Local Reduction of Invasive Yellowjacket Abundance Corresponds with Increases in Potential Pollinators and Native Wasps

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Local Reduction of Invasive Yellowjacket Abundance Corresponds with Increases in Potential Pollinators and Native Wasps

Jonathan Promowicz[1] and Robert Warren II[1, *]

Abstract - Invasive social insects can restructure arthropod communities through combined predatory and competitive effects. *Vespula germanica* Fabricius (German yellowjacket) is a globally widespread invader that often dominates local assemblages and displaces native congeners. We examined how reducing *V. germanica* abundance affected other insect groups in western New York by applying protein baits containing fipronil and comparing baited and control plots. Baiting reduced *V. germanica* numbers by about 60% and corresponded with increased captures of potential pollinators and native *Vespula*. Potential pollinator abundance rose by roughly 40%, richness by 7%, and native *Vespula* abundance by 39%. These results support the interpretation that *V. germanica* functions simultaneously as a top-down predator and a competitive dominant, suppressing both flower-visiting insects and native congeners. The partial recovery of these groups following suppression illustrates the strength of invader-driven trophic and interference processes in shaping arthropod assemblages. This pattern is consistent with *V. germanica* exerting coupled effects through predation and interference competition, as indicated by order-specific increases in Diptera and Coleoptera following suppression.

Introduction

Social insects occupy a paradoxical position in invasion ecology; though they represent only a small fraction of global insect diversity, they account for a disproportionate number of the world's most disruptive invasive species (Beggs et al. 2011, Holway et al. 2002, Moller 1996). Their cooperative foraging, division of labor, and capacity for rapid colony growth confer strong competitive and predatory advantages that enable them to dominate local arthropod communities (Cremer et al. 2007, Tsutsui and Suarez 2003). These traits allow social insects to persist and proliferate in disturbed or resource-patchy environments—conditions typical of urban landscapes—where native taxa are often constrained by habitat fragmentation or resource scarcity (Lester and Beggs 2019, Weber et al. 2024).

Among invasive eusocial wasps, *Vespula germanica* Fabricius (German yellowjacket) is globally recognized for its ecological impact and behavioral dominance. Originating in Europe and Western Asia, it has established across temperate regions of 5 continents, often becoming the numerically dominant vespid (Beggs et al. 2011, Wilson et al. 2009). Colonies are large, perennial in warm microhabitats, and forage broadly on arthropod prey and carrion, producing strong top-down effects on invertebrate assemblages (Harris 1991, Harris and Oliver 1993, Sackmann et al. 2000). In its introduced range *V. germanica* frequently displaces native congeners through interference and exploitative competition (Lester and Beggs 2019), and they can reduce local pollinator activity through both direct predation and competitive depletion of nectar resources (Brock et al. 2021, Lach 2007). These dual pressures—predatory and competitive—make *V. germanica* a particu-

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larly impactful invader with robust effects on ecosystem structure and function (Beggs et al. 2011, Lester and Beggs 2019, Sackmann et al. 2008).

Vespula germanica is well studied in New Zealand, Australia and South America. However, its ecological effects in North American urban environments are largely unknown, where its abundance and reliance on human structures may intensify urban invertebrate community impacts (Parrish and Roberts 1982, Reed and Landolt 2019). Urban and suburban landscapes differ sharply in vegetation structure, nesting opportunities and microclimate. These differences may mediate both invasive pressure and native community resilience (Cook 2019, Lester and Beggs 2019). Consequently, comparing wasp suppression and arthropod responses across urbanization levels can help clarify whether invasive dominance is limited primarily by biotic interactions or by habitat context. To test these ideas, we suppressed *V. germanica* using poison protein baits at two Western New York sites—one urban and one suburban—and quantified subsequent changes in pollinator abundance, pollinator richness and native *Vespula* abundance. We hypothesized that (1) *V. germanica* removal would increase pollinator abundance, reflecting release from top-down predation, and (2) native *Vespula* would increase where *V. germanica* was reduced, reflecting release from competitive exclusion. This framework integrates invasion and urban ecology, to assess how landscape context moderates the ecological role of an invasive social predator.

Materials and Methods

Study species and rationale

The German yellowjacket is a eusocial wasp native to Europe and Western Asia that has established invasive populations throughout temperate regions of North and South America, Australia, New Zealand, and Southern Africa (Beggs et al. 2011, Lester and Beggs 2019). Colonies typically begin in spring from overwintering queens and can reach several thousand workers by late summer (Harris 1991, Parrish and Roberts 1982). In thermally buffered habitats such as wall voids, attics, and basements, colonies may persist through winter, enabling early-season foraging and rapid population buildup (Moller et al. 1991, Plunkett et al. 1989). Workers are generalist predators and scavengers that collect insect prey and animal tissue for larvae while also foraging for carbohydrates from fruit, sap, and human refuse (Harris and Oliver 1993, Reed and Landolt 2019). These broad foraging habits and tolerance of disturbance allow *V. germanica* to dominate vespid assemblages and compete with native congeners in urban and suburban environments (Lester and Beggs 2019, Warren and Promowicz 2025).

Study sites and design

The study was conducted in Western New York State at two locations differing in land-use context. The first site was on the Buffalo State University campus in Buffalo, NY (42.9325, –78.8789), a densely developed urban landscape dominated by impermeable surfaces and fragmented vegetation. The second site was in the Village of Hamburg, NY (42.7202, –78.8332), a suburban area with extensive lawns, trees and residential greenspace. The sites were approximately 23 km apart. Both had high densities of *V. germanica* and minimal representation of native *Vespula* species, based on previous surveys (Warren and Promowicz 2025).

We suppressed *V. germanica* colonies using fipronil, a phenylpyrazole insecticide that disrupts γ-aminobutyric acid (GABA)-gated chloride channels, causing colony-level mortality in social insects (Cole et al. 1993, Harris and Etheridge 2001, Rust et al. 2017). Baits consisted of 25 g of canned chicken in water homogenized with 0.025% fipronil by weight. The protein substrate selectively attracts scavenging yellowjackets, while minimizing attraction of nectar-feeding insects (Edwards et al. 2018, Sanchez-Bayo and Goka 2014). Baits were placed on elevated wooden platforms 1.2 m above ground to prevent vertebrate access and were continuously monitored during two-hour deployments on 14 July and 16 September 2024. Foraging workers were observed removing fibers of the bait and returning to their nests, ensuring distribution of the toxicant throughout the colony (Harris and Etheridge 2001). *Vespula germanica* colonies expand exponentially through summer, making a "before and after" design impractical for poison treatment. Waiting until late summer when populations are high to employ poison baits might have allowed predation and competition effects before suppression. Therefore, we applied treatments and maintained controls simultaneously to separate natural seasonal increases from experimental effects.

At each site, we established 4 baited and 4 control plots. Baited plots were located 10 m from bait stations in the 4 cardinal directions, while control plots were placed 450 m away in comparable habitat. These distances were selected based on prior studies showing that *Vespula* forager activity declines sharply within 300 m of poison bait sites and returns to baseline levels beyond 400–500 m (Beggs and Rees 1999, Lester and Beggs 2019). To quantify yellowjacket and pollinator activity, we deployed paired Victor yellowjacket traps and blue vane traps at each plot. Victor traps were baited with a 60:40 mixture of fruit juice and beer, an attractant highly effective for *Vespula* species (Goldstein 1996, Warren and Promowicz 2005). Blue vane traps were filled with water and a drop of detergent to capture aerial pollinators (Hall 2018, Joshi et al. 2015). Toxic baiting was conducted in two 2-hour deployments on 14 July 2024 and 16 September 2024. Blue vane and Victor traps were deployed in 4 consecutive 7-day sampling periods beginning 23 September 2024.

Blue vane traps are designed to attract visually oriented, flower-visiting insects (Hall 2018, Joshi et al. 20115), but they may also capture non-pollinating taxa that respond to color or reflectance cues. For this reason, we refer to the blue vane trap catch as a flower-visitor proxy assemblage, (potential pollinators). Specimens were identified to order, which provides a low-resolution index of capture composition, but does not distinguish confirmed pollinators from non-pollinating taxa within orders (e.g., many Diptera and some Coleoptera). So results should be interpreted as changes in trap-based activity rather than pollination services. Accordingly, we report both pooled potential pollinator abundance and order-specific abundances for the dominant orders to show which groups contribute to any pooled differences.

Arthropods were preserved in 70% ethanol and identified to order. Potential pollinators in blue vane traps were identified to order and wasps in Victor traps were identified to species using Akre (1981), Buck (2008), Kimsey and Carpenter (2012). Vespid specimens were pinned and retained as vouchers to document identifications of *Vespula germanica* and native vespids. Voucher material is maintained in the Warren laboratory reference collection, Department of Biology, SUNY Buffalo State University (Buffalo, NY, USA). Baiting was conducted with authorization from the New York State Department of Environmental Conservation (letter of approval, 8 March 2023, J. M. Broughel, Chief, Pesticide Product Registration Section).

Data analysis

We used generalized linear mixed models (GLMMs) with a Poisson error distribution to test the effects of treatment and landscape context on the abundance of *V. germanica*, implemented in the R statistical environment (R Core Team 2025). Fixed effects included treatment (baited vs. control), site (urban vs. suburban) and their interaction. Random intercepts were included for sampling week to account for repeated temporal measures and for spatial cluster (10 m vs. 450 m) to address spatial autocorrelation. The dispersion parameter indicated no substantial overdispersion in the *V. germanica* model (dispersion = 1.05). Wald chi-squared tests for fixed effects were conducted using Type II ANOVA. We applied the same modeling framework to evaluate treatment and landscape effects on potential pollinator abundance, potential pollinator richness, pollinator abundance within each order, and native *Vespula* abundance."

In the pollinator abundance model, overdispersion was addressed by including an observation-level random effect. To further examine potential treatment and landscape interactions in the *V. germanica, potential pollinator orders* and native *Vespula* models, we performed *post hoc* pairwise comparisons of estimated marginal means with Tukey-adjusted contrasts.

Results

Across both sites and treatments, we collected 904 yellowjackets and 2377 other arthropods considered potential pollinators. *Vespula germanica* accounted for most captures (74%). The remaining 26% were native congeners: *V. maculifrons* Buysson, *V. flavopilosa,* Jakobson, and *V. alascensis* Packard. We captured very few (< 1%) additional vespid wasps (e.g., *Dolichovespula maculata* L., *Polistes dominula* Christ, *P. fuscatus* Fabricius, and *Vespa crabro,* L.) Potential pollinators were dominated by Diptera (47%), followed by Hymenoptera (30%), Coleoptera (21%) and Lepidoptera (2%) with <1% consisting of other orders.

A treatment × site interaction term indicated that *V. germanica* abundance (mean ± SE) was similar in suburban (15.5 ±1.9 · plot^{-1}) and urban (14.6 ±4.1 · plot^{-1}) control plots but declined more strongly with poisoning in suburban (3.6 ±1.1 · plot^{-1}) than urban (8.1 ±1.8 · plot^{-1}) plots (Table 1; Fig. 1). *Post-hoc* comparisons of the estimated marginal means indicated that *V. germanica* abundance differed across all treatment and landscape conditions, except between the suburban and urban control plots (*Est.* = 0.057, *SE* = 0.091, *z-ratio* = 0.637, *p-value* = 0.920).

Potential pollinator abundance was higher in baited plots (42.8 ± 7.1 · plot^{-1}) than in controlled plots (30.3 ± 5.4 · plot^{-1}; Table 2A; Fig. 2A), and greater in suburban (51.6 ± 7.4 · plot^{-1}) compared to urban (21.5 ± 3.3 · plot^{-1}) plots (Table 2A; Fig. 2B). Potential pollinator taxonomic richness also varied by site, with higher richness in suburban (6.8 ± 0.3 · plot^{-1}) than urban (5.6 ± 0.4 · plot^{-1}) plots (Table 2B, Fig. 3). A treatment × site interaction term indicated that potential pollinator abundance differed by order as Diptera (*Est.* = 0.726, *SE* = 0.044, *z-ratio* = −5.276, $P < 0.001$) and Coleoptera (*Est.* = 0.512, *SE* = 0.048, *z-ratio* = −7.100, $P < 0.001$) increased where *V. germanica* was poisoned but Hymenoptera (*Est.* = 0.880, *SE* = 0.069, *z-ratio* = −1.169, $P = 0.105$) and Lepidoptera (*Est.* = 0.900, *SE* = 0.048, *z-ratio* = −0.324, $P = 0.745$) were unaffected (Table 2C; Fig. 4).

A treatment × site interaction term indicated that native *Vespula* abundance increased from control (4.6± 0.9 · plot^{-1}) to baited plots (6.4 ± 1.2 · plot^{-1}) in suburban areas but differed little between control (2.1 ± 0.5 · plot^{-1}) and baited plots (1.3 ± 0.5 · plot^{-1}) in the urban areas (Table 3, Fig.5). *Post-hoc* comparisons of the estimated marginal means indicated that native *Vespula* differed across all treatment and landscape conditions, except between the urban control and bait plots (*Est.* = −0.405, *SE* = 0.274, *z-ratio* = −1.479, $P = 0.450$).

Collectively, the results indicate that fipronil baiting reduced *V. germanica* abundance by approximately 60%, accompanied by a 40% increase in potential pollinator abundance and a 7% increase in potential pollinator taxonomic richness. Native yellowjackets showed a 39% increase in suburban plots but little change in urban plots.

Table 1. Generalized linear mixed model results for German yellowjacket abundance · plot^{-1} as a function of treatment (control, bait), land use (suburban, urban) and an interaction between the two.

German yellowjackets	X^2	*df*	*P-value*
Treatment	107.744	1	<0.001
Land use	3.782	1	0.051
Treatment × land use	21.466	1	<0.001

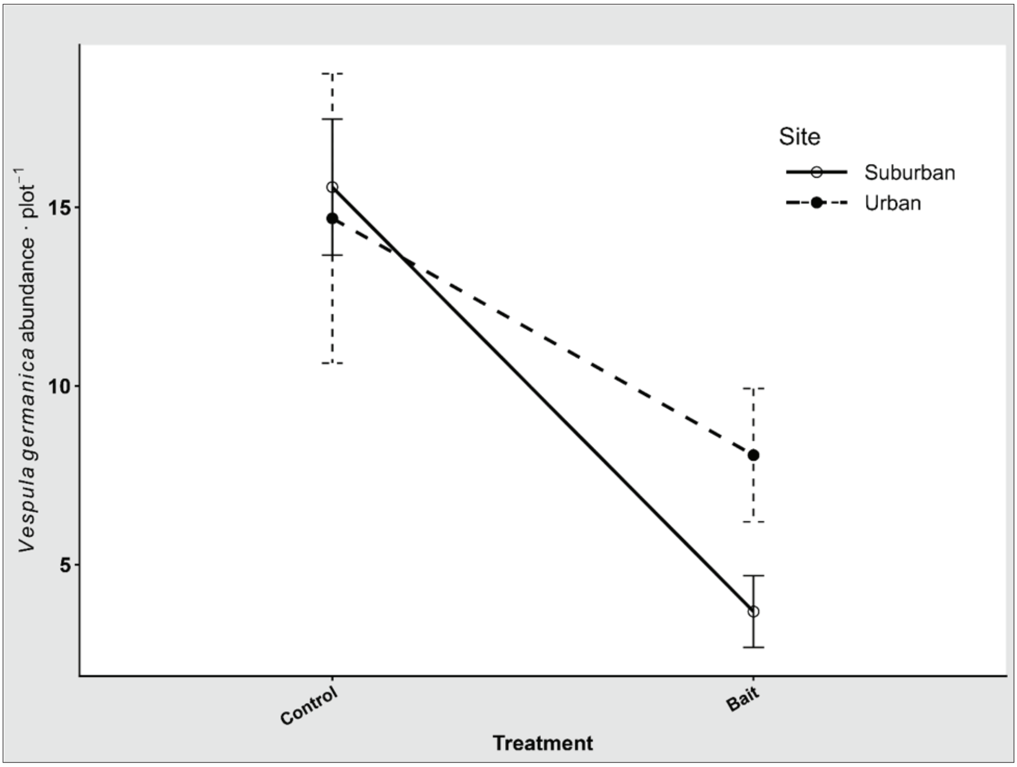

Figure 1. Interaction plot showing mean (± SE) *Vespula germanica* (German yellowjacket) abundance per plot across treatment (baited vs. control) and site (suburban vs. urban) categories. Control plots were located 450 m from bait stations, whereas bait plots were located 10 m from stations where poison baiting was applied. Fitted lines were added to aid interpretation of the interaction but should not be interpreted as continuous interpolations between data points.

Table 2. Generalized linear mixed model results for pollinator (**A**) abundance · $plot^{-1}$, (**B**) taxonomic richness · $plot^{-1}$, and (**C**) pollinator order · $plot^{-1}$ as functions of treatment (control, vs. bait), land use (suburban, vs. urban) and an interaction between the two.

A. Pollinator abundance	X^2	*df*	*P-value*
Treatment	4.237	1	0.039
Land use	31.284	1	<0.001
Treatment × land use	0.143	1	0.705
B. Pollinator richness	X^2	*df*	*P-value*
Treatment	0.491	1	0.483
Land use	3.242	1	0.071
Treatment × land use	0.193	1	0.659
C. Pollinator order	X^2	*df*	*P-value*
Treatment	60.999	1	<0.001
Land use	604.091	3	<0.001
Treatment × land use	19.975	3	<0.001

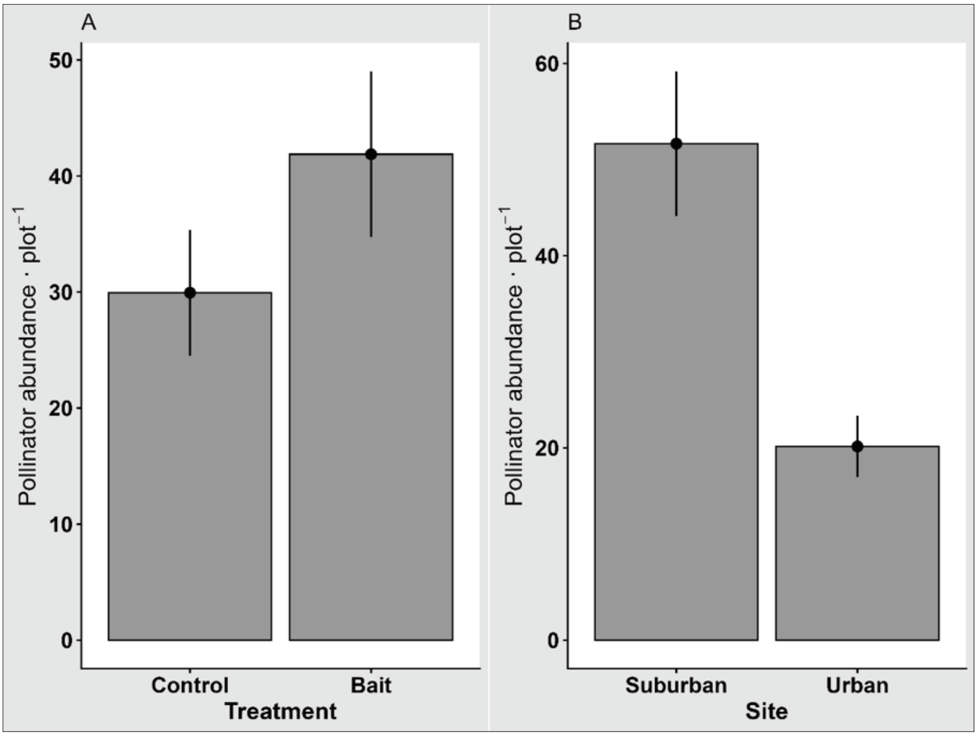

Figure 2. Bar plots showing mean (± SE) potential pollinator abundance by (A) treatment (control vs. baited) and by (B) site category (suburban vs. urban). Potential pollinator counts were pooled across all sampling weeks and included pooled individuals from the insect orders Diptera, Hymenoptera, Coleoptera and Lepidoptera.

Discussion

Through both predation and competition, *V. germanica* suppressed potential pollinator and native vespid activity, with the strength of these effects varying across the 2 study sites. Poison baiting reduced *V. germanica* abundance by approximately 60%, and this reduction corresponded with increases in potential pollinators and native *Vespula* in suburban plots, but not in urban ones. In suburban areas, potential pollinator abundance increased by about 40%, potential pollinator taxonomic richness by 7%, and native *Vespula* abundance by 39%. These patterns are consistent with the interpretation that *V. germanica* functions both as a top-down predator and as a competitive dominant that suppresses other insects through direct interference or resource monopolization. The influence of these mechanisms, however, appeared to depend on habitat structure. Greater vegetation cover and floral diversity in suburban landscapes may facilitate community recovery once *V. germanica* pressure is reduced, whereas the homogenized and impervious conditions of urban environments may limit recolonization and the resources needed for native species to rebound.

The decline of *V. germanica* following fipronil baiting is consistent with previous demonstrations that protein-based toxic baits can effectively target social wasp colonies with limited non-target effects (Edwards et al. 2018, Harris and Etheridge 2001, Rust et al. 2017). Also, potential pollinator responses to *V. germanica* removal were consistent with expectations. Diptera and Coleoptera—groups known to be common prey of *V. germanica*

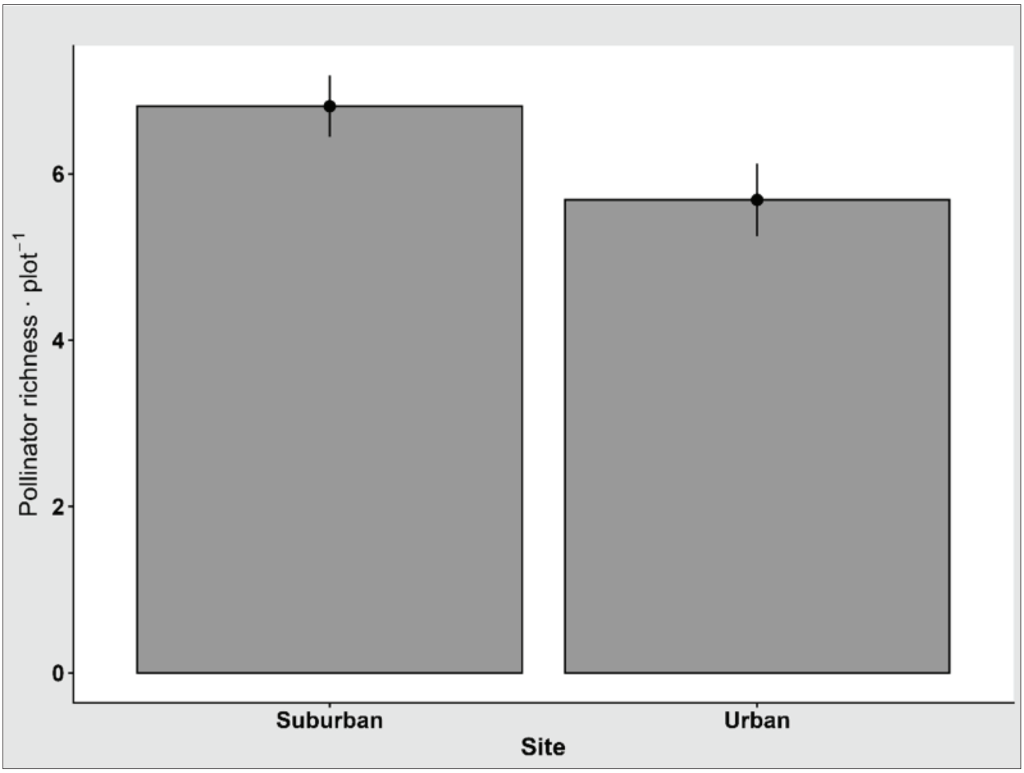

Figure 3. Bar plot showing mean (± SE) pollinator richness by site category (suburban vs. urban). Potential pollinator counts were pooled across all sampling weeks and included individuals from the insect orders Diptera, Hymenoptera, Coleoptera and Lepidoptera.

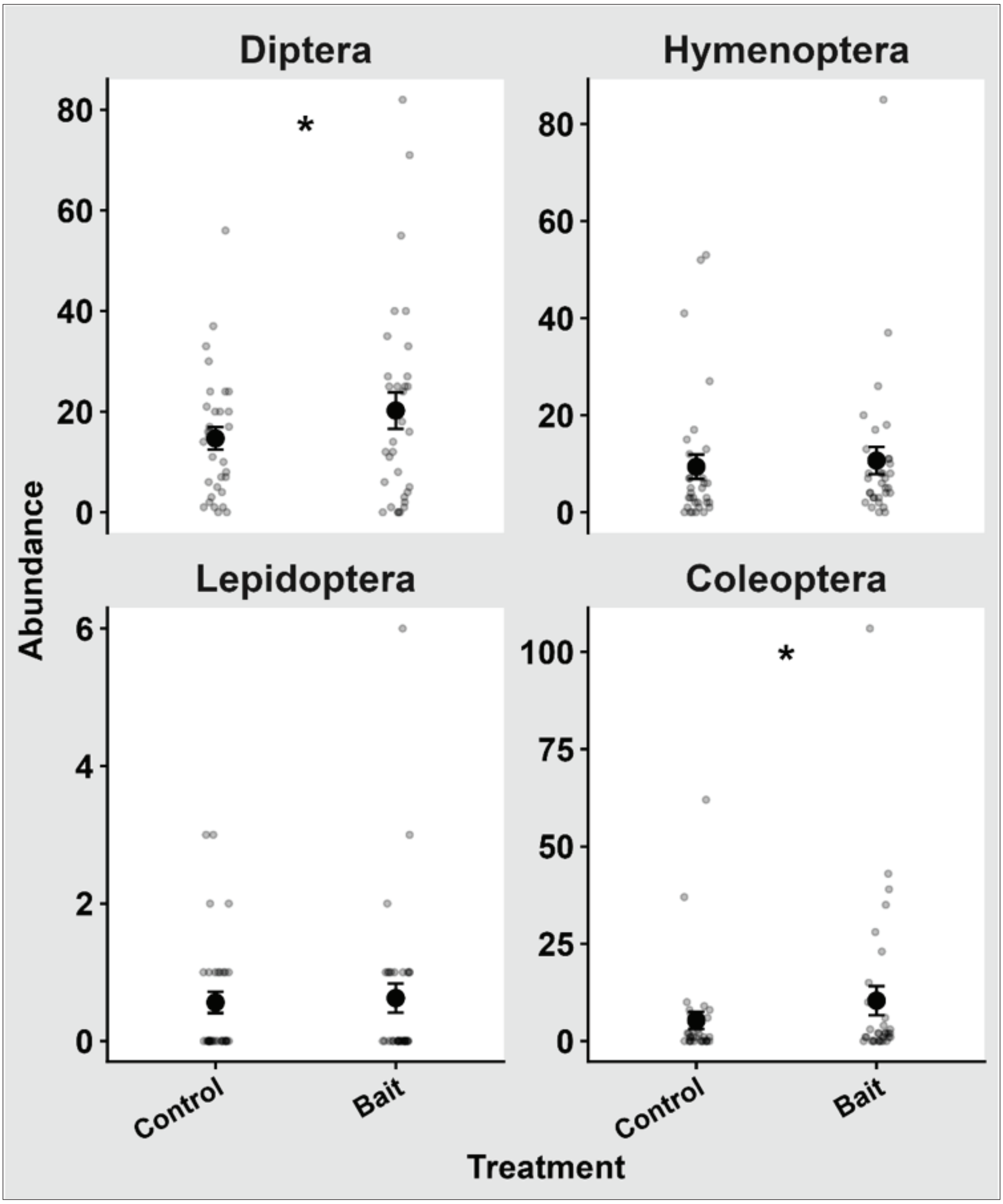

Figure 4. Strip charts showing order-specific abundances of the potential pollinator assemblage by treatment (control vs. baited). Gray points show individual trap observations and black points show mean abundance ± SE for each treatment within each order (Diptera, Hymenoptera, Lepidoptera, Coleoptera). Asterisks indicate orders for which baited plots differed from control plots in *post hoc* treatment contrasts (Tukey-adjusted *p-value* < 0.05).

(Harris 1991, Harris and Oliver 1993)—were more abundant in poison baited plots where *V. germanica* densities were reduced. Order-specific analyses show that the pooled flower-visitor proxy response was not uniform across taxa. Diptera and Coleoptera increased in baited plots, whereas Hymenoptera and Lepidoptera did not change detectably, indicating that suppression of *V. germanica* corresponded with taxon-dependent increases rather than a generalized response across orders. Native Vespula increased at one site, but this does not negate the treatment signal; arthropod activity increased where *V. germanica* was suppressed, consistent with reduced predation and interference from the invasive dominant

Table 3. Generalized linear mixed model results for native yellowjacket abundance · plot^{-1} as a function of treatment (control, bait), land use (suburban, urban) and an interaction between the two.

Native yellowjackets	X^2	*df*	*P-value*
Treatment	1.414	1	0.234
Land use	53.023	1	<0.001
Treatment × land use	5.518	1	0.018

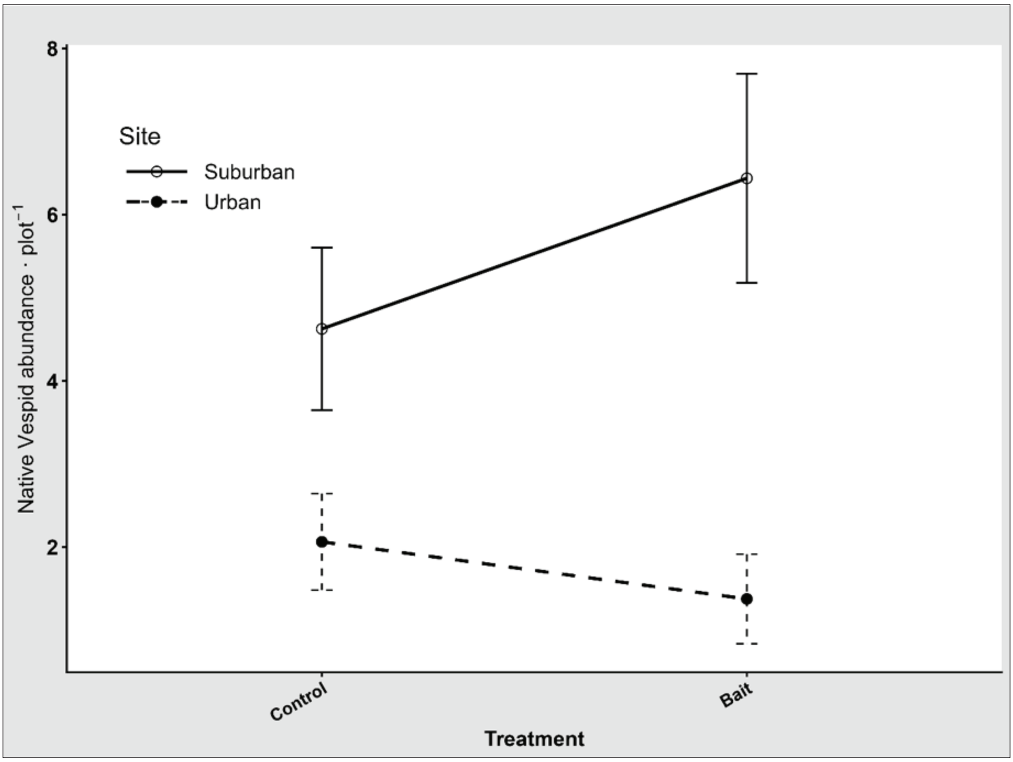

Figure 5. Interaction plot showing mean (± SE) native *Vespula* (yellowjackets) abundance across treatment (baited vs. control). Control plots were located 450 m from bait stations, whereas bait plots were located 10 m from stations where poison baiting was applied. Fitted lines were added to aid interpretation of the interaction but should not be interpreted as continuous interpolations between data points.

despite continued foraging by native congeners. These results align with prior findings where *Vespula* species have been shown to be major predators of native arthropods, removing hundreds of thousands of prey items per colony each season (Harris 1991, Sackmann et al. 2008). However, our results contrast with other experimental removals in those regions, where similar reductions in *Vespula* densities (60–80%) did not yield detectable changes in arthropod abundance or community composition (Duthie and Lester 2013, Sackmann et al. 2008). Those studies analyzed arthropods at finer taxonomic resolution than the order-level data available here, so differences in sensitivity may contribute to the contrast. Another possible explanation is the dominance of *V. germanica* at our sites (accounting for 74% of all vespids captured), combined with the urban and suburban land-use context of our study (in contrast with the rural habitats used in the previous studies).

Native *Vespula* responses suggest release from competitive exclusion. This is consistent with patterns observed in other systems where dominant invasive social insects suppress native congeners, e.g., *Linepithema humile* Mayr, and *Myrmica rubra* L. (Goodman and Warren II 2019, Human and Gordon 1997, Savolainen and Vepsalainen 1988). In urban plots, however, native vespid abundance changed little with baiting, possibly due to a combination of direct exposure to toxic baits and habitat constraints. Urban landscapes are dominated by impervious surfaces, which limit nesting opportunities for the native ground-nesting species (Weber et al. 2024), whereas *V. germanica* exploits human structures for nesting (Parrish and Roberts 1982, Reed and Landolt 2019). These structural advantages may give *V. germanica* a competitive edge in urban areas, reducing the potential for native species recovery. We note, however, that we tested local treatment effects at only 2 study sites which limits general inference about urban versus suburban land-use categories. Plot-level responses should be interpreted as site-specific, and our order-level identifications from blue vane traps provide a coarse index of capture composition rather than a measure of pollination function.

These findings are consistent with invasive social wasps exerting coupled effects through predation and interference competition, with responses that differed among arthropod orders. *Vespula germanica* functions as both consumer and competitor, altering the distribution and activity of other insects even at fine spatial scales. The modest but consistent increases in potential pollinators and native congeners following suppression indicate that invader-driven pressures can be rapidly transmitted through local food webs. More broadly, the study underscores how social organization, behavioral dominance, and trophic generalism—traits central to invasion theory—amplify ecological impact beyond abundance alone. Understanding these mechanisms is essential for explaining why invasive social insects, though few in number, exert disproportionate influence on community structure and ecosystem function.

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Statements and Declarations

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Competing Interests

The authors have no relevant financial or non-financial interests to disclose.

Author Contributions

Jonathan Promowicz and Robert Warren contributed to the study conception and design. Material preparation, data collection and analysis were performed by Jonathan Promowicz and Robert Warren. The first draft of the manuscript was written by Jonathan Promowicz and both authors commented on previous versions of the manuscript. Both authors read and approved the final manuscript.

Data availability

The data generated and analyzed for the current study are available in the Dryad digital depository (DOI: 10.5061/dryad.gmsbcc31g).

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