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Trapping yellowjackets (Hymenoptera: Vespidae) in northern Michigan: an observational study of meat foraging, a comparison of three carbohydrate baits, and an assessment of 20 seafood products

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ABSTRACT

Yellowjackets are often involved in pestiferous interaction with humans. In addition to stinging behavior, some yellowjackets can become serious ecological hazards. Control can be achieved through toxic baiting and non-toxic trapping. The three-part study, in Kalkaska County, northern Michigan, examined 1) foraging habits of meat scavenging species, 2) the relative effectiveness of acetic acid + isobutanol, heptyl butyrate, and apple juice—three carbohydrate baits, and 3) the attractiveness of 20 seafood products as potential bait products. The observational study and the seafood product assessment yielded no useful data due to low yellowjacket populations. The carbohydrate comparison indicated that *Vespula flavopilosa* favors apple juice; when analysis was restricted to Site 1, the Kruskal-Wallis test was significant ($p < 0.001$).

KEY WORDS: bait, control, foraging, *Vespula*, yellowjackets, apple juice

INTRODUCTION

Yellowjackets of the genus *Vespula* are often involved in pestiferous interaction with humans. Members of the *V. vulgaris* species group are especially problematic due to their characteristically large colony size, long colony duration, and tendency of individuals to scavenge aggressively from anthropogenic food sources (Akre 1995). Pestiferous activities range from nuisance behavior, such as harassment around food sources and occasional stinging, to more serious aggression when nests are disturbed (Akre 1995). These problems are dwarfed, however, by the severe ecological pressure exerted by invasive species of the *V. vulgaris* group, particularly *V. vulgaris*, *V. germanica*, and *V. pensylvanica*. These species have spread from their native regions of North America and Europe to become serious threats to other ecoregions, especially in New Zealand (*V. vulgaris*), South America (*V. germanica*), and Hawaii (*V. pensylvanica*) (Gambino 1992, Beggs and Rees 1999, Beggs 2001, Sackman et al. 2001).

Toxic baiting programs have been somewhat effective in controlling local yellowjacket populations (Sackman et al. 2001). Such efforts use meat bait to exploit the scavenging behavior of pestiferous wasps without killing non-target carbohydrate foragers such as honeybees (Spurr 1995). A recurring problem with meat baits, however, is that they quickly lose their attractiveness as they desiccate or spoil (Wood et al. 2006). Furthermore, they are expensive and unpleasant to handle. This has prompted research to find meat-based extracts that could be used as a substitute for actual meat. So far, this research has met with little success (Moore 2009).

An alternative to meat baiting is the use of either natural carbohydrates or synthetic substitutes. While carbohydrate baits are rarely used for toxic baiting, they can be effective in lowering local yellowjacket populations when used extensively and in conjunction with domestyle wasp traps (Wegner and Jordan 2005). The current industry standard for synthetic baits is a mixture of acetic acid and isobutanol (AAIB), which mimics volatiles released by fermenting fruit (Landolt et al. 2000). Heptyl butyrate (HB) is also used, but is primarily effective for the nonpestiferous *V. rufus* species group (Reed and Landolt 2002). Other proposed baits include apple juice and citrus-based soda (Wegner and Jordan 2005, Braun 2008), but studies testing the relative effectiveness of AAIB, apple juice, and citrus-based soda have been inconclusive (Knier 2010).

The purpose of my study was to contribute to the improvement of yellowjacket control methods by expanding our knowledge of yellowjacket foraging and examining the effectiveness of potential baits in the following three experiments.

First, I conducted an observational study to determine which vespid species are the most frequent meat scavengers. In a previous study, three species—*V. vulgaris, V. maculifrons,* and *V. flavopilosa*—were observed scavenging at meat baits placed around the Au Sable Institute, but not in high enough numbers to permit statistical analysis (Braun 2008). I sought to expand this investigation to more clearly determine the principle meat foraging species in the area.

Second, I tested the effectiveness of two industry standard synthetic yellowjacket attractants, HB and AAIB, compared to a natural attractant, apple juice. Recent studies have compared these attractants, but with conflicting results (Knier 2009). My goal in this experiment was to better ascertain which attractant is most effective. My hypothesis is that apple juice will demonstrate the greatest attractiveness because it is more similar to a food source in nature.

Third, I investigated the effectiveness of seafood products as yellowjacket attractants. This objective was based on reports of yellowjackets harassing workers at a seafood processing plant (H. C. Reed, personal communication) in addition to known attraction of foraging yellowjackets to a wide variety of meat sources (Reid et al. 1994, Spurr 1995). Because it was uncertain which seafood volatiles attracted yellowjackets, 20 different seafood products were prepared. Each product was tested against a negative control (drowning solution only) and a positive control with AAIB as bait. My primary hypothesis is that one or more seafood products will capture more yellowjackets than AAIB. My secondary hypothesis is that one or more products will capture more yellowjackets than the negative control, thus indicating effectiveness as a potential yellowjacket trapping lure.

While these three experiments were primarily designed to study yellowjackets, paper wasps (Vespidae: Polistes) are known to have similar foraging habits, and they are often captured and observed alongside yellowjackets. Since paper wasps are sometimes considered pestiferous (Mullen, 2009), I recorded any data pertaining to them as well.

STUDY AREA

This study took place in the vicinity of the grounds of the Au Sable Institute of Environmental Studies in Kalkaska County, in the northern Lower Peninsula of Michigan. The predominant vegetation is dry-mesic Northern Forest, characterized by White Pine (*Pinus strobus*), Red Maple (*Acer rubrum*), Sugar Maple (Acer saccharum), America Beech (*Fagus grandifolia*), Paper Birch (*Betula papyrifera*), and Large-toothed Aspen (*Populus tremuloides*), with Bracken Fern (*Pteridium aquilinum*) as the primary ground cover (Kost et al. 2007).

The observational study occurred at two sites. Site 1 was a sandy area on the bank of a shallow pond and wetland known as Louie’s Pond (N 44°49.370’/W 84°57.344’). Site 2, was another sandy area on the bank of Louie’s Pond (N 44°49.542’/W 84°57.228’), further away from the water and closer to the forest edge.

Experiment 1, testing the carbohydrate baits, occurred at 6 sites (Table 1) including: Site 1, the edge of a beech-maple-white pine forest bordering Louie's Pond; Site 2, the edge of a white pine-scotch pine forest bordering Beaver Pond; Site 3, a chainlink fence bordering the open field; Site 4, the edge of a mixed (beech-maple-white pine) forest that borders a mowed pipeline right-of-way; Site 5, the edge of a pine forest that borders South Bog; and Site 6, the edge of a white pine forest along a sandy beach on Big Twin Lake, known as The Pines.

Experiment 2, testing the seafood products, occurred at five sites (Table 2) including Site 1, the edge of a pine forest bordering Louie's Pond; Site 2, the edge of a pine forest bordering Beaver Pond; Site 3, the edge of a pine forest bordering the open field; Site 4, the edge of a mixed (beech-maple, pine) forest that borders the pipeline; and Site 5, the edge of a pine forest bordering South Bog.

I arranged all sites so that each trapping block/observation site was at least 50 m away from any other trapping block/observation site.

MATERIALS AND METHODS

Observational Study

I began my observational study at Site 1, but switched to Site 2 after 5 consecutive sessions during which no yellowjackets came to the bait. I conducted the remainder of my observation at Site 2.

I used Friskies© fish-based canned cat food for bait (Braun 2008). A dish containing approximately 39 g of cat food (1/4 can) was set on a white Styrofoam platform about 0.33 m off the ground.

I began the observational study on July 14th and continued until August 10th. Each observation session lasted 30 minutes and was conducted on sunny days when yellowjackets are most active (Jandt 2010). Air temperature was recorded at the beginning and end of each observation period. Observation periods occurred during four time slots: 0900-0930 EDT, 1000-1030 EDT, 1345-1415 EDT, and 1645-1715 EDT (Braun 2008, H. C. Reed, personal communication). When weather permitted, I conducted all four observation periods at one site in the same day. This was to allow yellowjackets the maximum amount of time to find the bait. I placed the bait at approximately 0700 EDT for the morning time slots. The morning bait was replaced with fresh bait at the beginning of the first afternoon session (1345 EDT).

Experiment 1:

I tested the relative effectiveness of AAIB, HB, and apple juice using Trappit™ Dome Traps, which consist of an opaque yellow bottom and transparent top. The traps were arranged in a randomized complete block design with six blocks. Each block consisted of three baited traps (AAIB, apple juice, HB) and a negative control trap (drowning solution only), for a total of 24 traps at the six trapping sites (Table 1). I hung the traps approximately 1.5 m above ground, away from any dense foliage that could hinder access (Moore 2009).

AAIB was be dispensed as using 15 ml vials, each containing two cotton balls soaked in 10 ml AAIB (1:1 ratio). HB was be dispensed in the same manner. Each vial had a 6 mm hole drilled in the lid to regulate the release of volatiles; this hole size has been documented to be optimum for attracting most yellowjacket species (Knier 2009). Vials were attached to the ceiling of the traps using wire. Both the AAIB and the HB bait vials were prepared by the lab of

Dr. Peter Landolt (USDA/ARS, Washington State University) and shipped to the Au Sable Institute.

For the traps baited with AAIB or HB, I filled the drowning basin to about one-half capacity (Moore 2009). The drowning solution consisted of distilled water with Ivory dish soap and boric acid mixed at a ratio of about 1 ml of soap to 10 g of boric acid per gallon of water. For the traps baited with apple juice, the bait also served as drowning solution. In these traps, I filled the drowning basin with apple juice and no dispensing vials were needed (Knier 2009).

I began trapping on July 5^{th} and continued through August 10^{th}, with the goal of coinciding with high yellowjacket populations (Braun 2008, H.C. Reed, personal communication). Traps were checked twice weekly and drowning solution and apple juice were changed once per week. AAIB and HB baited vials were replaced after four weeks (H.C. Reed, personal communication). All vespid specimens were collected in plastic bags and frozen. They were later identified to species using standard identification guides (Akre et al. 1980, Buck et al. 2008).

To control for position effect, I rotated the position of the traps in each block twice a week by shifting each trap down one position, with the trap formerly occupying the last position being moved to replace the trap formerly occupying the first position.

Since the data in previous trapping studies has not been normally distributed, I used the nonparametric Kruskal-Wallis test (Braun 2008, H. C. Reed, personal communication).

Experiment 2:

I tested 20 seafood products in four sets of five (Table 3). I made five replicate blocks of each set of baits in a randomized complete block design. In addition to the five baited traps, each block also included a positive control (AAIB) and a negative control (unbaited drowning solution), resulting in a total of seven traps. Thus, 35 traps were active during a given trapping interval, in blocks of seven. Each trapping interval tested one set of baits, so I conducted a total of 4 trapping intervals.

I used Trappit™ Dome Traps like those in Experiment 1. Seafood products were prepared by the lab of Dr. Peter Landolt and shipped frozen to the Au Sable Institute. I baited each trap by attaching a bait-containing vial to the ceiling of the trap with a wire. The vials containing seafood products were covered with mesh to facilitate dispersion of volatiles. Vials containing AAIB had a 6 mm hole drilled through the lid, as in Experiment 1. Each trap contained the drowning solution described in Experiment 1.

I began trapping on July 25th, after yellowjackets began to arrive at the carbohydrate traps. Trapping continued through August 13th. Because meat baits decay within 2–3 days, each trap was checked for wasps every 24 hours. I only conducted trapping during a series of sunny or partially cloudy days (Jandt 2010).

RESULTS

Observational Study:

No yellowjackets visited the bait during my observational study. I saw a queen yellowjacket (undetermined species) foraging in the vicinity of my site, but it showed no interest in the bait.

Experiment 1:

I captured a total of 45 yellowjackets (Table 4). Forty of them were of the genus *Vespula* and the remaining five were of the genus *Dolichovespula*. In addition to these, I captured 17 paper wasps (*Polistes fuscatus*).

Of the 40 *Vespula* specimens, I captured 26 *V. flavopilosa*, seven *V. maculifrons,* five *V. vulgaris*, one *V. consobrina*, and one *V. vidua*. Twenty-five of the *V. flavopilosa* specimens were captured in apple juice, and one was captured in AAIB. Four of the *V. vulgaris* specimens were captured in apple juice and one AAIB. Five of the *V. maculifrons* specimens were captured in AAIB and two in apple juice. The single *V. consobrina* specimen was found in apple juice, and the single *V. vidua* specimen was found in HB. Eight of the 40 *Vespula* specimens were queens: six *V. maculifrons*, one *V. vulgaris*, and one *V. vidua*.

Of genus *Dolichovespula*, I captured three *D. arenaria* and two *D. maculata*. Two of the three *D. arenaria* were found in apple juice, with the third being found in AAIB. The two *D. maculata* specimens were found in apple juice and AAIB, respectively.

I found *Polistes fuscatus* specimens in each of the four treatments: one in the control, eight in AAIB, two in HB, and six in apple juice.

V. flavopilosa was the only species that I captured in great enough numbers to warrant statistical analysis. I used the Kruskal-Wallis test to compare the bait preference of *V. flavopilosa* across the four treatments. While the numerical difference in the means suggests that *V. flavopilosa* prefers apple juice, the Kruskal-Wallis test showed that the difference was not significant ($p = 0.37$). When I limited my analysis to the data I obtained from Site 1, however, the difference was highly significant ($p < 0.001$).

Experiment 2:

I captured one *V. flavopilosa* specimen using Tanner crab shell + viscera. This was the only yellowjacket captured in any treatment, including the positive control (AAIB). No statistical analysis was performed.

DISCUSSION

All three components of my study suffered from a conspicuous dearth of data. While I am not aware of any formal population counts, there seemed to be remarkably few yellowjackets around the Au Sable Institute the summer of 2010.

Akre and Reed (1981) discussed the various factors that may influence annual yellowjacket abundance. Yellowjacket populations have been known to fluctuate dramatically between years of abundance and scarcity. Several factors have been proposed, including 1) weather, 2) queen fertility, 3) nesting site availability, 4) inter/intraspecific competition for nest sites, and 5) disease.

Most researchers agree that yellowjacket colonies are most vulnerable during the period between the emergence of the over-wintering queen and the emergence of the second brood (Akre and Reed 1981). Akre and Reed suggest that inclement spring weather is the most important factor in determining ultimate yellowjacket abundance, citing annual weather data and yellowjacket population estimates gathered from the Pacific Northwest. Periods of cold or rain during early nest development can hinder foraging, either by the queen or by the initial brood of workers. Any reduction in the opportunity to forage threatens the vitality of developing larvae that depend on protein-rich food supplied by adult foragers.

Weather is also the only proposed limiting factor that is not density-dependent. Northern Michigan never supports the extremely dense yellowjacket populations that are seen in the Pacific Northwest, so it seems unlikely that a density-dependent factor would be responsible for the low population at the Au Sable Institute during summer 2010.

While weather seems like the best candidate to explain the rapid population decline, archived weather data from spring 2010 in the Traverse City area of northern Michigan indicate that April, May, and June were unremarkable, although slightly warmer and slightly wetter than average. It was reported by one local resident, however, that the immediate vicinity of the Au Sable Institute experienced an overnight frost in early June (Lynn Drew, personal communication). This could have been detrimental to developing yellowjacket nests if they were not yet large enough to thermoregulate effectively, but it seems unreasonable to attribute the extremely low yellowjacket populations that I observed solely to inclement weather. Additional research would be required to explain the population declines more fully.

It is important to note that the scarcity of yellowjackets that I observed may have been limited to the immediate area of the Au Sable Institute. Yellowjacket populations are often densely clumped around favorable spots and virtually absent from other areas (Spradbery, 1973). It could be that the apparent scarcity around the Au Sable Institute was not a fair representation of the overall yellowjacket abundance of the general region of northern Michigan.

Observational Study:

It appears that the local yellowjacket population was not dense enough to be observed at a single protein source. I spent a total of seven hours (14 half-hour sessions) in observation without seeing a single visitor to the bait. In fact, I witnessed perhaps only five or six foraging yellowjackets all summer, including informal sightings. These findings suggest that this kind of observational study is not useful in areas of low yellowjacket abundance. I would recommend that a preliminary survey of yellowjacket populations be performed prior to conducting a similar study.

After 14 unsuccessful observation sessions, I decided to simulate high yellowjacket abundance by placing the bait directly in front of the entrance to a *V. flavopilosa* nest that I found about 60 m from my second observation site. In about 45 minutes, I observed probably between 20 and 30 visits, though I did not keep a formal count. This confirmed the attractiveness of the bait, but in a strictly qualitative manner. I noticed what appeared to be a distinct clumping of visits, perhaps suggesting some kind of social behavior, but this observation was both preliminary and unquantified.

Experiment 1:

I can tentatively conclude that V. flavopilosa prefers apple juice to AAIB or HB, supporting my initial hypothesis. While my findings were not statistically significant when I combined the data from all sites, I did find a significant preference for apple juice when I ran the Kruskal-Wallis test on the data from Site 1 alone. Excluding sites 2-6 was probably the most valid way to analyze the data for *V. flavopilosa* since I only captured this species at Site 1 and have no reason to believe it was even present at the other sites. A follow-up study with a greater amount of data would useful to verify these findings.

Perhaps the greatest value of this study is that it suggests an exceptional scarcity of yellowjackets around the Au Sable Institute in 2010. In 2008, another researcher conducted a nearly identical study at the Au Sable Institute that captured 677 yellowjacket specimens (Braun, 2008). My total of 45 specimens implies a 93% decline over the past two years. This drastic die-off could warrant further study, though it might be restricted to the immediate area of the Au Sable Institute. It is also possible that the low yellowjacket density this year is more typical for northern Michigan and that 2008 was an exceptionally high year. More likely, I suspect that 2008 and 2010 represent opposite extremes and that typical yellowjacket densities are somewhere in between. Without annual population estimates, though, this assertion is purely speculative.

It is worth noting that while apple juice captured the most yellowjackets, it also attracted the most non-target species. The vast majority of specimens were various flies. No formal counts were made, but it was not unusual to find what appeared to be at least 40-50 flies in an apple juice trap. Moths also made up a significant portion of the catch. Occasionally, a butterfly would be found in the apple juice. The most disappointing find was a single bumblebee specimen, which represents an unwanted trapping of a particularly beneficial non-target species that could suffer from attempts at yellowjacket control. Fortunately, no honeybees were found in any trap.

Experiment 2:

The assessment of seafood products was rendered unproductive, it would seem, by the apparent scarcity of yellowjackets. Since no specimens were caught in the positive control (AAIB), one cannot conclude that the seafood products were unattractive. Neither can anything meaningful be concluded from the single *V. flavopilosa* specimen found in the trap containing tanner crab shell + viscera. Any further study should be conducted at a location that is known to have high yellowjacket abundance.

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Table 1. Summary of study sites for Experiment 1

Site #	Name	Description	Coordinates
1	Louie's Pond	Pine forest edge along wetland	N 44°49.494 W 84°57.272'
2	Beaver Pond	Pine forest edge along wetland	N 44°49.690' W. 84°57.138'
3	Ball field	Chain-link fence around tennis court bordering open field	N 44°49.415' W 84°57.020'
4	Pipeline	Mixed forest edge along mowed strip	N 44°49.330' W 84°56.939'
5	South Bog	Pine forest edge along wetland	N 44°49.106' W 84°57.163'
6	Pines	Pine forest edge along lakefront	N 44°49.656' W 84°58.028'

Table 2. Summary of study sites for Experiment 2

Site #	Name	Description	Coordinates
1	Louie's Pond	Pine forest edge along wetland	N 44°49.412' W 84°57.315'
2	Beaver Pond	Pine forest edge along wetland	N 44°49.743' W 84°57.138'
3	Ball field	Pine forest edge along open field	N 44°49.369' W 84°57.002'
4	Pipeline	Mixed forest edge along mowed strip	N 44°49.410' W 84°56.930
5	South Bog	Pine forest edge along wetland	N 44°49.117' W 84°57.132'

Table 3. Seafood products used in experiment 2.

Bait No.	Contents
1	White Fish Meal
2	Pollock Oil
3	White Fish Meal + Pollock Oil
4	Salmon Meal
5	Hydrolysate Viscera
6	Hydrolysate Viscera + Fish Meal
7	Hydrolysate Heads
8	Hydrolysate Heads + Fish Meal
9	Stick Water
10	Stick Water Concentrate
11	Stick Water Concentrate + Fish Meal
12	Dried Pollock Viscera
13	Pollock Skin Dried
14	Tanner Crab Shell + Viscera
15	Dried Salmon Liver
16	Pollock Mitt + Salmon Roe
17	Goeduct + Halibit Head
18	Whole Dried Salmon
19	Whole Fish Dried + Fish Meal + Oil
20	Whole Raw Salmon

Table 4: Results of Experiment 1

Species		Treatment			
	Control	AAIB	HB	AJ	**Total**
V. flavopilosa		1		25	26
V. vulgaris		1		4	5
V. maculifrons		5		2	7
V. vidua			1		1
V. consobrina				1	1
D. arenaria		1		2	3
D. maculata		1		1	2
P. fuscatus	1	8	2	6	17
Total	1	17	3	41	62