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Trap Response of Michigan Social Wasps (Hymenoptera: Vespidae) to the Feeding Attractants Acetic Acid, Isobutanol, and Heptyl Butyrate.

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TRAP RESPONSE OF MICHIGAN SOCIAL WASPS (HYMENOPTERA: VESPIDAE) TO THE FEEDING ATTRACTANTS ACETIC ACID, ISOBUTANOL, AND HEPTYL BUTYRATE.

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ABSTRACT

Nine species of social wasps were captured in traps baited with acetic acid, isobutanol, heptyl butyrate and combinations of acetic acid and either isobutanol or heptyl butyrate. Three yellowjacket species in the *Vespula rufa* species group were captured in traps (*Vespula acadica* (Sladen), *Vespula consobrina* (Saussure), *Vespula vidua* (Saussure)). They responded similarly, with attraction only to heptyl butyrate. Three yellowjacket species in the *Vespula vulgaris* species group were also captured in traps (*Vespula vulgaris* (L.), *Vespula flavopilosa* Jacobson, *Vespula maculifrons* (Buyyson)). They responded similarly, with attraction primarily to the combination of acetic acid and isobutanol. The bald-faced hornet, *Dolichovespula maculata* (L.), was attracted to acetic acid and was more strongly attracted to the combination of acetic acid and isobutanol. The aerial yellowjacket, *Dolichovespula arenaria* (Fabr.), was attracted to isobutanol, and was more strongly attracted to the combination of acetic acid and isobutanol. These results add to our understanding of how to target various species of social wasps with chemical lures.

Several chemicals have been identified as attractants for workers of various species of social wasps. Heptyl butyrate and structurally-related compounds are strongly attractive to the yellowjackets *Vespula pensylvanica* (Saussure) and *Vespula atropilosa*, (Sladen) in the western U.S. (Davis et al. 1969, MacDonald et al. 1973), and somewhat attractive to *Vespula squamosa* (Drury) in the southeastern U.S. (Sharp and James 1979, Landolt et al. 2003). In these studies, small numbers of other species of wasps were trapped, but it is not clear if they were attracted to the chemicals tested. The combination of acetic acid with isobutanol is attractive to a number of species of yellowjackets as well as the bald-faced and European hornets and several paper wasps in the genus *Polistes* (Landolt 1998, 1999, Landolt et al. 2000). These chemicals have been evaluated and developed as attractants for trapping of nuisance wasps.

Despite these studies, there are large gaps in our knowledge of wasp responses to these chemicals. Results of studies by Grothaus et al. (1973) and Howell et al. (1974) have led to the conclusion that heptyl butyrate and related compounds are unattractive or are weakly attractive to species of wasps in the eastern U.S. (Akre et al. 1980, Sharp and James 1979). However, controlled, replicated experiments have yet to be done to evaluate attraction responses of some social wasp species to heptyl butyrate, which is in commercial use as a lure for wasps (i.e., Sterling International Inc., Spokane, WA). Similarly, tests with acetic acid and isobutanol have not been made in areas possessing populations of some wasp species. A comparison was made of wasp responses to these two attractants in the state of Washington for *Vespula germanica* (Fabr.), *V. pensylvanica*, and *Polistes aurifer* (Fabr.) (Landolt 1998, 1999), which helped assess the relative attractiveness of the lures to these wasps.

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In an effort to add to this knowledge base, we conducted a comparison of chemical attractants for wasps in northern Michigan, in a forested area possessing a number of species not previously targeted for studies with these chemical attractants. The objectives of this study were to (1) determine if the species of wasps known to be present are attracted to heptyl butyrate or are attracted to the combination of acetic acid and isobutanol, and to (2) gain some comparative insights into relative strengths of the attractants, where they are attractive to the same species of wasp.

MATERIALS AND METHODS

Five different chemical treatments were compared as attractants for trapping species of social wasps. These chemical treatments were 1) acetic acid, 2) isobutanol, 3) acetic acid and isobutanol, 4) heptyl butyrate, and 5) acetic acid and heptyl butyrate. All chemicals were dispensed from 8 ml polypropylene vials with 3 mm holes in the lid, using the system described by Landolt and Alfaro (2001) for trapping noctuid moths with acetic acid and 3-methyl-1-butanol. Five ml of a chemical were pipetted onto 2 cotton balls in the bottom of each vial. Traps were the Agrisense Trappit® (or Dome trap), which is a wet trap design that is opaque yellow below and clear above, with the trap entrance in the invaginated trap bottom. Traps contained 200 ml of a dilute soap solution (0.01% Dawn dishwashing liquid soap) to drown trapped wasps. The vial chemical dispensers were wired in place inside the top of the trap. Where two chemicals were tested together as one treatment, two vials were placed side by side within the trap.

Traps were hung in shrubbery and on tree branches in a forested area at the Au Sable Institute of Environmental Studies, 14 km southeast of Mancelona, Kalkaska County, Michigan. A randomized complete block design was used, with 5 replicate blocks of 6 treatments: the 5 chemical treatments plus an unbaited trap. Traps were placed about 10 m apart within blocks. The thirty traps were set out on 20 June 2001 and were checked weekly until 15 August 2001. During weekly checks, the drowning solution was changed, all captured insects were removed, and trap positions within blocks were randomized to provide additional replicates. A total of 40 replicates were obtained over the 8 weeks period. Lures were changed after 4 weeks.

For each species, weekly trap catch data were subjected to an analysis of variance (ANOVA), with means separated by Tukey's test following a significant F value in the ANOVA (DataMost 1995). For each species, block replicates that provided zero trap catches for all treatments for a week were not included in the analyses. Thus, for each species, the total number of replicates varied.

RESULTS

Nine different species of social wasps were captured in this study, in three different genera. Trap capture data for these 9 species is summarized in Table 1. Species of social wasps trapped were identified using Akre et al. (1980) and Jacobson et al. (1978). For all 9 species, numbers of worker wasps captured were sufficient to permit statistical analysis of the data. Wasps in the genera *Vespula* and *Dolichovespula* captured were generally workers, and *P. fuscatus* captured were females.

Numbers of *P. fuscatus* paper wasps captured in traps baited with the combination of acetic acid and isobutanol were significantly greater than in the unbaited traps. All other chemical lure treatments did not increase captures of that wasp in baited traps compared to control traps.

Numbers of *Dolichovespula maculata* (L.) captured were significant (greater than controls) for traps baited with acetic acid, acetic acid plus heptyl butyrate, and acetic acid plus isobutanol. The combination of isobutanol and

Table 1. Total numbers of wasps captured 20 June - 15 August 2001 in all traps, and mean ± SE numbers of wasps per trap per week for chemical treatments used as lures in traps. AA is acetic acid, IB is isobutanol, AAIB is acetic acid with isobutanol, HB is heptyl butyrate, and AAHB is acetic acid with heptyl butyrate.

Species	N		Control	AA	IB	AAIB	HB	AAHB
Dolichovespula arenaria	10	Totals	0	3	7	11	1	0
		Means	0.00 ± 0.00a	0.30 ± 0.21a	0.70 ± 0.30b	1.10 ± 0.30c	0.10 ± 0.10a	0.00 ± 0.00a
Dolichovespula maculata	35	Totals	2	161	4	340	2	88
		Mean	0.05 ± 0.05a	4.60 ± 2.18b	0.10 ± 0.07a	9.70 ± 2.64c	0.05 ± 0.05a	2.50 ± 1.06b
Polistes fuscatus	3	Total	0	1	0	4	0	0
		Mean	0.00 ± 0.00a	0.33 ± 0.33a	0.00 ± 0.00a	1.33 ± 0.33b	0.00 ± 0.00a	0.00 ± 0.00a
Vespula acadica	17	Total	0	1	0	0	52	33
		Mean	0.00 ± 0.00a	0.06 ± 0.06a	0.00 ± 0.00a	0.00 ± 0.00a	3.06 ± 076c	1.94 ± 0.62b
Vespula consobrina	23	Total	0	0	0	0	47	49
		Mean	0.00 ± 0.00a	0.00 ± 0.00a	0.00 ± 0.00a	0.00 ± 0.00a	2.04 ± 0.49b	2.13 ± 0.72b
Vespula vidua	27	Total	0	1	0	0	97	70
		Mean	0.00 ± 0.00a	0.04 ± 0.04a	0.00 ± 0.00a	0.00 ± 0.00a	3.59 ± 0.94c	2.59 ± 0.67b
Vespula flavopilosa	21	Total	4	23	9	180	8	15
		Mean	0.19 ± 0.11a	1.10 ± 0.47a	0.43 ± 0.16a	8.57 ± 2.99b	0.29 ± 0.11a	0.57 ± 0.18a
Vespula maculifrons	20	Total	8	4	21	78	4	8
		Mean	0.40 ± 0.17a	0.20 ± 0.12a	1.05 ± 0.31b	3.90 ± 0.80c	0.20 ± 0.12a	0.40 ± 0.18a
Vespula vulgaris	25	Total	3	1	5	74	1	0
		Mean	0.12 ± 0.06a	0.04 ± 0.04a	0.20 ± 0.08a	2.96 ± 0.69b	0.04 ± 0.04a	0.00 ± 0.00a

* Means in a row followed by the same letter are not significantly different at $p > 0.05$ by Tukey's test.
** N = number of replicates. Five replicates were set out each week for 8 weeks. For each species, replicates in which all treatments provided zero trap catches were excluded.

acetic acid was superior to acetic acid or isobutanol alone. Numbers of *D. maculata* wasps captured with the combination of heptyl butyrate and acetic acid were not significantly greater than with acetic acid alone.

Although only 22 *Dolichovespula arenaria* (Fabr.) were captured, numbers were significant for traps baited with isobutanol and with the combination of acetic acid and isobutanol. Additionally, the combination of acetic acid and isobutanol attracted more *D. arenaria* than did either isobutanol or acetic acid alone.

The three species in the *Vespula rufa* species group (Bequaert 1931), *Vespula acadica* (Sladen), *Vespula consobrina* (Saussure), and *Vespula vidua* (Saussure), all responded significantly to heptly butyrate and the combination of acetic acid with heptyl butyrate and not to other lure treatments (Table 1). Numbers of *V. acadica* were significantly greater in traps baited with heptyl butyrate in comparison to the combination of acetic acid and heptyl butyrate.

The three species in the *Vespula vulgaris* species group (Bequaert 1931, Jacobson et al. 1978), *Vespula flavopilosa* Jacobson, *Vespula maculifrons* (Buysson), and *Vespula vulgaris* (L.), were all significantly attracted to the combination of isobutanol and acetic acid, and were not trapped with heptyl butyrate. Numbers of *V. maculifrons* captured in traps baited with isobutanol alone were also significantly greater than numbers captured in unbaited traps.

DISCUSSION

The results of this study clearly demonstrate for the first time the attraction of several species of social wasps to heptyl butyrate and of several other species of social wasps to the combination of acetic acid and isobutanol. Heptyl butyrate is a strong attractant for the yellowjackets *V. pensylvanica* and *V. atropilosa* ((Davis et al. 1969, 1973, MacDonald et al. 1973) and had been considered unattractive or a weak attractant for *V. squamosa* (Grothaus et al. 1973, Howell et al. 1974). We here demonstrated attraction of *V. acadica, V. consobrina* and *V. vidua* to the same compound. These three species in the *Vespula rufa* species group have been captured before in traps baited with heptyl butyrate (Reierson and Wagner 1978), but these were not controlled experiments that might demonstrate attractiveness to the chemical.

The combination of isobutanol and acetic acid was known previous to this study to be attractive to *V. pensylvanica* and *V. germanica* (Landolt 1998), *Polistes aurifer* Saussure (Landolt 1999), and *V. maculifrons*, *V. squamosa*, *Vespa crabro* (L.), *D. maculata*, *Polistes fuscatus* (F.), *Polistes metricus* (Say), and *Polistes dominulus* Fabr.(Landolt et al. 2000). The results summarized in this paper support previous evidence of *D. maculata*, *P. fuscatus*, and *V. maculifrons* attraction to this lure (Landolt et al. 2000) and also demonstrate attraction of *D. arenaria*, *V. flavopilosa*, and *V. vulgaris* wasps to acetic acid with isobutanol.

For most of the 9 species of wasps that were trapped, acetic acid alone was not attractive, although in several species acetic acid enhanced responses to isobutanol. The exception was *D. maculata*, which was captured in traps baited with acetic acid alone. This finding is consistent with the earlier results of trapping experiments in Maryland and Oklahoma (Landolt et al. 2000), demonstrating attraction of *D. maculata* to acetic acid alone. *Vespula pensylvanica*, *V. squamosa*, *V. maculifrons*, *P. fuscatus*, *Polistes perplexus* Cresson, and *Polistes annularis* (L.) were weakly attracted to acetic acid in another study (Landolt et al. 2000).

For *D. maculata, D. arenaria, P. fuscatus, V. flavopilosa, V. maculifrons, and V. vulgaris*, numbers of wasps trapped with the combination of acetic acid and isobutanol were greater than the sums of the numbers trapped with either compound tested separately. That is, the trap catch data indicate that the two chemicals were enhancing or synergistic in attracting these wasps. This pattern is consistent with that seen in previous studies demonstrating attraction of social wasps to these two chemicals, including *D. maculata*, *P. fuscatus*, and *V. maculifrons* (Landolt et al. 2000).

For those species of wasps attracted to heptyl butyrate, there was no indication of any enhancement or synergism with the combination of heptyl butyrate and acetic acid. For *V. acadica*, *V. consobrina*, and *V. vidua*, responses to the combination of acetic acid and heptyl butyrate appear to be due simply to a response to heptyl butyrate. In the case of *D. maculata*, the response to the combination of acetic acid and heptyl butyrate appears to be due solely to the response to acetic acid.

With this added information on wasp responses to these lures, taxonomic patterns are more evident. For example, the three species of yellowjackets that are in the *Vespula rufa* species group, *V. acadica*, *V. consobrina*, and *V. vidua*, responded in a similar fashion to the lures, with significant responses to heptyl butyrate and not to isobutanol and acetic acid. This response was the same as that observed for the related species *V. atropilosa* (Landolt 1998). For the three species of yellowjackets in the *Vespula vulgaris* species group, *V. flavopilosa*, *V. maculifrons*, and *V. vulgaris*, responses were also similar, with significant attraction to the combination of acetic acid and isobutanol, and with no response to heptyl butyrate or acetic acid. This attraction pattern is similar to that observed previously for another species in the *V. vulgaris* species complex, *V. germanica*, and confirms previous findings for *V. maculifrons*. Results with *V. pensylvanica* however (Landolt 1998) are contrary to this pattern. *Vespula pensylvanica* is in the *V. vulgaris* species group (Bequaert 1931) but responds well to both types of lures: heptyl butyrate and the combination of acetic acid and isobutanol. Several species of *Polistes* in the *Fuscopolistes* subgenus (Richards 1978) are attracted to the combination of acetic acid and isobutanol, including *P. fuscatus, P. aurifer, P. metricus* (Landolt 1999, Landolt et al. 2000). Species of *Polistes* do not appear to respond to heptyl butyrate, but may respond weakly to acetic acid (Landolt et al. 2000). As in other studies, the strengths of responses to these chemicals by different wasp species are not determined. For example, it is not known if low, but significant, numbers of wasps in traps are due to a weak response or are due to low populations or low activity at the trapping site. In this study, that is a question particularly for *D. arenaria*. Although numbers in traps baited with isobutanol and acetic acid with isobutanol were statistically significant, they were a small fraction of the numbers captured of other species. This wasp was not captured in significant numbers in trapping studies conducted in Maryland (Landolt 2000), where it is generally present (Akre et al. 1980).

As a practical matter, it is important to know which species of wasps might be trapped with different chemicals. For example, yellowjackets in the *V. vulgaris* species group are considerably more pestiferous than yellowjackets in the *V. rufa* species group, due to differences in nesting phenology, colony size, and foraging behavior. It would not be advantageous to trap species of wasps in the *V. rufa* group with heptyl butyrate in an area where members of the *V. vulgaris* group are problematic but are not attracted to heptyl butyrate. However, the results here and elsewhere (Davis et al. 1969; Landolt 1998; Landolt 1999; Landolt et al. 2000, 2003; Day and Jeanne 2001) indicate that most, if not all, North American vespine wasps are attracted either to heptyl butyrate, to the combination of acetic acid and isobutanol, or to both lures.

It is interesting that there were no wasp species in this study that responded to both lures: either they were attracted to heptyl butyrate or they were attracted to acetic acid with isobutanol. This underscores the uniqueness of *V. pensylvanica* which can be trapped with heptyl butyrate (Davis et al.1969) or acetic acid with isobutanol (Landolt 1998). It is assumed that the attraction responses to these chemicals, evidenced by captures of wasps in traps, are based on differences in wasp food foraging behavior, but there is little information available on the presence of these compounds in materials consumed by wasps.

Acetic acid is a product of microbial fermentation of sugars, while isobutanol is produced in small amounts by the bacteria *Citrobacter freundii* (DeMilo et al. 1996) and was also found in fermented sugar solutions by Utrio and Eriksson (1977). Esters similar to heptyl butyrate are often found in fruit odors (i.e. Mattheis et al. 1991 for apple volatiles). While it seems logical to assume that wasp response to these chemicals is a strategy to locate carbohydrates, specifically sugars, it is not yet known what natural sugar sources might be located by orientation to heptyl butyrate or to acetic acid with isobutanol.

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LITERATURE CITED

Akre, R. D., A. Greene, J. F. MacDonald, P. J. Landolt, and H. G. Davis. 1980. Yellowjackets of America North of Mexico. U.S. Department of Agriculture, Agriculture Handbook No. 552, 102 pp.

Bequaert, J. 1931. A tentative synopsis of the hornets and yellowjackets of America. Entomol. Americana 12: 71-138.

DataMost. 1995. StatMost statistical analysis and graphics. DataMost, Salt Lake City, UT.

Davis, H. G., G. W. Eddy, T. P. McGovern, and M. Beroza. 1969. Heptyl butyrate, a new synthetic attractant for yellow jackets. J. Econ. Entomol. 62:1245.

Davis, H. G., R. W. Zwick, W. M. Rogoff, T. P. McGovern and M. Beroza. 1973. Perimeter traps baited with synthetic lures for suppression of yellowjackets in fruit orchards. Environ. Entomol. 2: 569-571.

Day, S. E. and R. L. Jeanne. 2001. Food volatiles as attractants for yellowjackets (Hymenoptera: Vespidae). Environ. Entomol. 30: 157-165.

DeMilo, A. B., C.-J. Lee, D. S. Moreno, and A. J. Martinez. 1996. Identification of volatiles derived from *Citrobacter freundii* fermentation of a trypticase soy broth. J. Agric. Food Chem. 44: 607-612.

Grothaus, R. H., H. G. Davis, W. M. Rogoff, J. A. Fluno, and J. M. Hirst. 1973. Baits and attractants for east coast yellowjackets, *Vespula* spp. Environ. Entomol. 2: 717-718.

Howell, J. O., T. P. McGovern, and M. Beroza. 1974. Attractiveness of synthetic compounds to some eastern *Vespula* species. J. Econ. Entomol. 67:629-630.

Jacobson, R. S., R. W. Matthews, and J. F. MacDonald. 1978. A systematic study of the *Vespula vulgaris* group with a description of a new yellowjacket species in eastern North America (Hymenoptera: Vespidae). Ann. Entomol. Soc. Amer. 71: 299-312.

Landolt, P. J. 1998. Chemical attractants for trapping yellowjackets *Vespula germanica* and *Vespula pensylvanica* (Hymenoptera: Vespidae). Environ. Entomol. 27: 1229-1234.

Landolt, P. J. 1999. A chemical attractant for the golden paper wasp, *Polistes aurifer* Saussure (Hymenoptera: Vespidae). J. Kansas Entomol. Soc. 71:69-73.

Landolt, P. J. and J. F. Alfaro. 2001. Trapping *Lacanobia subjuncta*, *Xestia c-nigrum*, and *Mamestra configurata* (Lepidoptera: Noctuidae) with acetic acid and 3-methyl-1-butanol in controlled release dispensers. Environ. Entomol. 30: 656-662.

Landolt, P. J., H. C. Reed, J. R. Aldrich, A. L. Antonelli, and C. Dickey. 2000. Social wasps (Hymenoptera: Vespidae) trapped with acetic acid and isobutanol. Florida Entomol. 82: 609-614.

Landolt, P. J., H. C. Reed, and D. J. Ellis. 2003. Trapping yellowjackets (Hymenoptera: Vespidae) with heptyl butyrate emitted from controlled release dispensers. Florida Entomol. (In press).

MacDonald, J. F., R. D. Akre, and W. B. Hill. 1973. Attraction of yellow jackets (*Vespula* spp) to heptyl butyrate in Washington State (Hymenoptera: Vespidae). Environ. Entomol. 2: 375-379.

Mattheis, J. P., J. K. Fellman, P. M. Chen, and M. E. Patterson. 1991. Changes in headspace volatiles during physiological development of Bisbee Delicious apple fruit. J. Agric. Food Chem. 39: 1902-1906.

Reierson, D. A. and R. E. Wagner. 1978. Trapping to determine the sympatry and seasonal abundance of various yellowjackets. Environ. Entomol. 7: 418-422.

Richards, O. W. 1978. The Social Wasps of the Americas Excluding the Vespinae. British Museum of Natural History. London. 580 pp.

Sharp, J. L. and J. James. 1979. Color preference of *Vespula squamosa*. Environ. Entomol. 8: 708-710.

Utrio, P. and K. Eriksson. 1977. Volatile fermentation products as attractants for Macrolepidoptera. Ann. Zool. Fennici 14: 98-104.