Isobutanol and acetic acid are ineffective at attracting yellowjackets (Hymenoptera: Vespidae) in southwestern British Columbia

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ABSTRACT

In two field-trapping experiments in British Columbia, Canada, western and northern yellowjackets, *Vespula pensylvanica* (Saussure) and *V. alascensis* (Packard) (Hymenoptera: Vespidae), respectively, were caught in traps baited with a heptyl butyrate–based synthetic chemical lure. Very few yellowjackets of either species were caught in traps baited with a blend of isobutanol and acetic acid. Catches of western yellowjackets were not increased by the addition of isobutanol and acetic acid to the heptyl butyrate–based synthetic lure, whereas catches of northern yellowjackets were decreased in one experiment. These results support an evidence-based reconsideration of the notion that multiple yellowjacket species throughout their geographic ranges are uniformly attracted to isobutanol and acetic acid.

Keywords: Vespidae, yellowjackets, chemical ecology, trapping

INTRODUCTION

In western North America, the most abundant and pestiferous native yellowjacket species is the western yellowjacket, *Vespula pensylvanica* (Saussure) (Hymenoptera: Vespidae) (Akre *et al.* 1980). Less common, but also pestiferous, is the northern yellowjacket, *Vespula alascensis* (Packard) (formerly misidentified as the common yellowjacket, *Vespula vulgaris* Linnaeus; Carpenter and Glare 2010).

Synthetic attractants have been developed as operational vespid wasp lures (Landolt 1998; Rust and Su 2012; Landolt and Zhang 2016). One compound that is highly attractive to certain species of yellowjackets is heptyl butyrate (MacDonald *et al.* 1973; El-Sayed *et al.* 2009). It was identified as an attractant for western yellowjackets during field testing of 293 synthesised esters (Davis *et al.* 1969; McGovern *et al.* 1970). The Environmental Protection Agency (2009) states that heptyl butyrate is found in the volatiles produced by fresh plums and apples, suggesting that it plays a major role in food host finding. However, recent studies have failed to detect heptyl butyrate in up to 171 esters in plums (Lozano *et al.* 2009; Chai *et al.* 2012; Zhang *et al*. 2023). Li *et al.* (2023) found it among 35 volatile esters in the fruit aroma of one of four dwarfing apple rootstocks, but

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in another study, it was not present in the fruit aroma of 35 apple varieties (Wu *et al.* 2022).

An alternative role for heptyl butyrate was discovered by Buteler *et al.* (2018), who found that it is produced by workers of German yellowjackets, *Vespula germanica* (Fabricius), and that, when it is combined with the odours of a foodstuff, other workers are strongly attracted to that foodstuff. The marked attraction of western yellowjacket workers to heptyl butyrate (Landolt and Zhang 2016) suggests that they may also employ heptyl butyrate as a pheromone or, alternatively, that they exhibit a kairomonal response to heptyl butyrate produced by workers of a sympatric species.

An attractive composition for numerous species of yellowjackets is the "Landolt lure", a blend of isobutanol (2-methyl-1-propanol) and acetic acid, both of which were isolated and identified from the headspace volatiles of fermenting molasses (Landolt 1998, 2000; Landolt *et al.* 1999, 2000, 2005). Landolt (1998) found that the composition of isobutanol and acetic acid was 1.2 times more attractive to western yellowjackets than heptyl butyrate alone was and that combining acetic acid with heptyl butyrate increased trap catches by 2.7 times over those in traps baited with heptyl butyrate alone. Combining isobutanol or isobutanol plus acetic acid with heptyl butyrate was not tested. Similar results were found for northern yellowjackets (Landolt *et al.* 2005), except that combining acetic acid with heptyl butyrate increased catches by 9.9 times over those by traps baited with heptyl butyrate alone and that the blend of isobutanol plus acetic acid caused catches that were 37.5 times higher than catches in traps baited with heptyl butyrate alone.

From 2008 to 2014, Contech Enterprises Inc. (Victoria, British Columbia, Canada; no longer in business) marketed the "Contech lure", a highly attractive heptyl butyrate–based emulsifiable concentrate lure. We tested the hypothesis that combining the blend of isobutanol and acetic acid with the 10-component Contech lure would increase catches of native yellowjackets in British Columbia over catches in traps baited with either lure alone.

METHODS

Two experiments employing jar traps (Experiment 1, N = 12) or collapsible bag traps (Experiment 2, N = 10; Contech Enterprises Inc., Victoria, British Columbia, Canada; no longer in business; Trottier and Borden 2025) were conducted from 20 to 25 August 2015. Both experiments were set up as randomised complete linear blocks with traps at least 5 m apart at two locations in Abbotsford, British Columbia. Experiment 1 was in a raspberry farm (latitude 49.039882°, longitude –122.446992°), with traps hung 1.0–1.5 m high from wires supporting canes, and Experiment 2 was in a vineyard (latitude 49.049115°, longitude –122.451730°), with traps hung from perimeter fencing or from wires supporting vines.

Both experiments tested the emulsifiable concentrate Contech lure as one of three treatments. In the commercial lure, heptyl butyrate comprised 77.94% of the 10 active ingredients in the emulsifiable concentrate. The other ingredients were heptanol (4.76%), heptyl acetate (2.82%), hexyl butyrate (0.52%), benzyl acetate (0.93%), heptyl isobutyrate (2.14%), α-terpineol (9.3%), octyl butyrate (0.81%), and 1,2-propanediol butyrate (0.38%; Trottier and Borden 2025). The

surfactant (CO-630, MilliporeSigma Canada, Ltd., Oakville, Ontario, Canada) made up 19.4%, and water made up 78.6%. The lure was packaged in a sachet holding 50 mL of the emulsifiable concentrate, including 1.0 g of the blend of active ingredients. The instructions were to dilute the 50 mL of emulsifiable concentrate in 400–450 mL of water to bait each trap.

The second treatment was the Landolt lure, made up in the same manner as the Contech lure, in an emulsifiable concentrate containing isobutanol (99.0% pure, Caledon Laboratories Ltd., Georgetown, Ontario) and acetic acid (99.7% pure, Anachemia Canada Inc., Montreal, Quebec, Canada). The third treatment was both lures together. For both experiments, the emulsifiable concentrates were made up in bulk and diluted with water in a bucket. Equal aliquots were poured into each trap using a graduated cylinder. The surfactant acted to break the surface tension in the drowning fluid, ensuring that captured wasps would quickly drown.

In Experiment 1, the formulation of the Landolt lure was made up by adding 5400 mL of water to 600 mL of the emulsifiable concentrate, which reduced the concentrations of isobutanol and acetic acid to 0.5% (5.0 mg/mL). A 200-mL aliquot, containing 1.0 g each of isobutanol and acetic acid, was poured into each trap. This approximately duplicated the dose of each compound in the Landolt (1998) lure, except that Landolt (1998) released 1.0 g of isobutanol from a polyethylene vial cap suspended in the air space above the drowning solution. Contech lures were also formulated by adding 5400 mL of water to 600 mL of emulsifiable concentrate, so that the 200 mL of formulation in each trap contained approximately 312 mg of heptyl butyrate. For the combined lures, 4800 mL of water was added to 600 mL of the Landolt lure emulsifiable concentrate and 600 mL of the Contech lure emulsifiable concentrate. Each trap held 200 mL of the formulation, containing 1.0 g each of isobutanol and acetic acid and 312 mg of heptyl butyrate.

In Experiment 2, the emulsifiable concentrates were diluted exactly as in Experiment 1, but 450 mL of the formulation was poured into each trap, raising the dose of isobutanol and acetic acid per trap to 2.25 g of each ingredient, 2.25 times the dose in the Landolt (1998) drowning solution. When 450 mL of the Contech lure was poured into each trap, the dose of heptyl butyrate per trap was raised to 702 mg. Using 450 mL of combined lure formulation raised the doses per trap to 2.25 g each of isobutanol and acetic acid and 702 mg of heptyl butyrate.

Captured yellowjackets were separated from the drowning solution using a sieve, identified to species using abdominal markings (Akre *et al.* 1980), and counted. Because Shapiro–Wilk tests disclosed a nonnormal distribution for at least one data set in each experiment, the data were transformed by $\log_{10}(x + 1)$ before analysis using two-way analysis of variance, with treatment and replicate as fixed and random effects, respectively, followed by Tukey's honestly significant difference test ($\alpha = 0.05$).

RESULTS

In both experiments, western yellowjackets responded strongly to the heptyl butyrate–based Contech lure, and the trap catch was not enhanced when the two lures were combined (Experiment 1, $F_{2,22} = 486.6757$, $P < 0.0001$; Experiment 2,

$F_{2,18}$ = 152.3569, P < 0.00001; Fig. 1A, B). The total catches of western yellowjackets in traps baited with isobutanol and acetic acid in experiments 1 and 2 were 2 and 22, respectively. In neither experiment was there a significant effect of replicate (Experiment 1, $F_{11,22}$ = 1.0172, P = 0.4638; Experiment 2, $F_{9,18}$ = 1.0649, P = 0.4317).

In Experiment 1, only 13 northern yellowjackets were caught, and they were distributed similarly among the three treatments ($F_{2,22}$ = 0.8589, P = 0.4373; Fig. 1C). In this experiment, significant variation occurred among replicates ($F_{11,22}$ = 2.8977, P = 0.01619), apparently caused by several traps that caught no northern yellowjackets. In contrast, in Experiment 2, baiting traps with both lures reduced catches of northern yellowjackets to a level that was not significantly different from catches in traps baited with either the Contech lure or the isobutanol and acetic acid blend; traps baited with isobutanol and acetic acid caught no northern yellowjackets ($F_{2,18}$ = 12.1685, P = 0.0005; Fig. 1D). No effect of replicate was observed ($F_{9,18}$, P = 0.06509).

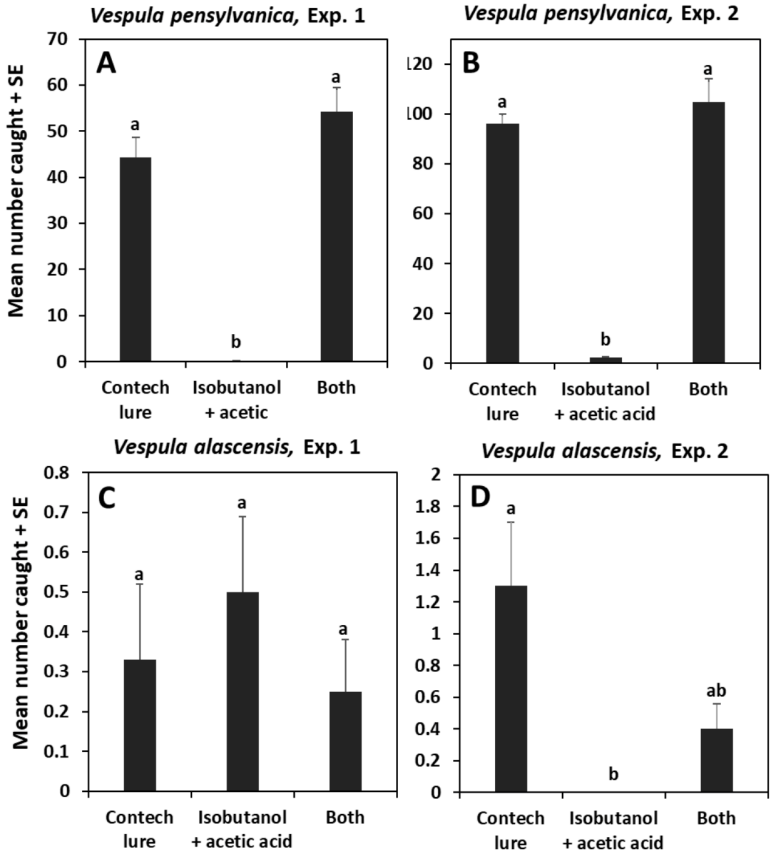

Figure 1. Comparison of catches in experiments 1 and 2 in traps baited with 10- or two-component synthetic chemical lures, alone or combined, for western (A, B) and northern (C, D) yellowjackets. For each species within each experiment, bars with the same letters are not significantly different, Tukey's honestly significant difference test, $P \leq 0.05$.

DISCUSSION

The lack of a substantial response to the blend of isobutanol and acetic acid in both experiments was unexpected. The result with western yellowjackets is in stark contrast to the significant catches in traps baited with this blend found by Landolt (1998, 2000) and Landolt *et al.* (1999). However, a few western yellowjackets were caught, and the higher catch in Experiment 2 (22 western yellowjackets) than in Experiment 1 (two western yellowjackets) may have been an effect of more than doubling the doses of isobutanol and acetic acid.

Similarly, Landolt *et al.* (2005) found high catches of northern yellowjackets in Alaska, United States of America, to the blend of isobutanol and acetic acid and no significant catches in traps baited with heptyl butyrate, a result contradicted in British Columbia by the lack of catches to the same isobutanol and acetic acid blend and a significant response to the heptyl butyrate–based Contech blend (Fig. 1D).

The lack of increased catches of western yellowjackets when the two lures were combined (Fig. 1A, B) provides further evidence for the lack of bioactivity of the isobutanol and acetic acid blend for this species in southwestern British Columbia. For northern yellowjackets, the apparent interference between the Contech lure and the blend of isobutanol and acetic acid when they were combined in Experiment 2 was also unexpected. Such apparent interference is similar to that found for western yellowjackets when heptyl butyrate was combined inside a trap with chicken extract (Liang and Pietri 2017) and when the Contech lure was combined with rotisserie chicken (Trottier and Borden 2025). However, Buteler *et al.* (2018) found enhanced attraction of German yellowjackets in the field when heptyl butyrate was added to ground beef, and Borden *et al.* (2024) found enhanced attraction of western yellowjackets when a small amount of fishmeal fertiliser (but not chicken powder) was added to a heptyl butyrate–based lure. The active ingredients in raw beef and fishmeal fertiliser are unknown.

Landolt *et al.* (2000) showed that 2-methyl-1-butanol elicited attraction of western and German yellowjackets equivalent to that elicited by isobutanol. A blend of 2-methyl-1-butanol and calcium acetate is registered as a wasp attractant insecticide in the United States of America (EPA registration number 84565-7), with label claims that it attracts seven species of yellowjackets, including western and German yellowjackets and, presumably, northern yellowjackets (apparently erroneously listed as common yellowjackets). Our results suggest that the claims may not universally apply throughout the geographic ranges of these species.

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COMPETING INTERESTS

Tamara L. Trottier has no competing interests. John H. Borden was employed by Contech Enterprises Inc. and Scotts Canada Ltd. during completion of this project. Neither company had any input into how the research was conducted or the results interpreted.

REFERENCES

Akre, R.D., Greene, A., MacDonald, J.F., Landolt, P.J., and Davis, H.G. 1980. Yellowjackets of America north of Mexico. Agriculture Handbook No. **552**. United States Department of Agriculture, Washington, DC, United States of America.

Borden, J.H., Branca, A.S., and Banfield, M.G. 2024. Composition and method for attracting vespid wasps. US Patent Application Publication No. US2024/0415113.

Buteler, M., Fernandez, P., Stadler, T., Weaver, D.K., Yossen, B., and Lozada, M. 2018. Heptyl butyrate, a putative pheromone involved in social communication of *Vespula germanica* wasps. Insectes Sociaux, **65**: 95–101.

Carpenter, J.M. and Glare, T.R. 2010. Misidentification of *Vespula alascensis* as *V. vulgaris* in North America (Hymenoptera: Vespidae; Vespinae). American Museum Novitates, **2010**:1–7.

Chai, Q., Wu, B., Liu, W., Wang, L., Yang, C., Wang, Y., *et al*. 2012. Volatiles of plums evaluated by HS-SOME with GC-MS at the germplasm level. Food Chemistry, **130**: 432–440.

Davis, H.G., Eddy, G.W., McGovern, T.P., and Beroza, M. 1969. Heptyl butyrate: a new synthetic attractant for yellow jackets. Journal of Economic Entomology, **62**: 1245.

El-Sayed, A.M., Manning, L.-M., Unelius, C.R., Park, K.C., Stringer, L.D., White, N., *et al*. 2009. Attraction and antennal response of the common wasp, *Vespula vulgaris* (L.), to selected synthetic chemicals in New Zealand beech forests. Pest Management Science, **65**: 975–981.

Environmental Protection Agency. 2009. Biopesticides registration action document. Heptyl Butyrate, PC Code 100247. Environmental Protection Agency, Office of Pesticide Programs, Biopesticides and Pollution Prevention Division, Washington, DC, United States of America.

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

Landolt, P.J. 2000. Chemical attractants for yellowjackets and paper wasps. United States Patent No. 6 083 498.

Landolt, P., Pantoja, A., and Green, D. 2005. Yellowjacket wasps (Hymenoptera: Vespidae) trapped in Alaska with heptyl butyrate, acetic acid and isobutanol. Journal of the Entomological Society of British Columbia, **102**: 35–42.

Landolt, P.J., Reed, H.C., Aldrich, J.R., Antonelli, A.L., and Dickey, C. 1999. Social wasps (Hymenoptera: Vespidae) trapped with acetic acid and isobutanol. Florida Entomologist, **82**: 609–614.

Landolt, P.J., Smithhisler, C.S., Reed, H.C., and McDonough, L.M. 2000. Trapping social wasps (Hymenoptera: Vespidae) with acetic acid and saturated short chain alcohols. Journal of Economic Entomology, **93**: 1613–1618.

Landolt, P.J. and Zhang, Q.-H. 2016. Discovery and development of chemical attractants used to trap pestiferous social wasps (Hymenoptera: Vespidae). Journal of Chemical Ecology, **42**: 655–665.

Li, Yanmei, Ma, Z., Li, Yanbiao, Li, W., Sun, L., Xu, J., *et al*. 2023. Modification of fruit quality and leaf mineral composition of 'Nagafu No. 2' apple grafted onto four dwarfing interstocks. Journal of Plant Growth Regulation, **42**: 7240–7256.

Liang, D. and Pietri, J.E. 2017. Enhanced trapping of yellowjacket wasps (Hymenoptera: Vespidae) via spatial partitioning of attractants. Insects, **8**: 17.

Lozano, M., Vidal-Aragón, M.C., Hernández, M.T., Ayuso, M.C., Bernalte, M.J., García, J., and Velardo, B. 2009. Physiochemical and nutritional properties and volatile constituents of six Japanese plum (*Prunus salicina* Lindl.) cultivars. European Food Research and Technology, **228**: 403–410.

MacDonald, J.F., Akre, R.D., and Hill, W.B. 1973. Attraction of yellowjackets (*Vespula* spp.) to heptyl butyrate in Washington State (Hymenoptera: Vespidae). Environmental Entomology, **2**: 375–379.

McGovern, T.P., Davis, H.G., Beroza, M., Ingangi, J.C., and Eddy, G.W. 1970. Esters highly attractive to *Vespula* spp. Journal of Economic Entomology, **63**: 1534–1536.

Rust, M.K. and Su, N.-Y. 2012. Managing social insects of urban importance. Annual Review of Entomology, **57**: 355–375.

Trottier, T.L. and Borden, J.H. 2025. Response of yellowjackets (Hymenoptera: Vespidae) to meat, fish, and a heptyl butyrate–based synthetic chemical lure. Canadian Entomologist, 157: e33. https://doi.org/10.4039/tce.2025.10016.

Wu, X., Bi, J., and Fauconnier, M.-L. 2022. Characteristic volatiles and cultivar classification in 35 apple varieties: a case study of two harvest years. Foods, **11**: 690.

Zhang, Q., Zhu, S., Lin, X., Peng, J., Luo, D., Wan, X., *et al*. 2023. Analysis of volatile compounds in different varieties of plum fruits based on headspace solid-phase microextraction–gas chromatography–mass spectrometry technique. Horticulturae, **9**: 1069.