THE ATTRACTIVENESS OF MANUKA OIL AND ETHANOL, ALONE AND IN COMBINATION, TO *XYLEBORUS GLABRATUS* (COLEOPTERA: CURCULIONIDAE: SCOLYTINAE) AND OTHER CURCULIONIDAE

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The increasing volume of international commerce in the last century has resulted in an exchange of organisms at an alarming rate. Among those exhibiting a significant threat to forests are the bark and ambrosia beetles and their associated fungi. Between 1985 and 2005, 18 scolytinae species introductions to the U.S. were recorded, and others have been documented since (Haack 2006; Rabaglia et al. 2010). The redbay ambrosia beetle, *Xyleborus glabratus* Eichhoff (Coleoptera: Curculionidae: Scolytinae) and the associated laurel wilt fungus (*Raffaela lauricola* Harrington, Fraedrich & Aghayeva) (Harrington et al. 2008), is one such insect-fungus species complex. First detected in Port Wentworth, Georgia in 2002, the beetle and pathogen have since spread to North and South Carolina, Alabama, Mississippi, and Florida (Bates et al. 2013).

Female beetles carry the symbiotic fungus in mandibular mycangia and inoculate hosts upon attack during gallery formation, ultimately resulting in death of the host (Fraedrich et al. 2008). Beetles readily attack and transmit the lethal laurel wilt fungus to healthy redbay [*Persea borbonia* (L.) Spreng; Laurales: Lauraceae] and swamp bay [*Persea palustris* (Raf.) Sarg.], and to a lesser degree, other members of the family Lauraceae, including sassafras [*Sassafras albidum* (Nutt.) Nees] and avocado (*Persea americana* Mill.) (Fraedrich et al. 2008; Hanula et al. 2008; Kendra et al. 2011a). Confirmed cases of the disease have been reported in Florida's commercial avocado (*Persea americana* Mill.) plantations, and there is considerable concern over the risk posed to the $ 23.5 million/year avocado industry (USDA Economic Research Service 2013). Early detection of this destructive pest is an integral part of managing populations.

Xyleborus glabratus is not known to possess a long range sex pheromone and this aspect of its biology limits trapping efforts to using host volatiles. Unlike other Xyleborini, it is not attracted to ethanol [Hanula et al. 2008, 2011; Kendra et al. 2014]. It is, however, attracted to manuka oil (from *Leptospermum scoparium* Forst. & Forst. [Myrtaceae]), phoebe oil (from *Phoebe porosa* Mex. [Lauraceae]), and cubeb oil (from *Piper cubeba* L. [Piperaceae]) species which possess sesquiterpenes also present in Lauraceae species in the U.S. (Hanula & Sullivan 2008; Hanula et al. 2013; Kendra et al. 2011a, b). Unfortunately, because most Xyleborini are attracted to ethanol, national pest survey programs use ethanol and do not incorporate any of these extracts (Miller & Rabaglia 2009). The objectives of this study were to determine if the addition of manuka oil to ethanol would inhibit the responses of Xyleborini and other Curculionidae with known attraction to ethanol, and whether or not the combination of these attractants would alter the attractiveness of manuka oil to the redbay ambrosia beetle.

Sets of 3 Lindgren 8-unit funnel traps baited with ultra-high release ethanol lures (prod. no. 6160, Synergy Semiochemicals Corp., Burnaby, British Columbia, Canada), manuka oil (whole lure, Synergy Semiochemicals Corp. prod. no. P-385), or ethanol + manuka oil were deployed in random order along a straight line ca. 15 m apart from 15 May-18 Jun 2011 at each of 6 widely dispersed laurel wilt (LW) monitoring plots in SE Georgia (Cameron et al. 2012). Trapping sites were selected to represent varying stages of LW disease development and ambrosia beetle population levels. Curculionidae collected were identified to genus and species where possible.

The data were analyzed as a complete randomized block design ANOVA using SAS ver. 9.1 (SAS Institute 2002-2003). The dependent variables were total Curculionidae (individuals) and total curculionid species collected among treatments. The analysis of total beetles collected among treatments required the data be log-transformed to meet the assumptions of ANOVA. Post-hoc means were compared using the Ryan-Einot-Gabriel-Welsch test (Day & Quinn 1989).

Nineteen Scolytinae species and one Cossoninae species [*Stenoscelis brevis* (Boheman)] were collected and identified (and a number of unidentified specimens within the genus *Hypothenemus*) over the course of the experiment (Table 1). Analyses of total species and total beetles indicated a significant treatment effect [(F = 14.96; df = 2, 10; P = 0.0010); (F = 13.22; df = 2, 10; P = 0.0016), respectively]. Significantly more species and beetles were collected in traps baited with either ethanol alone or ethanol plus manuka oil than in those with manuka oil alone (Table 2). Collection of total species and individuals in traps baited with ethanol alone did not significantly differ from those baited with both manuka oil and ethanol (Table 2).

The purpose of this study was to determine if manuka oil affected trap captures of beetles responding to ethanol and vice versa. With that in mind, this study shows that ethanol is relatively attractive to many Scolytinae when compared to manuka oil and the combination of the two did not reduce the number of species or total beetles captured but, as found by others, ethanol is not attractive to *X. glabratus* (Hanula & Sullivan 2008; Hanula et al. 2008, 2011; Kendra et al. 2014). Ethanol also appeared less attractive to the Cossoninae species *S. brevis*, which is unexpected given that others report finding this little understood species and a sister species, *S. andersoni* Buchanan, in dead or dying woody species (Anderson 1952; Ulyshen & Hanula 2009). Such hosts would typically release ethanol and presumably attract species found in these circumstances (Klimetzek et al. 1986; Montgomery & Wargo 1983). As reported by Kendra et al. (2014), we did not find a large difference in total Scolytinae (excluding *X. glabratus*) collected between the ethanol and ethanol + manuka oil treatments (286 and 254 beetles, respectively). While our collections of individual species were too low to test any inhibitory effects of manuka oil on attracting specific species, we observed that different species comprised the total when using ethanol alone or both the ethanol + manuka oil attractants, suggesting the possibility cannot be ruled out. Further replication and attention to site characteristics which would affect local Scolytinae population abundance and diversity would be required to test this hypothesis.

TABLE 1. TOTAL CURCULIONIDAE CAPTURED IN TRAPS BAITED WITH ETHANOL, MANUKA OIL OR BOTH ATTRACTANTS FROM 15 MAY-18 JUN 2011 IN GEORGIA.

	Ethanol	Ethanol + Manuka Oil	Manuka Oil	TOTAL
Subfamily Cossoninae				
Stenoscelis brevis (Boheman)	0	2	17	19
Subfamily Scolytinae				
Ambrosiodmus obliquus (LeConte)	0	1	0	1
Ambrosiodmus rubricollis (Eichhoff)	0	0	1	1
Ambrosiophilus atratus (Eichhoff)	2	0	1	3
Cnesinus strigicollis LeConte	1	0	0	1
Cnestus mutilatus (Blandford)	3	0	0	3
Cyclorhipidion bodoanum (Reitter)	5	8	0	13
Dryoxylon onoharaensis (Murayama)	11	7	0	18
Gnathotrichus materiarius (Fitch)	1	7	2	10
Hypothenemus rotundicollis (Eichoff)	0	1	0	1
Hypothenemus sp.	14	0	0	14
Monarthrum fasciatum (Say)	1	1	0	2
Monarthrum mali (Fitch)	5	6	1	12
Pityophthorus lautus Eichhoff	1	0	0	1
Xyleborinus saxesenii (Ratzeburg)	96	37	0	133
Xyleborus affinis Eichhoff	1	2	0	3
Xyleborus ferrugineus (Fabricius)	3	28	2	33
Xyleborus glabratus Eichhoff	4	75	38	117
Xyleborus pubescens Zimmermann	0	1	0	1
Xylosandrus compactus (Eichhoff)	1	1	1	3
Xylosandrus crassiusculus (Motschulsky)	141	152	2	295
TOTAL	290	329	65	684

TABLE 2. MEAN NUMBER OF CURCULIONIDAE SPECIES AND TOTAL NUMBER OF BEETLES CAPTURED IN TRAPS BAITED WITH ETHANOL, MANUKA OIL OR BOTH ATTRACTANTS FROM 15 MAY-18 JUN 2011 IN GEORGIA.

		No. of Species		Total Beetles	
Treatment	N	Mean	SE	Mean[1]	SE
Ethanol	6	6.0 a	0.58	48.3 a	17.43
Ethanol+Manuka Oil	6	6.7 a	1.05	54.8 a	29.59
Manuka Oil	6	2.0 b	0.82	10.8 b	9.26

Means followed by the same letter are not significantly different ($P < 0.05$).
[1]Mean total beetles log-transformed for analysis. Untransformed means presented.

SUMMARY

The addition of a trap baited with manuka oil or longer lasting cubeb oil lures (Hanula et al. 2013) along with those baited with ethanol for surveys targeting detection of non-native, invasive Curculionidae could improve these surveys by also targeting the destructive redbay ambrosia beetle.

Key Words: attractant, detection, invasive species, laurel wilt, Lindgren funnel trap, survey

RESUMEN

La adición del señuelo de aceite de manuka a trampas cebadas con etanol en los sondeos de detección de Curculionidae no nativos invasivos puede mejorar estos sondeos al también detectar el destructivo e invasivo escarabajo ambrosia del laurel rojo.

Palabras Clave: atrayente, detección, especies invasoras 017, marchitez del laurel, trampa embudo Lindgren, sondeo

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