Yellowjacket (Hymenoptera: Vespidae) Repellency by Natural Products of Paper Wasps and Avon's Skin-so-Soft© [1]

Gregg Henderson, David C. Blouin[2], and Robert L. Jeanne[3]

Department of Entomology, Louisiana State Experiment Station
Louisiana State University Agricultural Center
Baton Rouge, LA 70803.

J. Entomol. Sci. 28(4):387-392 (October 1993)

ABSTRACT Methyl palmitate and butyl palmitate, ant repellents first isolated from the sternal glands of paper wasps, were tested with a methyl ester homolog, methyl myristate, and Avon's Skin-So-Soft Bath Oil© against foraging German yellowjackets. Repellency remained high for six days for all compounds except methyl palmitate. Avon's Skin-So-Soft© was the most repellent. We suggest that this is due to two active ingredients, isopropyl palmitate and mineral oil.

KEY WORDS Insecta, *Vespula*, ants, repellents, palmitates.

A secretion from the sternal gland (van der Vecht's gland) of the tropical paper wasp, *Mischocyttarus drewseni* de Saussure, protects the wasp brood from certain predaceous ants when applied to the nest petiole (Jeanne 1970). This secretion similarly protects temperate paper wasps in the genera *Polistes* (Turillazzi and Ugolini 1979, Post and Jeanne 1981) and *Ropalidia* (Kojima 1983). In *P. fuscatus* (F.), one of the gland's active repellent components is methyl palmitate; a synthetic methyl ester homolog, methyl myristate, also proved to be a powerful ant repellent (Post et al. 1984, Henderson and Jeanne 1989). Similar compounds, butyl palmitate and Z/E-9-octadecenoate (stereochemistry not determined), were recently identified as ant-repelling components of van der Vecht's gland in a *Ropalidia* sp. and *Mischocyttarus immarginatus* Richards, respectively (Jeanne and Henderson, unpublished).

Ants are one of the most important predators of social wasp brood (Richards and Richards 1951, Jeanne 1975), and the repellent palmitates are hypothesized to have evolved in response to this selection pressure (Jeanne 1970, Post and Jeanne 1981, Jeanne et al. 1983, Henderson and Jeanne 1989). It has been reported that these products also repel flies (Henderson et al. 1991) and honey bees (Jeanne and Henderson, unpublished). We decided to test the repellency of methyl palmitate, butyl palmitate, and methyl myristate against the German yellowjacket, *Vespula germanica* L. This insect is particularly annoying to people in outdoor situations in temperate regions where food accumulates (e.g., zoos, parks, compost piles). In addition, we compared these compounds to Avon Skin-So-Soft Bath Oil© (the hand

[1] Accepted for publication 26 August 1993.

[2] Department of Experimental Statistics, Louisiana State University Agricultural Center, Baton Rouge, LA 70803.

[3] Department of Entomology, University of Wisconsin, Madison, WI 53706.

cream contains octyl palmitate, and the bath oil, isopropyl palmitate), because both anecdotal evidence and empirical studies (Schreck and Kline 1981, Schreck and McGovern 1989) have provided evidence for Avon's Skin-So-Soft© repellency to flying and biting insects when applied to the skin or clothing.

Materials and Methods

A nest of German yellowjackets was located under a house porch in a residential section of Madison, WI (Dane Co.) on 10 September, 1990. Large numbers of German yellowjackets were found foraging at a compost pile on the side of a second home 20 m from the nest. Foraging traffic was evident between the porch nest and the compost pile. Other yellowjacket colonies were apparently also foraging at this location, as indicated by their flight pathways, although no aggression between foragers was observed at the compost.

Fifteen RC Cola® cans were opened and placed on top of a 90 × 40 × 40 cm platform next to the compost pile in an attempt to attract the wasps away from the compost pile. Attracting German yellowjackets to the soda and away from another food source took much longer than anticipated. Even after entrainment, if the soda cans were removed overnight, wasps needed a 4-h retraining period. The trials started after one week, when the wasps had switched their foraging to the soda and had a visitation rate of 25/min.

The experimental design included four treatments, methyl palmitate (MP), methyl myristate (MM), butyl palmitate (BP) (all purchased from American Tokyo Kasel, Inc., Portland, OR), and Avon's Skin-So-Soft Bath Oil© (Avon©; Avon Products, Inc., NY) at three different concentrations (5%, 10%, and 100%). Hexane served as the carrier for all solutions. Treatments were pipetted onto each of 12 newly opened can tops of RC Cola® (0.5 mls at each concentration) as uniformly as possible. Three untreated cans served as controls, for a total of 15 cans. This set-up was repeated on a second set of 12 newly-treated cans (and three untreated controls).

To determine the repellency of the treatments, behavioral observations were taken for 2½ h each day for six days beginning on 19 September (2nd set started 21 September). The wasps had to land on the can top in order to reach the can opening to feed. Responses were scored as follows. A wasp that flew off of the can once tarsal or antennal contact for <1 sec was made was scored as ""repelled" (r). Wasps that remained on the can top >1 sec were scored as "not repelled" (nr). A wasp did not have to imbibe the liquid to be scored as not repelled. These observations were used to calculate the repellency index (R), R = r/(r + nr), the proportion of wasps repelled.

Testing took place in the late morning/early afternoon hours when sunlight directly hit the can tops. Every one-half hour of the observation period, the cans were rearranged on the platform to control for the possibility that the wasps learn to accept or avoid a particular can by its location. After each day's observation, test cans were removed and placed in a nearby enclosed garage. Untreated cans, the same ones that were used for the initial training, were removed from the garage and placed on the platform until the next day, when treated cans were again tested. The continuous food source ensured the wasps maintained a strong foraging population at the platform.

The experiment was analyzed on the Statistical Analysis System (SAS Inst. 1985) using a split plot plus split plot with repeated measures design (General Linear Models Procedure).

A third test determined if mineral oil alone (the first ingredient in Avon Skin-So-Soft Bath Oil©) is repellent to yellowjackets and if butyl palmitate (BP) might repel wasps as effectively as Avon© when combined with mineral oil (50/50). Five percent solutions of Avon©, mineral oil (MO), or BP + MO, were applied to each of 12 RC Cola® cans and behavioral bioassays on yellowjacket repellency were recorded as previously described (except that only one-and-a-half-hour observation periods for three consecutive days (29 September to 1 October) were recorded).

Results

At all concentrations, MM, BP, and Avon©, were highly repellent to the wasps throughout the six day trials (Table 1). Treatments differed significantly in their repellency toward yellowjackets, whereas yellowjacket repellency changed little with day and concentration (Table 2). The Avon© product was the most repellent. MP repelled a mean of only 9% of the yellowjackets and did not differ significantly from the control. MP remained as a solid at the tested temperatures and its reduced volatility in this state probably affected repellency. Though not significant, BP and MM showed some reduction in repellency with increasing days of the test. Avon© and MP, on the other hand, were always strongly repellent or hardly repellent, respectively.

The repellent chemicals were irritating to the wasps and grooming of the legs and antennae frequently occurred in repelled wasps. Wasps sometimes jerked away from the treated lids as if they had received an electric shock.

Mineral oil was repellent to yellowjackets, and when added to BP the repellency increased, equalling the effectiveness of Avon© (Table 3).

Discussion

Our research shows that German yellowjackets learn food source locations and will entrain to that resource, showing site fidelity. It is possible that the repellent palmitates studied here will prove useful for redirecting foraging yellowjackets away from food that brings them into close contact with people.

Avon's Skin-So-Soft Bath Oil© was most effective in repelling yellowjackets. Although there are several compounds in this product, the two main ingredients are mineral oil and isopropyl palmitate (which is similar to MM, MP, and BP). The mineral oil and palmitate combination in this product provide us with a readily available repellent that appears to mimic the natural repellents produced by paper wasps.

Although the scope of the work presented here is of a strongly applied nature, the discovery of these repellents was made by observing paper wasps in their natural habitat. In the context of the wasp nest, the palmitates produced are applied to the slim nest petiole to protect the brood from being accessed by ants via this route. However, in addition to ants, flies, parasitic wasps, and predacious tettigoniids are also known to be predators or parasites to wasp brood (Nelson 1968, West-Eberhard 1969, Henderson et al. 1991, O'Donnell 1993). Yet

Table 1. Repellency of methyl palmitate (MP), methyl myristate (MM), butyl palmitate (BP) and Avon's Skin-So-Soft Bath Oil© to German yellowjackets at three concentrations over a six day period. SD = standard deviation.

Chemical	Concentration (%)	Mean proportion repelled ± SD
MP	5	0.06 ± 0.14
	10	0.06 ± 0.14
	100	0.16 ± 0.25
MM	5	0.70 ± 0.34
	10	0.72 ± 0.33
	100	0.75 ± 0.34
BP	5	0.63 ± 0.32
	10	0.75 ± 0.30
	100	0.86 ± 0.30
Avon	5	0.98 ± 0.05
	10	0.98 ± 0.07
	100	1.0 ± 0.0
Control	–	0.02 ± 0.02
	–	0.04 ± 0.05
	–	0.05 ± 0.03

Table 2. Analysis of yellowjacket repellency using a split plot and split plot with repeated measures test. Conc = concentration, Chem = chemical treatment, Day = day of the observation.

Source	DF	Mean Square	F Value	Pr > F
CONC	2	0.126	1.53	0.2237
REP (CONC)	3	0.010	0.13	0.9439
CHEM	4	6.201	75.33	0.0001
CHEM *CONC	8	0.029	0.35	0.9413
CHEM*REP(CONC)	12	0.031	0.38	0.9676
DAY	5	0.130	1.58	0.1750
CONC*DAY	10	0.016	0.20	0.9959
CHEM* DAY	20	0.060	0.72	0.7895
CHEM*CONC*DAY	40	0.010	0.13	1.0000

Table 3. Repellency of soda cans with 1 ml of a 5% solution toward yellowjackets over a three-day period.

5% Solutions	N	Repelled	Not Repelled	R/R + NR
Mineral Oil (MO)	12	56	64	0.46
BP ± MO	12	39	11	0.78
Avon Bath Oil	12	12	3	0.75

another insect to add to this list, though not shown to be a natural pest, is the German yellowjacket. With many known, or potential, predators of the brood it appears odd that paper wasps should apply the repellents only to the nest petiole. But, in fact, gaster rubbing does occur away from the nest petiole and close to cells containing eggs and newly eclosed workers of paper wasps (West-Eberhard 1982). Many hypotheses have been proposed for this behavior; an overlooked one is that it functions for the purpose of applying repellents.

Acknowledgment

We thank S. C. Johnson and Son, Inc. (Racine, WI), and especially D. Bybee and E. E. Shaefer, for research support. Earlier support by Hatch Grant #2588 helped to formulate this study. R. Kachadoorian was kind enough to let us make observations in her backyard. This paper was approved for publication by the Louisiana State University Agricultural Center and the Louisiana Agricultural Experiment Station as manuscript number 93-17-7072.

References Cited

Henderson, G. and R. L. Jeanne. 1989. Response of aphid-tending ants to a repellent produced by wasps (Hymenoptera: Formicidae, Vespidae). Ann. Entomol. Soc. Am. 82: 516-519.

Henderson, G., J. D. Wells and R. L. Jeanne. 1991. Methyl palmitate and methyl myristate repel flies. Fla. Entomol. 74: 365-368.

Jeanne, R. L. 1970. Chemical defense of brood by a social wasp. Science 168: 1465-1466.
1975. The adaptiveness of social wasp architecture. Q. Rev. Biol. 50: 267-287.

Jeanne, R. L., H. A. Downing and D. C. Post. 1983. Morphology and function of sternal glands in polistine wasps (Hymenoptera: Vespidae). Zoomorphology 103: 149-164.

Kojima, J. 1983. Defense of the pre-emergence colony against ants by means of a chemical barrier in *Ropalidia fasciata* (Hymenoptera: Vespidae). Jpn. J. Ecol. 33: 213-223.

Nelson, J. M. 1968. Parasites and symbionts of nests of *Polistes* wasps. Ann. Entomol. Soc. Amer. 61: 1528-1539.

O'Donnell, S. 1993. Interactions of predaceous katydids (Orthoptera: Tettigoniidae) with neotropical social wasps (Hymenoptera: Vespidae): are wasps a defense mechanism or prey? Ent. News 104: 39-42.

Post, D. C. and R. L. Jeanne. 1981. Colony defense against ants by *Polistes fuscatus* (Hymenoptera: Vespidae) in Wisconsin. J. Kans. Entomol. Soc. 54: 599-615.

Post, D. C., M. A. Mohamed, H. C. Coppel and R. L. Jeanne. 1984. Identification of ant repellent allomone produced by social wasp *Polistes fuscatus* (Hymenoptera: Vespidae). J. Chem. Ecol. 10: 1799-1807.

Richards, O. W. and M. J. Richards. 1951. Observations on the social wasps of South America (Hymenoptera, Vespidae). Trans. Roy. Ent. Soc. London, 102: 1-70.

SAS Institute. 1985. SAS user's guide: statistics, version 5. SAS Institute Inc., Cary, N. C. 956 pp.

Schreck, C. E. and D. L. Kline. 1981. Repellency determinations of four commercial products against six species of ceratopogonid biting midges. J. Am. Mosq. Control. Assoc. 41: 7-10.

Schreck, C. E. and T. P. McGovern. 1989. Repellents and other personal protection strategies against *Aedes albopictus*. J. Am. Mosq. Control Assoc. 5: 247-250.

Turillazzi, S. and A. Ugolini. 1979. Rubbing behavior in some European *Polistes* (Hymenoptera: Vespidae). Monit. Zool. Ital. 13: 67-70.

West-Eberhard, M. J. 1969. The social biology of polistine wasps. Misc. Pub. Mus. Zool. 140: 1-104.

1982. The nature and evolution of swarming in tropical social wasps (Vespidae, Polistinae, Polybiini). *In*: Social Insects in the Tropics (P. Jaisson, ed.). Vol 1., Univ. Paris XIII Press, Paris, pp. 97-128.