SOCIAL WASPS (HYMENOPTERA: VESPIDAE) TRAPPED WITH ACETIC ACID AND ISOBUTANOL

P. J. LANDOLT[1], H. C. REED[2], J. R. ALDRICH[3], A. L. ANTONELLI[4] AND C. DICKEY[2]
[1]USDA-ARS, 5230 Konnowac Pass Rd., Wapato, WA 98951

[2]Dept. Biology, Oral Roberts University, Tulsa, OK 74171

[3]USDA-ARS, Insect Chemical Ecology Laboratory, Beltsville, MD 20705

[4]Washington State University, Puyallup, WA 98371

ABSTRACT

The combination of acetic acid and isobutanol is attractive to different species of Vespidae in different areas of the United States. In Washington, the blend was attractive to workers and queens of *Vespula pensylvanica* (Saussure), *Vespula germanica* (F.), and workers of *Dolichovespula maculata* (L.). In Maryland, these chemicals were attractive to worker *Vespula maculifrons* (Buysson), worker *V. germanica*, worker *Vespula squamosa* (Drury), worker *D. maculata*, worker *Vespa crabro* L., and female *Polistes dominulus* F. In Oklahoma, the blend was attractive to worker *V. maculifrons*, worker *V. squamosa*, female *Polistes fuscatus* (F.), and *Polistes annularis* (L.). Several species were weakly attracted to acetic acid alone; *V. maculifrons* and *D. maculata* in Maryland, and *V. squamosa*, *V. maculifrons*, *P. fuscatus*, *P. perplexus*, and *P. annularis* in Oklahoma. Queens of *V. germanica* in Washington, workers of *V. maculifrons* in Maryland, as well as workers of *V. squamosa* and *V. maculifrons* in Oklahoma were weakly attracted to isobutanol alone.

Key Words: Vespidae, wasps, lures, attractants, traps, acetic acid, isobutanol

RESUMEN

La combinación de ácido acético e isobutanol atrae a diferentes especies de Vespidae en áreas distintas de los Estados Unidos. En el estado de Washington la mezcla atrajo a trabajadores y reinas de *Vespula pensylvanica* (Saussure), *Vespula germanica* (F.) y trabajadores de *Dolichovespula maculata* (L.). En el estado de Maryland, estos químicos fueron atrayentes a trabajadores de *Vespula maculifrons* (Bysson), *V. germanica*, *V. squamosa*, *D. maculata* y *V. cabro*, así como a hembras de *Polistes dominulus* F. En el estado de Oklahoma, la mezcla atrajo a trabajadores de *V. maculfrons* y *V. squamosa*, así como a hembras de *Polistes fuscatus* (F.) y de *Polistes annularis* (L.). Varias especies fueron atraídas de manera leve al ácido acético solo: *V. maculifrons* y *D. maculata* en Maryland y *V. squamosa*, *V. maculifrons*, *P. fuscatus*, *P. perplexus* y *P. annularis* en Oklahoma. Reinas de *V. germanica* en Washington, trabajadores de *V. maculifrons* en Maryland, así como trabajadores de *V. squamosa* y *V. maculifrons* en Oklahoma, fueron atraídos de manera ligera al isobutanol solo.

Chemical attractants are valuable management tools for pest insects, including many social wasps, and yet are not available for use for many pest species of Vespidae. A wide variety of food baits are attractive to some yellowjacket species (*Vespula*) (Spurr 1995, 1996), indicating strong chemotactic responses of wasps to food materials. Heptyl butyrate and octyl butyrate are strongly attractive to the western yellowjacket *V. pen-*

sylvanica (Saussure) and to *Vespula atropilosa* (Sladen) (Davis et al. 1969, 1972), but are only weakly attractive to other North American vespids (Grothaus et al. 1973, Howell et al. 1974, Sharp and James 1979). More effective chemical attractants are needed for other pestiferous species, such as the eastern yellowjacket *Vespula maculifrons* (Buysson), the southern yellowjacket *Vespula squamosa* (Drury), and some species of *Polistes*.

The combination of acetic acid and isobutanol is attractive to some species of social wasps and is useful as a bait for traps (Landolt 1998, 1999). Workers of *V. pensylvanica* and workers of the German yellowjacket, *Vespula germanica* (F.), as well as females and males of the golden paper wasp, *Polistes aurifer* Saussure, were captured in traps baited with this combination of chemicals in Yakima County, Washington (Landolt 1998). This chemical blend is probably a feeding attractant because the compounds were isolated from fermented molasses solutions which are attractive to many insects (Frost 1926, Ditman and Cory 1933, Landolt 1995), including Vespidae (Thomas 1960). The combination of acetic acid and isobutanol is the first chemical attractant useful for trapping *V. germanica* (Landolt 1998) and the first chemical attractant for any species of *Polistes* (Landolt 1999).

We report here a series of field tests to determine what species of social wasps are attracted to acetic acid and isobutanol. We expect that many social wasp species could be attracted to these compounds when foraging for carbohydrate foods. If this hypothesis is correct, the combination of acetic acid and isobutanol can be used as an attractant for a greater number of pest species over a broad geographic range.

Materials and Methods

All experiments were conducted with the Trappit Dome Trap (Agrisense, Fresno, CA). This is a plastic trap similar in shape to the glass McPhail trap (Newell 1936) commonly used for flies. The trap entrance is in the bottom of the trap, the top half is clear, and the bottom half is opaque and yellow in color. Traps contained 150-200 ml of a drowning solution comprised of water, clay, detergent, and food dyes (Landolt 1998). Acetic acid, when tested as an attractant, was added to the drowning solution at 0.5% by volume. Isobutanol (1 ml) was dispensed from a 2 ml polyethylene cap mounted on a pin at the top of the inside of the trap. It is assumed that the isobutanol was released through the walls of the cap.

Each experiment involved the comparison of 4 treatments; an unbaited control, 0.5% acetic acid in the drowning solution, 1 ml of isobutanol in the polyethylene cap, and the combination of 0.5% acetic acid in the drowning solution and 1 ml of isobutanol in a polyethylene cap. A randomized complete block design was used, with the 4 treatments included in each block. Traps were checked 1-3 times per week, with traps moved one position each time traps were checked. The drowning solution was replaced weekly and polyethylene caps were replaced monthly in experiments lasting longer than 1 month. This experiment was conducted in 4 different geographic areas, selected to target a variety of species of Vespidae.

The first location was in Yakima County, Washington, conducted in April and May of 1998. This time and area was selected to determine if queens of *V. pensylvanica* and *V. germanica* respond to acetic acid and isobutanol. Previous studies targeted workers and were conducted from mid to late summer when queens were not foraging (Landolt 1998). Traps were set up at 5 sites near Yakima on 22 April 1998. Four of these sites were in apple orchards and one was in a suburban yard. Traps were placed in trees at about 2 m height. Traps were checked weekly and were maintained until 26 May 1998.

The second location was the USDA-ARS Beltsville Agricultural Research Center in Beltsville, Prince George's Co., Maryland. This location was selected to determine if

workers of *V. maculifrons* and other *Polistes* species are attracted to acetic acid and isobutanol. Six blocks of traps were set up on the grounds of the Center on 4 August 1998. Two blocks were placed in a windbreak of holly trees (*Ilex* sp.), and 4 blocks were positioned along the borders of woodlots comprised primarily of deciduous hardwood trees. Traps were maintained until 18 August 1998 and were checked 2-3 times per week.

The third location was in western Washington. A trapping site was selected on the grounds of the Washington State University Agricultural Experiment Station at Puyallup, Pierce Co., Washington. This site was selected to determine if workers of *Vespula vulgaris* L., the common yellowjacket, are attracted to the combination of acetic acid and isobutanol. Four blocks of traps were set up on 25 August 1998, on ornamental plantings of trees and shrubs. Traps were about 5 m apart within blocks, and blocks were more than 30 m apart. Traps were checked weekly and were maintained until 14 October 1998.

The fourth location was in Tulsa, Oklahoma. Trapping sites were at a residence and in 4 suburban parks. This location was selected to determine if workers of *V. maculifrons* and *V. squamosa* and several species of *Polistes* present in that area are attracted to acetic acid and isobutanol. Six blocks of traps were set up on 8 August 1998 in trees and shrubs in ornamental plantings and along fence lines. Traps were checked weekly and maintained until 18 November 1998.

Data were analyzed by Wilcoxon signed rank test, with a significance limit at $p \leq 0.05$. Data were analyzed for each wasp species trapped at each site separately. For all species and all locations, data were excluded for dates on which no wasps were captured with any of the treatments.

Results

At the Yakima County location, significant numbers of queens of *V. pensylvanica* were captured in traps baited with the combination of acetic acid and isobutanol. Although small numbers of *V. pensylvanica* queens were captured in traps baited with acetic acid and in traps baited with isobutanol, these were not significantly greater than numbers captured in unbaited traps (Table 1). Eighty-six *V. pensylvanica* queens were captured in this test. Numbers of queens of *V. germanica* captured in traps baited with isobutanol and in traps baited with acetic acid with isobutanol (combination) were significantly greater than in unbaited traps (Table 1). There was no significant difference, however, between numbers of queens of *V. germanica* captured in traps baited with isobutanol versus the combination of acetic acid with isobutanol, despite the higher numbers in the traps baited with the combination of acetic acid and isobutanol. A total of 102 *V. germanica* queens were captured in this test. Twenty-seven *P. aurifer* were also captured in this test, but these numbers were insufficient for statistical comparisons.

In the test at the Beltsville, Maryland location, 232 *V. maculifrons* workers, 31 *V. squamosa* workers, 68 *V. germanica* workers, 6 *Vespula flavopilosa* (Jacobson) workers, 22 *Vespa crabro* L. (European hornet) workers, and 38 *Dolichovespula maculata* (L.) (bald-faced hornet) workers, were captured in traps, in addition to 23 *Polistes dominulus* (Christ), 10 *Polistes fuscatus* (F.), 1 *Polistes exclamans* Vierick, and 3 *Polistes metricus* Say females. One male of *P. dominulus* was also captured in a trap. Numbers of wasps captured were suitable for statistical comparisons (exhibited significant differences among treatments) for *V. maculifrons*, *V. squamosa*, *V. germanica*, *V. crabro*, *D. maculata*, and *P. dominulus* (Table 1). *Vespula maculifrons* workers were captured in significant numbers in traps baited with acetic acid, isobutanol, and the combination of acetic acid and isobutanol, with the greatest captures in traps baited

TABLE 1. MEAN (± SE) NUMBERS OF FEMALE SOCIAL WASPS CAPTURED PER TRAP PER CHECK AT 4 LOCATIONS, IN TRAPS BAITED WITH WATER (CONTROL), ACETIC ACID, ISOBUTANOL, AND ACETIC ACID WITH ISOBUTANOL (COMBINATION).[1]

	Control	Acetic acid	Isobutanol	Combination
WA, Yakima Co.				
V. pensylvanica queens	0.3 ± 0.3b	1.3 ± 0.8b	0.9 ± 0.5b	6.1 ± 1.0a
V. germanica queens	0.2 ± 0.1b	0.1 ± 0.1b	3.4 ± 0.6a	5.3 ± 1.4a
MD, Beltsville				
V. maculifrons workers	0.0 ± 0.0c	0.2 ± 0.1b	0.3 ± 0.2b	7.2 ± 2.0a
V. germanica workers	0.0 ± 0.0b	0.0 ± 0.0b	0.0 ± 0.0b	2.2 ± 1.0a
V. squamosa workers	0.0 ± 0.0b	0.0 ± 0.0b	0.1 ± 0.1b	0.9 ± 0.3a
D. maculata workers	0.0 ± 0.0c	0.4 ± 0.2b	0.0 ± 0.0c	0.9 ± 0.4a
V. crabro workers	0.0 ± 0.0b	0.0 ± 0.0b	0.0 ± 0.0b	0.7 ± 0.3a
P. dominulus	0.0 + 0.0b	0.0 + 0.0b	0.0 + 0.0b	0.9 + 0.2a
WA, Pierce Co.				
V. pensylvanica	0.0 ± 0.0b	0.0 ± 0.0b	0.0 ± 0.0b	2.4 ± 0.5a
V. germanica	0.0 ± 0.0b	0.1 ± 0.1b	0.0 ± 0.0b	0.8 ± 0.2a
D. maculata	0.0 ± 0.0c	1.3 ± 0.5b	0.1 ± 0.1c	4.0 ± 1.2a
OK, Tulsa				
V. squamosa	0.0 ± 0.0c	1.7 ± 0.5b	2.7 ± 1.2b	14.4 ± 3.8a
V. maculifrons	0.0 ± 0.0d	2.8 ± 0.7b	1.5 ± 1.1c	12.1 ± 2.7a
P. fuscatus	0.0 ± 0.0c	3.8 ± 2.3b	0.1 ± 0.1c	9.7 ± 4.3a
P. perplexus	0.0 ± 0.0b	2.4 ± 0.9a	0.1 ± 0.1b	2.1 ± 0.5a
P. annularis	0.1 ± 0.1b	1.2 ± 0.5b	0.0 ± 0.0b	1.6 ± 0.9a

[1]Means within a row followed by a different letter are significantly different by Wilcoxon signed rank test at $p < 0.05$.

with the combination of acetic acid and isobutanol. *Vespula germanica* and *V. crabro* workers were captured in significant numbers only in traps baited with the combination of acetic acid and isobutanol. The greatest captures of *D. maculata* were also in traps baited with the combination of acetic acid and isobutanol, but numbers in traps baited with acetic acid alone were also significantly greater than in unbaited traps. Females of the paper wasp *P. dominulus* were captured in significant numbers only in traps baited with the combination of acetic acid and isobutanol.

In the test at the western Washington location in Puyallup, 20 *V. pensylvanica* workers, 27 *V. germanica* workers, 2 *V. vulgaris* workers, and 130 *D. maculata* workers were captured in traps. Numbers of *V. pensylvanica* and *V. germanica* workers captured in traps baited with the combination of acetic acid and isobutanol were significantly greater than in unbaited traps (Table 1). Numbers of *D. maculata* captured in traps baited with acetic acid were significantly greater than in unbaited traps, but numbers in traps baited with the combination of chemicals were significantly greater than in either unbaited traps or traps baited with acetic acid (Table 1).

In the test at the Tulsa, Oklahoma area, 581 *V. squamosa* workers, 809 *V. maculifrons* workers, and 150 *P. fuscatus*, 112 *Polistes perplexus* Cresson, 33 *Polistes annu-*

laris (L.), and 12 *P. metricus* paper wasps were captured in traps over the 12 week trapping period. Numbers of *V. maculifrons* and *V. squamosa* yellowjackets captured in traps baited with acetic acid alone, isobutanol alone, and the combination of acetic acid and isobutanol were significantly greater than in unbaited traps (Table 1). However, for both species of yellowjackets, the numbers captured in traps baited with the combination of acetic acid and isobutanol were significantly greater than the numbers captured in traps baited either with acetic acid or with isobutanol. Significant numbers of *P. fuscatus* paper wasps were captured in traps baited with acetic acid or in traps baited with the combination of acetic acid and isobutanol (Table 1). The numbers of *P. fuscatus* paper wasps captured in traps baited with the combination of acetic acid and isobutanol were significantly higher than in traps baited with acetic acid alone. Significant numbers of *P. perplexus* paper wasps were captured in traps baited with acetic acid or with the combination of acetic acid and isobutanol (Table 1). For this species, there was no difference between numbers of wasps captured in traps baited with acetic acid alone or with acetic acid and isobutanol in combination. Despite the low numbers captured in the experiment, numbers of *P. annularis* captured in traps baited with the combination of acetic acid and isobutanol were significantly greater than in unbaited traps.

DISCUSSION

The results of these experiments demonstrate that a number of species of social wasps are attracted to the combination of acetic acid and isobutanol. The previous finding of attraction of worker *V. germanica* (Landolt 1998) to this blend was reconfirmed with the results of the tests in Beltsville, Maryland and Puyallup, Washington. Attraction of *V. maculifrons* and *V. squamosa* was demonstrated both in Maryland and Oklahoma. Attraction of *D. maculata* to the blend of chemicals was shown in Maryland and Puyallup, Washington, while *V. crabro* were trapped with the same chemicals in Maryland. *Polistes dominulus* was trapped with acetic acid and isobutanol in Maryland and *P. fuscatus* and *P. annularis* were trapped with the same chemicals in Oklahoma. This is a total of 5 species of yellowjackets (*Vespula*/*Dolichovespula*), one species of hornet (*Vespa*) and 4 species of paper wasps (*Polistes* spp) that are known to respond to this chemical attractant (Landolt 1998, 1999).

The lack of response of certain species is also of interest, although the reasons for a lack of captures of a given species are not determined. In Washington, *Vespula atropilosa* (Sladen) has not been captured in traps baited with acetic acid and isobutanol in significant numbers, despite a known population at the trapping locations. The aerial yellowjacket, *Dolichovespula arenaria* (F.), and *V. vulgaris* have not been captured in significant numbers in these trapping tests, despite their general distribution. However, neither of these two species has been known to be present at trapping sites during experiments, either in these tests or in previous experiments with these compounds (Landolt 1998). It is possible that these two species and others have not been captured because populations at trapping sites have been very low during the experiments. The responsiveness of species to this attractant may also reflect their sugar or carbohydrate foraging behavior, which for some species are well known. *Polistes fuscatus* and *P. annularis* stock cells of nests with concentrated sugars or honey (Rau 1928, Strassmann 1979).

A formulation dispensing acetic acid and isobutanol should be a useful lure for trapping most pestiferous species of Vespidae throughout North America and other areas of the world. In North America, *V. pensylvanica*, *V. maculifrons*, *V. germanica*, *V. vulgaris*, and *V. squamosa* are the most pestiferous because of their abundance, colony size, and foraging habits (Akre et al. 1980). *Vespula vulgaris* is the only major North American pest species that is not yet documented to be attracted to the combi-

nation of acetic acid and isobutanol. *Vespula germanica* is a major pest in Europe as well as many other areas of the globe where it has been introduced, including New Zealand, Tasmania, Australia, Chile, and Argentina (Edwards 1976). Following these results, it is expected that other pest species of Vespidae, particularly Palearctic Vespinae, are likely to be attracted to this chemical blend.

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