in traps baited with ipsenol and lowest in those not baited with either ipsdienol or ipsenol (Table 3). The addition of ipsdienol to traps baited with ethanol + α-pinene

Table 3. Mean ($\pm$ SE) catches of beetles in traps baited with ethanol + α -pinene (EA), with or without ipsenol (S) and/or ipsdienol (D), in northcentral Georgia in 2007 ($n = 10$).^{*} (—) indicates none captured.

Family and Species	EA	EA + D	EA + S	EA + D + S
Cerambycidae				
<i>Acanthocinus obsoletus</i>	0.7 $\pm$ 0.3a	7.0 $\pm$ 2.0b	7.0 $\pm$ 2.1b	8.8 $\pm$ 2.1b
<i>Monochamus titillator</i>	2.2 $\pm$ 0.8a	17.9 $\pm$ 2.9b	23.4 $\pm$ 4.7b	22.5 $\pm$ 2.7b
Cleridae				
<i>Thanasimus dubius</i>	0.4 $\pm$ 0.2a	0.7 $\pm$ 0.3a	1.9 $\pm$ 0.5b	0.2 $\pm$ 0.1a
Curculionidae				
<i>Hylastes salebrosus</i>	9.2 $\pm$ 1.0ab	10.5 $\pm$ 1.8b	11.6 $\pm$ 1.2b	5.4 $\pm$ 0.8a
<i>Ips avulsus</i>	1.8 $\pm$ 0.9a	10.1 $\pm$ 1.5b	15.4 $\pm$ 1.8	44.1 $\pm$ 7.3c
<i>Ips calligraphus</i>	0.7 $\pm$ 0.2a	7.1 $\pm$ 1.7c	2.1 $\pm$ 0.4b	8.8 $\pm$ 1.0c
<i>Ips grandicollis</i>	32.3 $\pm$ 3.2a	26.1 $\pm$ 3.0a	152.3 $\pm$ 19.8b	131.4 $\pm$ 19.4b
<i>Orthotomicus caelatus</i>	2.2 $\pm$ 0.4a	9.8 $\pm$ 1.3b	3.1 $\pm$ 0.7a	4.2 $\pm$ 0.8a
Histeridae				
<i>Platysoma</i> spp.	4.2 $\pm$ 1.1a	16.5 $\pm$ 2.4b	72.4 $\pm$ 5.4d	48.3 $\pm$ 2.4c
Trogossitidae				
<i>Temnoscheila virescens</i>	23.1 $\pm$ 3.1a	52.9 $\pm$ 6.7b	54.6 $\pm$ 7.6b	58.5 $\pm$ 6.1b
Zopheridae				
<i>Aulonium tuberculatum</i>	—	1.7 $\pm$ 0.5a	9.7 $\pm$ 2.1b	9.1 $\pm$ 1.4b
<i>Lasconotus</i> spp.	57.6 $\pm$ 8.1a	39.4 $\pm$ 8.4a	141.2 $\pm$ 24.3b	63.2 $\pm$ 15.7a

^{*} Means in row followed by different lowercase letters are significantly different at $P < 0.05$ (Holm-Sidak test).

increased catches of *Platysoma* spp. but decreased catches in traps baited with ethanol + α -pinene + ipsenol.

Catches of the predators *Temnoscheila virescens* (F.) (Trogossitidae) and *Lasconotus* spp. (Zopheridae) were affected by all three model factors (Table 2). Trap catches of *T. virescens* in traps baited with ethanol + α -pinene increased with the addition of either ipsdienol or ipsenol (Table 3). There was no significant increase in catches in traps baited with both compounds compared to traps baited with each ipsdienol or ipsenol separately. In contrast, catches of *Lasconotus* spp. occurred in traps baited with ipsenol + ipsdienol negating attraction (Table 3). There

Table 4. Mean ($\pm$ SE) catches, and *F* and *P* values (ANOVA) for beetle species not affected by the lure treatments (ipsdienol and/or ipsenol) in northcentral Georgia in 2007 (*n* = 10).

Family and Species	Mean $\pm$ SE	<i>F</i> _{3,27}	<i>P</i>
Buprestidae			
<i>Buprestis lineata</i>	10.7 $\pm$ 1.0	2.466	0.084
Carabidae			
<i>Coptodera aerata</i>	8.6 $\pm$ 0.7	0.319	0.812
Cerambycidae			
<i>Acanthocinus nodosus</i>	0.8 $\pm$ 0.1	0.643	0.643
<i>Arhopalus rusticus</i>	1.5 $\pm$ 0.6	0.749	0.533
<i>Neoclytus scutellaris</i>	1.9 $\pm$ 0.4	1.193	0.331
<i>Xylotrechus sagittatus</i>	6.8 $\pm$ 0.8	0.961	0.425
Curculionidae			
<i>Dendroctonus terebrans</i>	25.5 $\pm$ 2.2	2.768	0.061
<i>Dryophthorus americanus</i>	1.2 $\pm$ 0.2	1.114	0.361
<i>Dryoxylon onoharaense</i>	74.7 $\pm$ 5.7	1.615	0.209
<i>Hylastes tenuis</i>	14.3 $\pm$ 0.9	1.973	0.142
<i>Hylobius pales</i>	6.0 $\pm$ 0.6	0.224	0.879
<i>Monarthrum fasciatum</i>	1.0 $\pm$ 0.3	1.330	0.285
<i>Monarthrum mali</i>	2.4 $\pm$ 0.4	0.307	0.820
<i>Pachylobius picivorus</i>	34.0 $\pm$ 1.9	1.884	0.156
<i>Stenoscelis brevis</i>	1.0 $\pm$ 0.2	2.611	0.072
<i>Xyleborinus saxesenii</i>	53.1 $\pm$ 2.9	0.522	0.671
<i>Xylosandrus crassiusculus</i>	23.4 $\pm$ 2.0	1.415	0.260
Elateridae			
<i>Alaus myops</i>	3.5 $\pm$ 0.3	1.543	0.226
Passandridae			
<i>Catogenus rufus</i>	1.3 $\pm$ 0.2	1.235	0.316
Trogossitidae			
<i>Tenebroides</i> spp.	1.7 $\pm$ 0.2	0.045	0.987
Zopheridae			
<i>Pycnomerus sulcicollis</i>	3.3 $\pm$ 0.4	1.017	0.401

was a significant effect of lure treatments on catches of the predator *Aulonium tuberculatum* LeConte (Zopheridae) ($F_{2,18} = 8.530$, $P = 0.002$); none were caught in traps baited solely with ethanol + α -pinene (Table 1). Catches were greatest in traps baited with ipsenol or ipsdienol + ipsenol (Table 3). There was no lure effect on catches of the predators *Tenebroides* spp. (Trogossitidae) and the fungivore *Pycnomerus sulcicollis* LeConte (Zopheridae) (Table 4).

Discussion

The objective of lure combinations in detection programs for bark and woodboring beetles and associated species is to detect the maximum number of species. The abundance of some species can be enhanced by various combinations, whereas others may be reduced. In assessing the trade-off, managers should retain lure combinations that satisfy their objectives in a detection program. Abundance for these species in traps is likely associated with the likelihood of detecting those species when population numbers are low.

The answer to the question of retaining ipsdienol and/or ipsenol in a generic pine beetle blend is unclear from the current study. Decisions by managers will likely depend on target groups for their programs. For example, with bark beetles, only catches of *I. avulsus* benefited from both compounds being added to the blend (Table 3). Results were mixed for the other four species of bark beetles. Catches of three species were lower in traps baited with both ipsdienol and ipsenol than in traps baited with the compounds individually. Catches of three other species of bark beetles, two species of reproduction weevils, and five species of ambrosia beetles in traps baited with ethanol + α -pinene were not adversely affected by ipsdienol and/or ipsenol (Table 4). To maximize detection, managers may want to use two traps for detection of bark beetles, one baited with ethanol + α -pinene + ipsdienol and a second baited with ipsenol instead of ipsdienol. If the species of interest is *I. avulsus*, then managers may want to delete ethanol and α -pinene, as both compounds reduce catches of that species (Miller and Crowe 2018, Miller 2020). The best lure blend for *I. avulsus* is ipsenol + ipsdienol + lanierone (Miller et al. 2005).

With respect to predators, only the attraction of *T. virescens* to traps baited with ethanol + α -pinene was enhanced by the addition of either ipsdienol or ipsenol, with no benefit of including both compounds in the blend (Table 3). In contrast, catches of three other predatory species were enhanced by the addition of ipsenol but not ipsdienol. Addition of ipsdienol to traps baited with ipsenol negated the attractiveness of ipsenol in the blend for *Lasconotus* spp. (Table 3). Although ipsdienol enhanced catches of *Platysoma* spp., catches were highest in traps baited with ipsenol. Ipsdienol reduced catches of *Platysoma* spp. in traps baited with ipsenol (Table 3). For detection of predators, preference by managers for traps baited with ethanol + α -pinene + ipsenol may be in order. However, in management programs for bark and woodboring beetles, managers would likely prefer to avoid depletions of predators that may be controlling pest species. In such cases, ipsdienol should be the preferred compound to add to traps baited with ethanol + α -pinene.

In a study across North America, adding the binary blend of ipsdienol + ipsenol enhanced catches of *Monochamus* spp. in traps baited with ethanol + α -pinene (Miller et al. 2013). For two species of Cerambycidae in the present study, attraction to traps baited with ethanol + α -pinene was enhanced by the addition of ipsdienol or ipsenol, but there was no benefit of including both compounds in the blend (Table 3). There was no adverse effect of either compound on catches of four other species of cerambycids in traps baited with ethanol + α -pinene. Similar results were found with ipsdienol and ipsenol for *Monochamus scutellatus* (Say) and *Monochamus clamator* (LeConte) in traps cobaited with α -pinene or ethanol + α -pinene in British Columbia (Allison et al. 2003). However, it is possible that both ipsdienol and ipsenol may not be required for all these species. For example, ipsenol was as effective as monochamol (a pheromone used by numerous *Monochamus* spp.) in trapping four of seven species of *Monochamus* and enhanced catches in traps baited with monochamol for six of the seven species (Miller et al. 2016).

This study was conducted at one location in north-central Georgia. Clearly, additional studies are required with numerous other species over a broad geographic area. It is possible that the addition of other pheromones to traps baited with ethanol + α -pinene + ipsenol might yield better results than ipsdienol for a broad, generic lure blend for bark and woodboring beetles, at least in the Southeast. For example, various species of woodborers are attracted to traps baited with fuscumol and sulcatol in Georgia (Miller 2022). Allison et al. (2012b) found that catches of *M. titillator* and *Monochamus carolinensis* Olivier in traps baited with α -pinene were enhanced by the addition of the hardwood cerambycid pheromone *syn*-2,3-hexanediol. More focused research is required to develop multifunctional lure blends for the detection of bark and woodboring beetles in the future.

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