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Developing Baits for the Control of Yellowjackets in California

Michael K. Rust, Donald A. Reierson, and Rick Vetter

Department of Entomology
University of California, Riverside
Riverside, CA

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Executive Summary

- Monitoring with traps is an essential element in the pest management of yellowjackets. In addition to locating areas of high foraging activity, traps help quantify the foraging activity and establish when baiting programs should begin.
- The most useful traps collect yellowjackets in a preserving fluid such as ethyl alcohol (ETOH) or propylene glycol antifreeze. However, antifreeze was chosen for our trapping because it is cheaper than alcohol and has fewer restrictions when mailing specimens.
- The western yellowjacket, *Vespula pensylvancia*, was the most frequently encountered species. *V. atropilosa* and *V. sulphurea* are sometimes sympatric with *V. pensylvanica* but are nearly always less abundant in the specific locations where the species are encountered.
- Intensive trapping with heptyl butyrate attractant can reduce the numbers of foraging yellowjackets, but trapping alone will not provide area-wide control. Placing rings of traps surrounding picnic areas or pool areas (interceptive trapping strategies) did reduce the number of stings reported park users.
- A prototype Contech heptyl butyrate flexible bag wet trap was a good monitoring tool. Sterling and other kinds of dry traps are effective at attracting and capturing yellowjackets, but live trapped wasps tend to dismember others in the trap. This makes it difficult to count the number trapped. Depending on price and availability, the PMP may wish to consider the Contech trap.
- The only registered bait (Onslaught®, microencapsulated esfenvalerate) was not effective as a bait toxicant against the western yellowjacket, *V. pensylvanica*.
- Swanson's® brand canned minced white chicken and Purina Friskies® Ocean Whitefish Dinner were consistently the most accepted bait bases tested.
- Chicken or whitefish baits consisting of 0.0025 to 0.025% fipronil were the consistently most effective baits tested.
- The best results were obtained when the numbers of yellowjacket foragers exceeded 10 wasps/day/trap. A second baiting within 6-8 weeks after the initial baiting provided outstanding reductions in the numbers of yellowjackets.
- Dinotefuran baits (0.001 to 0.025%) provided inconsistent results. The dinotefuran was usually too toxic, killing workers before they could adequately recruit and scavenge the bait.
- Chlorfenapyr, chlorantraniliprole, indoxacarb, and spinosad were not effective baits.

Introduction. The overall objective of this study was to develop an effective baiting strategy to control pestiferous yellowjackets in California. Certain species of yellowjackets (Vespidae) are annoying and dangerous. Predatory species belonging to the *vulgaris* subgroup are efficient predators of Diptera (flies), Orthoptera (crickets and grasshoppers) and immature Lepidoptera (caterpillars). They alter their foraging habits and become scavengers as the density of worker wasps/area increases as the abundance of native prey declines. Pest species tend to construct subterranean nests, have thousands of foraging workers, and scavenge for protein foods. Yellowjackets can be dangerous if their nest is disturbed. Guard wasps readily attack and sting if their nest is disturbed. More importantly, aggressive foragers away from a nest may sting as they compete for human food or drink. Interactions with humans increase with location and wasp density, and such interactions may result in intentional or accidental stings. Although <5% of humans are sensitive or hypersensitive to wasp venom, this represents large numbers of individuals. Because of their relative smaller size, children are at greater risk.

Yellowjackets are highly seasonal. Colonies usually begin in the spring from overwintering mated queens, peak during the summer, and extinguish by mid-fall. The number of workers foraging is typically not large enough before July 4 to conduct bait trials. The level of yellowjacket activity is dependent upon adequate rainfall and the resultant insect food supplies. Wildfires also greatly decrease potential food sources and yellowjacket populations. The number of foragers dramatically decreases in October. Rarely does a colony live from one year to the next.

Baiting is a low-risk technique that implements a combination of a palatable food substance and an effective toxicant. There is presently only one active ingredient (AI) registered as a bait for yellowjacket control (Onslaught, microencapsulated esfenvalerate). Our previous studies have shown this product to be ineffective against yellowjackets. We explored several operational strategies for the PMP to assist clientele such as homeowners and facilities managers who have a legal responsibility to provide a safe, comfortable environment for their customers.

2006 Research

Fig. 1. Silent Valley RV park in the mountains near Idyllwild, CA.

Important elemental aspects of the study were undertaken simultaneously during 2006. We developed a standardized, safe and replicable monitoring technique to quantify yellowjacket populations. Monitoring is critical to determine areas of infestation and the success of baiting. Success is determined by the difference in trap catch before and after baiting. Heptyl butyrate lure attracted yellowjackets to series of plastic bottle traps we previously found effective against *V. pensylvanica*. Several areas where cooperators expressed interest in the project were surveyed with traps, and three were selected for study. The sites included (1.) three large regional Santa Clara County Parks, (2.) a 10-acre Health Spa near Corona, CA

(Riverside County), (3.) an 800-space RV park near Idyllwild, CA (Riverside County, elevation ~ 3,500 feet, Fig. 1), and (4.) a portion of land around the Soboba Casino, a tribal facility in San Jacinto, CA (Riverside County).

Traps (Fig. 2) were placed according to UCR instruction. The Parks & Recreation Department serviced the traps weekly in Santa Clara, as did Orkin Pest Control service technicians at the spa and Soboba tribal property. We maintained the traps at the RV park. Yellowjackets captured in each trap in each location were sent to UCR for identification and tally. We examined tens of thousands of specimens during 2006.

Fig. 2. Two-part UCR yellowjacket bottle trap. Glass vial protruding from right side contains heptyl butyrate dispensed from dental wick, collecting liquid in bottom.

Monitoring and identification - Long-term trapping is an efficient technique for determining the presence and number of yellowjackets. Sampling with an insect aerial net may confirm the presence of species but cannot reliably be used to determine abundance. Trapping in 2006 confirmed earlier work that the predominant species of yellowjacket in California is *V. pensylvanica* and that *V. atropilosa* and *V. sulphurea* are sometimes sympatric with *V. pensylvanica* but are nearly always less abundant in the specific locations where the species are encountered.

In order to be counted and identified, captured specimens needed to be maintained intact. Dry traps could not be used because captured wasps dismember previously captured ones. Cooperators needed a reliable fluid with which they could capture and preserve specimens for us to identify. Ethyl alcohol (ETOH) is a standard good preserving fluid, but is generally unavailable except by research permit. Denatured isopropyl alcohol (IPA) is a commercially available common preservative, but we were unsure as to whether it was repellent in traps. We have previously used propylene glycol antifreeze (Sierra® Antifreeze/Coolant, Old World

Industries, Inc., Northbrook, IL) in pitfall traps for ants, spiders and other insects. It is safe, economical, and an effective preserving liquid, killing captured specimens quickly and not discoloring them. Antifreeze is approximately half the cost of IPA. In our tests IPA was significantly repellent as compared to ETOH or antifreeze in yellowjacket traps (Fig. 3). Specimens collected in antifreeze could be shipped by our cooperators in the mail or by UPS. Antifreeze was superior, and was utilized in all future trials.

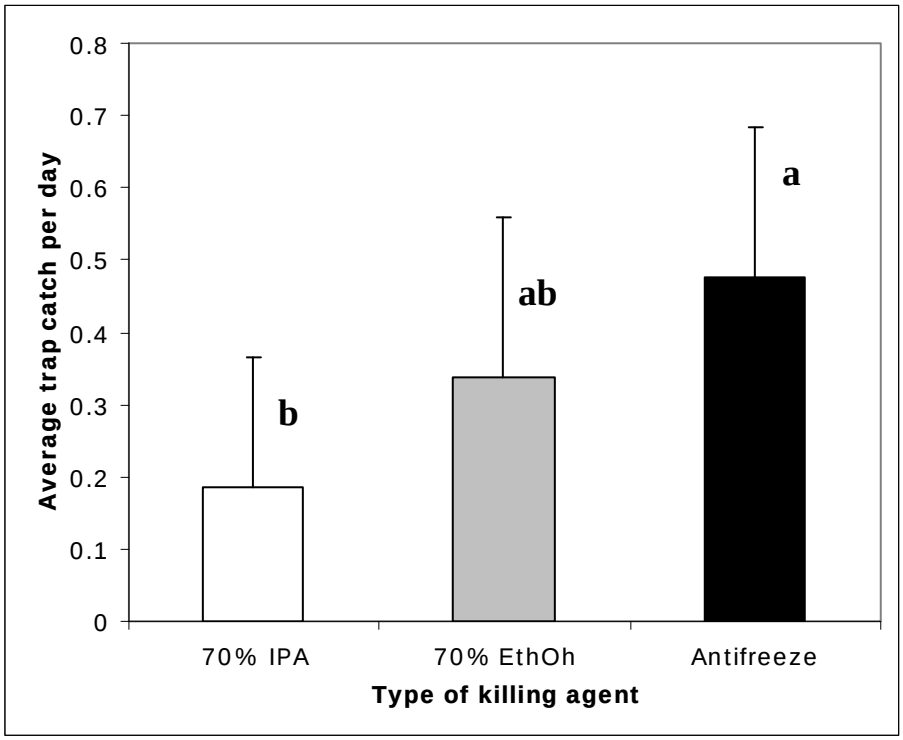

Fig. 3. Seasonal comparison of three preserving fluids used during 2006 in traps for collecting *V. pensylvanica* in California (Tukey's HSD, $P < 0.05$; columns with same letter are not significantly different).

Bait acceptance - The objective of this phase of the project was to develop an effective bait. During the summer, yellowjackets prefer protein-based foods. Problematic species may maintain energy reserves by consuming sweets, but they primarily forage meat. Some meats are foraged, while some are ignored. As a start point for the study, we sought a convenient protein source as a possible bait matrix. Canned pet foods are convenient and inexpensive, some being reported in the literature to be effective bait bases for toxicants. Initial acceptance trials in the spring, 2006 suggested that Swanson's brand canned chicken is the most foraged canned food and that fresh ground chicken is even more preferred. However, because Swanson's is expensive (i.e. about $2.50 per 4-oz can), and fresh ground chicken spoils quickly, we decided to evaluate the palatability to yellowjackets of an assortment of commercially available canned pet foods. We evaluated 18 canned cat foods as to whether yellowjackets would forage them. A variety of flavors and textures was chosen. We concentrated on cat food because of convenience. The pet foods were purchased at a local market. About 2 tablespoonfuls of cat food and a control (Swanson's® brand canned minced white chicken) in 2-oz clear plastic salsa cups (Dixie® PL2C)

were positioned randomly on picnic tables or grills in infested parks (Fig. 4, top). We observed and recorded the number of wasps landing and taking away bits of each food. We made at least 2 studies simultaneously in each location. Most foods were neglected or only barely foraged, acceptance or neglect of the foods being apparent within about 30 min or so. Analysis (Student *t*-test, $P < 0.05$) of the number of wasps on the foods indicated which were statistically most

Fig. 4, *left*, Assortment of canned pet foods for acceptance trial; *right*, yellowjackets displaying preference by foraging some foods while neglecting others.

preferred. Besides landing rates, acceptance was also calculated from the quantity of food the yellowjackets foraged during the exposure. The volume of food remaining in each cup (2 tbsp = 30cc) was assessed with measuring spoons the following day. Yellowjackets were prevented from feeding on a series of cups containing test foods. These were weighed before and after the feeding tests and served as evaporation checks. The volume of each food taken by the yellowjackets was statistically analyzed (Student *t*-test, $P < 0.05$).

Another series of acceptance trials with the few cat foods which had been foraged most was made a week later. The purpose of this trial was to clarify which cat foods were best. Pre-weighed cups of those foods were exposed to forgers. Besides landing counts, the difference between the initial weight and final weight provided additional quantification of which foods were most preferred.

Similar presentations were then made with the most preferred cat food (i.e. Friskies® Ocean Whitefish) into which dilutions of < 0.05% acetamiprid, chlorfenapyr, esfenvalerate, fipronil, imidacloprid, indoxacarb, or spinosad were mixed. We tested only reportedly non-repellent or biologically active insecticides that would have negligible effect on the environment and non-target organisms as candidate bait ingredients. Only small amounts of toxicant-laden cat foods were used in these trials so that nests in the area would not be affected.

Preliminary bait efficacy trials - Of the cat foods + toxicant, the most foraged was indoxacarb in Purina Friskies® Ocean Whitefish Dinner at 0.05% (wt/wt). Indoxacarb is unique in that it is

metabolically activated in insects from a low-toxicity 'pro-insecticide' to an active form. This activation does not occur in mammals. Similarly, chlorfenapyr is a unique, slow metabolic toxicant which appeared to be particularly promising as a bait ingredient. We used these 2 materials in preliminary bait control trials. The other toxicants tested at the 0.05% rate were repellent. Lower rates of the other toxicants may be more highly foraged, but because indoxacarb was taken well, we did not evaluate lower rates of other toxicants in 2006.

Preliminary trials for control were conducted in Santa Clara, at the Spa, and in Idyllwild, but the 2 former sites were used primarily for trapping studies. Aliquots of Ocean Whitefish bait were dispensed from 2-oz salsa cups in custom 8-in by 8-in by 6-in cages made with 1/2-in hardware cloth sides stapled to wooded tops and bottoms. A hardware cloth door on one side of the cage was kept closed with a plastic twist-tie after the cage was loaded. The cages were suspended with baling wire about 4 or 5 ft above the ground from low branches of trees (Fig. 5) in areas where traps had indicated yellowjackets were abundant. Foraging yellowjackets could forage bait after flying through the openings between the wire, but humans or animals could not gain access to it. Efficacy was calculated as the reduction in the number of yellowjackets trapped per week after treatment compared to the number trapped per week before.

Results of the bait trial in Idyllwild are shown in Table 1. Excellent control was achieved with 0.05% chlorfenapyr and indoxacarb bait. Baiting resulted in >90% reduction in the number of yellowjackets within 2 weeks. The reductions continued for a month, at which time there were too few yellowjackets in the control area to draw definite conclusions. The results were encouraging, especially when one takes into account the large number of yellowjackets foraging in the area before baiting. We observed apparently good results in Santa Clara, but the cooperator there had too few monitor traps for us to acquire adequate numerical data. However, although we apparently had good results in Santa Clara and traps indicated excellent control in Idyllwild, we were cautious because the baiting begun September 22, relatively late in the

Fig. 5, *top*, Hanging a bait station containing salsa cups of test bait; *bottom*, a bait station containing test bait *in situ*.

yellowjacket season. These and lower rates were tested when large numbers of yellowjackets were present earlier in the next yellowjacket season.

Insecticide transfer - The traditional concept regarding baiting is that wasps forage toxic food bait and feed it to larvae in the nest, thereby killing larvae and adults which may receive regurgitated food. However, our research this year with caged wasps as well as with ants and termites indicates traditional transfer in oral or anal secretions may be complemented by lethal intraspecific transfer of toxicant among individuals in the colony as a result of foraging wasps coming in contact with a toxic surface. Unsuspecting insects become donors as they encounter insecticides such as fipronil and indoxacarb. This is not a common occurrence among other toxicants. Besides specific physical attributes of the toxicant that allows for transfer, it is important there be delayed toxicity after exposure, during which time the wasp behaves normally.

Fig. 6. Metal screen cage treated with 0.5% fipronil.

We showed that relevant transfer may occur. Specially constructed 1/4-in metal hardware cloth cages dipped into 0.05% fipronil aqueous liquid were allowed to dry (Fig 6). Transfer among yellowjackets was then demonstrated by the resultant effect of placing the treated cage over the nest entrance of a yellowjacket nest (Fig. 7). Guard wasps and many others flew out of the nest and into the cage. The cage was left in place 15 to 20 minutes, at which time it was removed and the wasps in the cage allowed to escape. The wasps in the cage were contaminated with a dose of fipronil insufficient to kill them within a short time. We observed destruction of the nest and excavation of the nest by wild animals with 24 hours. The contaminated wasps released from the cage apparently returned to the nest where insecticide was transferred from them to workers and brood in the nest.

Fig. 7. Treated cage being placed over a yellowjacket nest entrance.

This transfer was lethal to the wasps, and suggests to us that a material such as fipronil may have

special transfer characteristics that may be especially useful in a yellowjacket baiting program.

Because of the excellent results found in the transfer studies, we examined the possibility of a novel non-food bait strategy. In a preliminary late-season trial, Petri dishes plated with 0.05% fipronil were placed in our bait cages and presented to foraging yellowjackets. For these trials, heptyl butyrate dispensed from a vial in the dishes enticed foragers into the cage where they inadvertently contacted fipronil in the dish. Since no food was present, contaminated foragers that searched unsuccessfully for food could return to their nest after locating food elsewhere. We hoped that because of the delayed toxic effect of fipronil, larvae in the nest would succumb after contact with donor foragers. Based on our observations and those of campers who used the sites near where this study was done, this 'contact baiting' appeared to reduce the number of foragers. However, this study was done in October, when the number of yellowjackets receded naturally. We were encouraged about the possibility of using low rates of a non-food contact 'bait' to control yellowjackets.

Table 1. Results of a preliminary trial showing the effectiveness of chlorfenapyr (Phantom®) and indoxacarb in cat food[a] as bait to control the western yellowjacket, *Vespula pensylvanica*.

		% Reduction[b] at week		
Bait AI (0.05%)	Avg. before No./trap/day[c] (total)	1	2	4
Chlorfenapyr	45.2 (1,898)	90.7	90.0	99.7
Indoxacarb	54.1 (2,273)	95.4	93.6	99.7
Untreated	32.2 (1,354)	0.0	0.0	24.7

[a] Toxicant 0.05% AI formulated SC in Friskies Ocean Whitefish Dinner.
[b] Baiting begun 15 September 2006; Silent Valley RV Park, Idyllwild, CA.
[c] Six traps per location left for 7 days; bait and control sites ca. 0.5 mile apart.

2007 Research

Trapping and baiting studies were done at seven sites in 2007. The sites included 1.) three large regional Santa Clara County Parks, 2.) a 10-acre Health Spa near Corona, CA (Riverside County), 3.) Silent Valley RV park near Idyllwild, CA (Riverside County, elevation ~ 3,500 feet), a RV recreation site near Corona, Glen Eden Spa, and vineyard in Napa Valley.

Monitoring for yellowjacket activity was done with heptyl butyrate and alcohol collecting containers. Traps were placed according to UCR instruction. The Parks and Recreation Department serviced the traps weekly in Santa Clara, as did Orkin Pest Control service technicians at the spa. We maintained the traps at the RV park near Idyllwild. We and personnel at the Napa vineyard maintained traps at this site. Yellowjackets captured in each trap in each location were sent to UCR for identification and tally. We examined tens of thousands of specimens during 2007.

Bait acceptance - In 2007, the objective was to expand on the choice feeding studies and develop an effective bait.

We had outstanding cooperative assistance throughout the summer from Santa Clara County Department of Parks and Recreation. Supervisor Mr. Craig Crawford and his staff worked with us to install traps and bait stations. They maintained the stations and >50 traps on a weekly basis, and shipped all the specimens they captured to us each week. Two researchers from UCR joined Mr. Crawford on this project in the Santa Clara parks at least once a month. Four Santa Clara County Regional Parks were involved in the yellowjacket study in 2007. Yellowjackets are inherently problematic throughout the summer in sections of these large, heavily-used parks. Yellowjacket problems most years were so severe that people were warned about yellowjackets when they enter the park.

Fig. 8. Pavilion at Santa Teresa Park in Santa Clara County, CA.

Santa Teresa Regional Park.- Two techniques to mitigate the yellowjacket situation were tried at the day-use picnic area in Santa Teresa Park (Fig. 8). One technique was *remedial control* with minced chicken bait, a technique we used that greatly reduced yellowjacket populations in a park in southern California in 2006. The other technique was interceptive 'mock baiting' whereby we attempted to prevent yellowjackets from becoming problematic at a specific site.

We tried prevention at a single large (100 ft by 200 ft) picnic food pavilion by trapping or baiting them with an interceptive ring of traps containing heptyl butyrate as a lure or minced chicken-based bait in stations placed about every 150 feet in a circle about 200 feet from the pavilion. The pavilion is a roofed open-air structure on a concrete slab containing several wooden picnic tables and two barbeque pits. The surrounding acreage is prime yellowjacket terrain. Yellowjackets historically swarm into

the pavilion and sting people as they are eating or cooking. The intent was to intercept foragers before they entered the picnic area, thereby reducing the likelihood of picnickers being stung.

Vasona Regional Park.- This is the Santa Clara Park Headquarters park. It is > 40 acres and includes a 5-acre fishing lake, extensive grassy picnic areas, ball fields, and playgrounds (Fig. 9). The park is surrounded by urban housing. Rangers at the park can predict where in the park there will be yellowjacket problems, usually near the lake and in specific picnic areas adjacent to native hillside covered with brush that provides cover and camouflage for nests. Expecting large numbers of yellowjackets by August, baiting was begun August 1 with 0.05% indoxacarb and 0.05% Onslaught® (microencapsulated es-fenvalerate) in minced chicken at selected sites in the park. Onslaught was selected because, although its instructions for use are ambiguous, it is the only product currently registered for use as a yellowjacket bait. To ensure freshness, bait was prepared on site with a mini-Cuisinart food processor. It was dispensed in 2-tbsp aliquots from 2 aluminum weigh pans in each of 4 wire mesh stations suspended from trees about 150 to 200 feet apart. We set up the bait trials and Santa Clara county staff monitored the sites weekly.

Fig. 9. Picnic grounds at Vasona Lake in Santa Clara County, CA.

Results

Silent Valley RV Camp.- The continued drought, severe frost episodes during early spring, and brush fires greatly affected several of our test sites. The RV camp was located about 5 miles south of Banning, CA (33° 51' 0.6.28" N; 116° 50' 49.04" W; 3,625 ft elevation) on California Route 243. It had survived the extensive Espranza fire that burned over 20,000 acres of brush in the San Jacinto Mountains during the last week of October 2006. However, the immediate surrounding area outside its property was totally burned. The surrounding area was denuded of plants and most insects. *V. pensylvanica* continued to be the most common species collected in the traps (Fig. 10). The numbers of *V. pensylvanica* trapped dropped dramatically in 2007. For example, the total

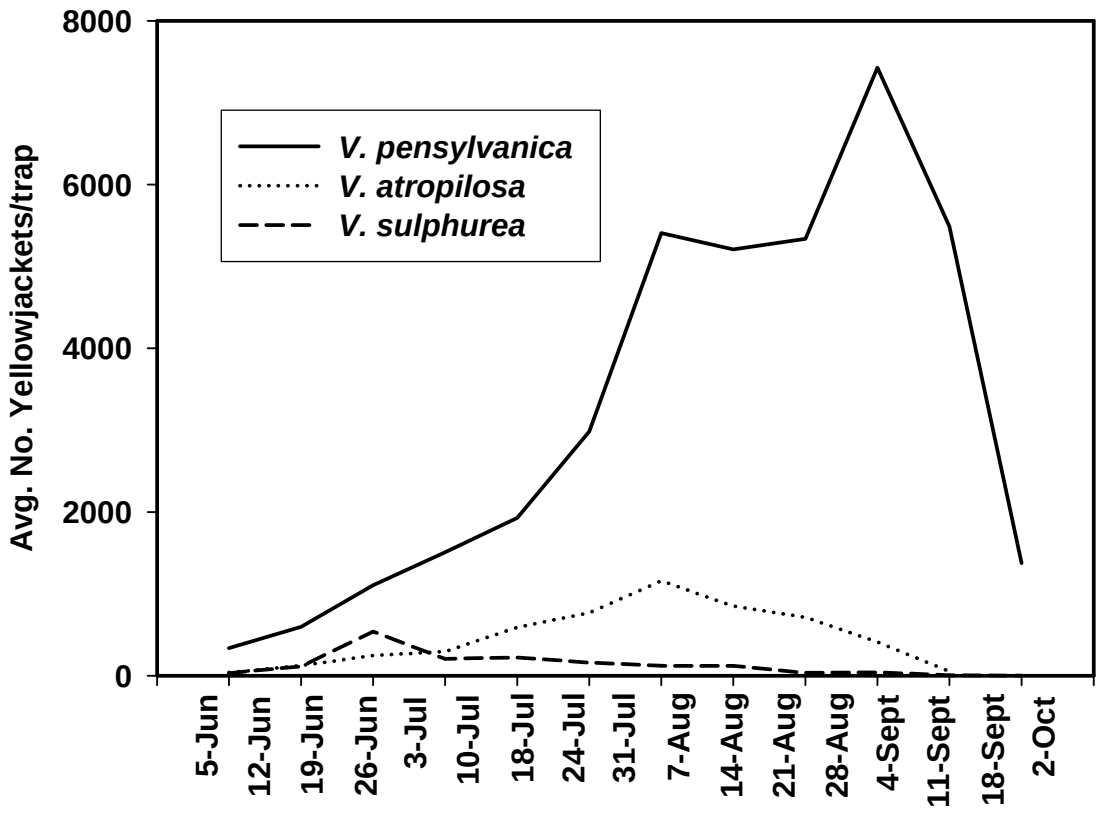

Fig. 10. The number of *Vespula pensylvanica*, *atropilosa*, and *sulphurea* trapped each week at Silent Valley RV park in 2006.

number of *V. penslyvanica* trapped on July 11, 2006 was 337 compared with only 139 on the same date in 2007 (Fig. 11). The differences continued throughout the summer reaching a maximum on September 11 when only 1,749 yellowjackets were trapped per week compared with 7,428 in 2006. The average number of yellowjackets never reached sufficient enough numbers to conduct baiting studies during 2007. We attribute this significant population effect on a drastic reduction in the amount of suitable prey for the yellowjackets. There was neither the normal amount of live prey or insects or other animals on which to scavenge.

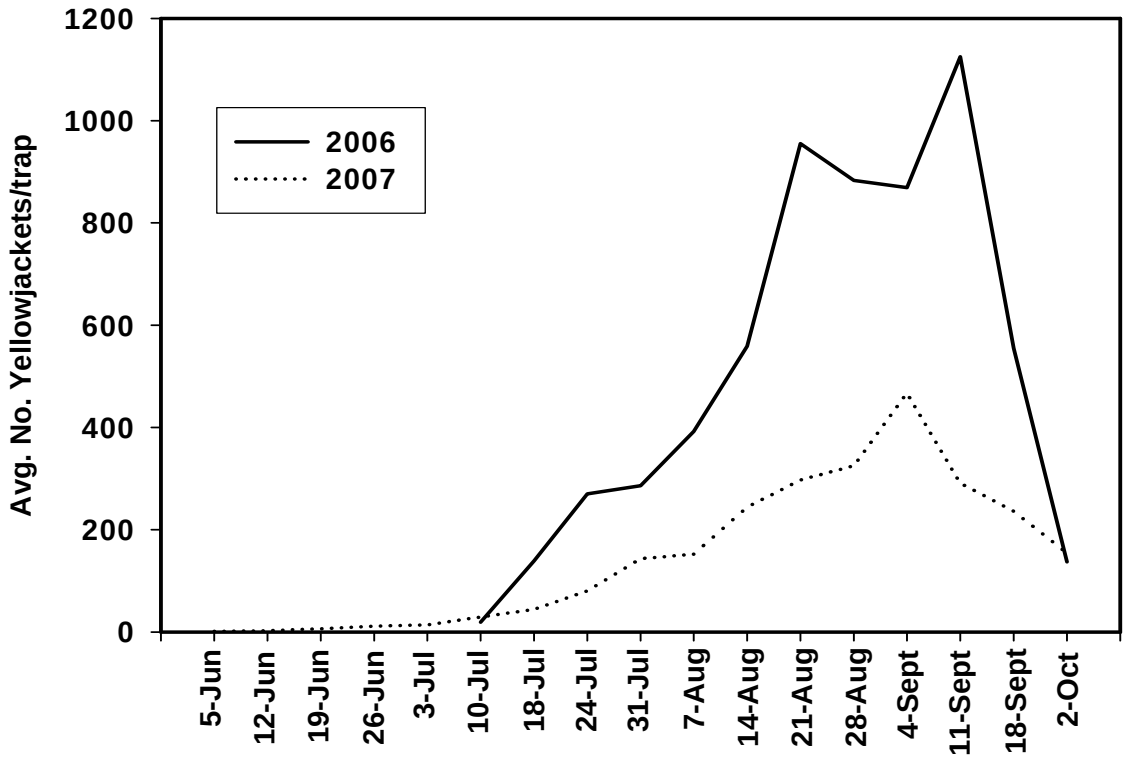

Fig. 11. Average number of 3 different species of yellowjackets from 30 traps at Silent Valley RV camp in southern California.

Glen Ivy Resort.- The continued drought and severe frost episodes during 2007 had a similar drastic impact on the numbers of yellowjackets at the Glen Ivy Resort near Corona, CA. Sixty traps were monitored throughout both yellowjacket seasons. The traps collected 2,132 yellowjackets on July 13, 2006 compared with only 25 on the same date in 2007 (Fig. 12). The numbers of yellowjackets never increased sufficiently in 2007 and monitoring was discontinued September 7.

Glen Eden RV site.- The 155-acre resort is nestled in the foothills of the Santa Ana Mountains about 15 miles south of Corona. Located in a dry oak woodland area, the resort is plagued annually by huge numbers of yellowjackets. The yellowjackets nest in native chaparral that surrounds the resort and they regularly forage on resort property. It is impossible to practically locate nests in and around the resort. A pool and outdoor cooking are especially attractive to yellowjackets. Accidentally encountered nests are destroyed.

Thirty monitoring traps were installed in early April 2007. Numbers of trapped yellowjackets increased slowly and on July 6 an average of 6.7 yellowjackets/trap were collected.

Santa Teresa Regional Park.- A maintained peripheral ring of heptyl-butyrate traps greatly reduced the number of yellowjackets at the pavilion. The success of the 'mock baiting' is shown in Fig. 13. On average, <10 yellowjackets/day were collected in each of 4 monitor traps at the pavilion (avg. total = 21.6), whereas >30 to 70 were captured in each of 24 ring traps (avg. total = 1078). This 50-fold difference indicates how well the ring traps intercepted foragers. Interceptive trapping may be even more effective if the traps were hung closer to one another.

Because a significant number of yellowjackets persisted near the pavilion, we baited the area 28 August. We tested (wt/wt) 0.1% dinotefuran; 0.05% indoxacarb SC; and 0.05% chlorfenapyr (Phantom SC) in minced chicken dispensed from custom wire mesh cages. As with the ring of traps, foraging diminished at the pavilion. However, foraging was not totally extinguished at the peripheral traps. This leads us to conclude that the baiting was only marginally effective. Performance may be improved by using more dispenser bait stations.

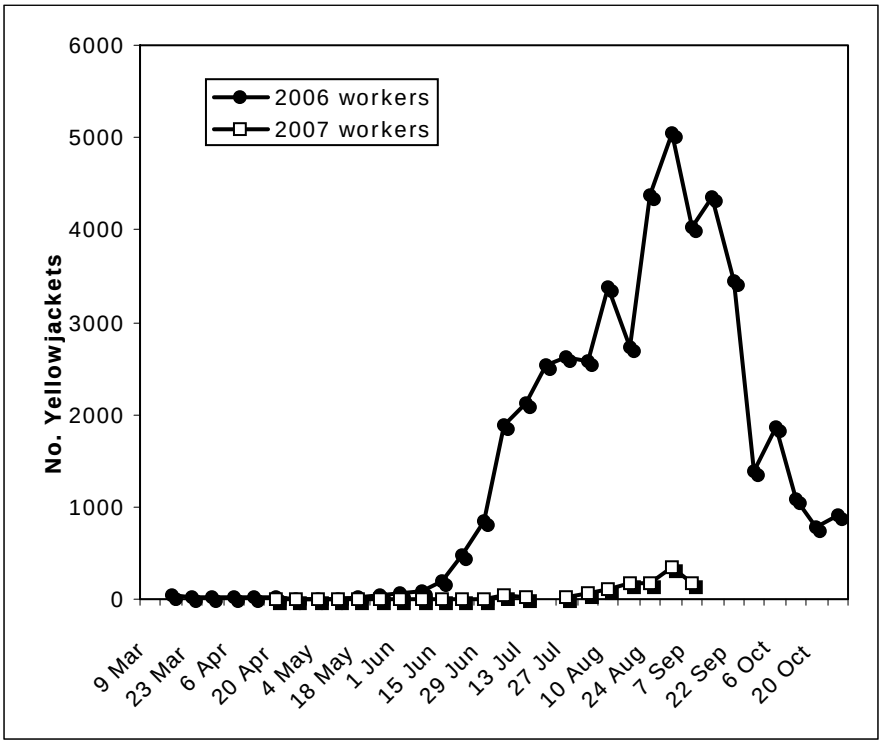

Fig. 12. The number of yellowjacket workers trapped at Glen Ivy Resort in 2006 and 2007.

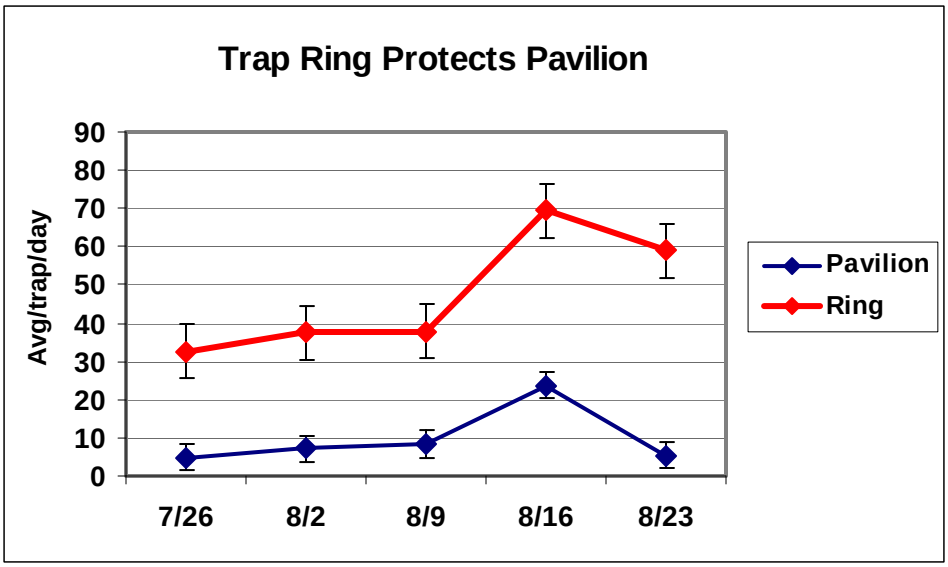

Fig. 13. Number of yellowjackets trapped by peripheral rings of traps 'mock-baiting' at Santa Teresa Regional Park.

Vasona Regional Park.- Summarized in Table 2, results of these bait trials were disappointing. Indoxacarb, 0.05% in minced chicken provided good control in other locations, but neither it nor Onslaught provided significant control at Vasona. Additional stations may have helped, but it is more likely that we started baiting before there were a sufficient number of foragers. Trap precounts averaged only 5.5 to 5.7 wasps/trap/day. This confirmed our past finding that about >10 wasps/trap/day was about the minimum number of foragers needed to take enough toxic bait to the developing colony to have a measurable effect. Low trap captures in an unbaited control area in Vasona indicated that yellowjackets were not likely to become a problem at Vasona and baiting, therefore, was not needed. This was substantiated by the fact that virtually no stings or encounters with yellowjackets were reported by Vasona park users this year.

Table 2. Baiting for yellowjacket control at Vasona Park, Santa Clara County, in 2007.

		Avg no. per trap/day (± % change) [b]		
Bait (% wt/wt)[a]	Precount	1 week	2 weeks	3 weeks
0.05% indoxacarb	5.5	11.5 (+ 109)	5.3 (3.6)	5.0 (9.1)
0.05% Onslaught	5.7	18.5 (+ 224.6)	8.8 (+ 54.4)	6.8 (+ 19.3)
Untreated control	10.3	19.8 (+ 92.2)	12.0 (+ 16.5)	12.0 (+ 16.5)

[a] Avg of 4 traps per area; precount 1 August 2007; bait matrix Swanson's minced chicken.
[b] In parentheses, + is % increase compared to precount; no + is % reduction.

Hellyer Regional Park.- This is Maintenance Division headquarters park for the Santa Clara County Parks & Recreation Department. Because of its reported good activity against insects, we conducted preliminary bait acceptance and activity trials at Hellyer with dinotefuran WP. Whitmire Research Laboratories, Inc. provided pre-weighed aliquots of 0.1% dinotefuran specifically for yellowjacket studies. Baiting with the

dinotefuran WP and 0.05% indoxacarb SC in minced chicken was done at specific locations in the park. Bait was dispensed in mid-July from aluminum weigh pans in wire mesh stations as was done at Vasona Regional Park. As at Vasona, the results were disappointing. Little bait was foraged and only a few yellowjackets were observed feeding at either bait mix. All the baits dried within 48 hours, with almost none of it being foraged. This led us to more closely examine the prebait counts. As at Vasona, it was apparently premature to bait for control. Although 343 yellowjackets per 11 traps (avg 31.2) were caught during the week prior to baiting mid-July at Hellyer, the average was only 4.5 wasps/trap/day. This is about half the number needed for effective baiting. As at Vasona, the absence of reported stings and encounters at Hellyer confirmed the unusually low numbers we observed. Although nearly always a problem during the summer, areawide yellowjacket control was not needed at Hellyer in 2007. Specific nests were treated if found and troublesome.

We did, however, determine that 0.1% dinotefuran provided a rapid devastating toxic effect on yellowjackets and their colony. Bait was presented about 100 feet from two active yellowjacket colonies we located at Hellyer (Fig. 14). We observed foraging

Fig. 14. Counting worker traffic at a nest entrance (arrow) at Hellyer Park.

Fig. 15. Workers foraging dinotefuran bait. Returning worker died in < 15 minutes.

on the bait and return of some wasps to their colony. The bait had rapid effects on foragers, some dying within minutes. Outgoing wasp traffic at the nest entrance gradually diminished from about 15 per minute to 0 within about 30 minutes and there was no resurgence of activity by the following week. Staff excavated the colony and reported that all stages were dead. We have never before observed effects this rapid. This indicated that small amounts of dinotefuran can affect control and that dinotefuran has potential for use in yellowjacket bait. Rapid kill usually affects foragers before they can return with enough AI to affect other members of the colony (Fig. 15). However, dinotefuran may be active at exceptionally low rates. These trials suggested that lower doses of dinotefuran may be more effective than higher rates.

Ed Levin Regional Park.- This park has a fishing lake surrounded by picnic areas. This was the first year that we have used Ed Levin as a test site. The park has historically experienced severe yellowjacket problems. Baiting was done late in the year at Sandy Wool picnic area, an area adjacent to the lake. Yellowjackets have been problematic at Ed Levin nearly every summer, but we were unaware until informed about the park's problems late September 2007. We visited the park and jointly agreed with park personnel where to install monitor traps and bait stations. We provided active ingredient for their maintenance staff to incorporate into a 0.05% indoxacarb minced chicken bait. We suspect that the bait was installed too late in the season to have much effect. We did not get good pre- and postbait counts from the Ed Levin site because their staff did not mark the traps properly. However, we were encouraged because although the park was baited late in the season, rangers and staff reported that the 0.05% indoxacarb bait seemed to noticeably reduce the number of foragers around the shore of the lake and in the nearby camp sites.

2008 Research

We chiefly evaluated baits for control. Mostly new technology low-impact novel insecticides were tested in the baits. We conducted tests over a wide range of geographical areas with the hope that the results would be universal throughout California.

Bait trials at Glen Eden. - This 155-acre resort is nestled against the foothills of the Santa Ana Mountains about 15 miles south of Corona, CA. A pool and outdoor activities are especially attractive to yellowjackets and the resort residences reported a perennial problem with yellowjackets. The yellowjackets nest in the rugged native chaparral that surrounds the resort and regularly forage in the resort.

Four of our standard sentinel heptyl butyrate monitor traps were placed at Tom's Place, the Pool, and the Dry Wash (Appendix I, Fig. 1). The traps were hung from low branches in trees and bushes about 50 yards apart. Yellowjackets were collected in containers of diluted antifreeze that were changed about every 3-4 days.

Five bait stations were placed out at Tom's Place and the Dry Wash. Our custom hardware cloth bait stations were hung from trees and shrubs about 50-75 yards apart (Fig. 5). They were interspaced among the monitoring stations and placed in an arc that extended beyond the traps to intercept yellowjackets as they entered the resort. The bait stations were left in place one week and then returned to the laboratory. A weighed or precise volumetric amount of fipronil SC was mixed into batches of four 85-g cans of chicken in a Quisinart 21-oz capacity mini food processor (model DLC-1SS). A maximum of 3 cans of chicken were prepared at any given time. Chicken + insecticide added via pipette were mixed to coarse slurry with 15 short pulses of the processor. Longer processing reduced the mix to a semi-liquid slurry that yellowjackets will not forage. Bait was spooned into preweighed 2-oz plastic salsa cups to about 3/4 full, weighed to determine the amount of bait per cup, capped, and refrigerated until taken to the field. The baits tested included 0.05% indoxacarb. 0.05% chlorfenapyr, 0.025% dinotefuran, and 0.025% fipronil.

Monitoring traps were placed out and regularly checked every 3-4 days after baiting.

Bait trials at Glen Ivy Hot Springs. - A 10-acre spa located at the foothills of the Santa Ana Mountains near Corona, CA has a perennial problem with yellowjackjets foraging in to the spa from the adjacent chaparral (Appendix I, Fig. 2). The site had been intensively trapped with Sterling traps by a cooperating Pest Management Professional (PMP) and we have routinely monitored with our UCR traps (Fig. 2). In spite of the trapping, yellowjackets still created problems by late summer.

We placed out 8 traps on 18 and 26 August 2008 and picked up the traps on August 25 and September 3. Baits containing 0.0025, 0.005, and 0.025% fipronil were prepared by mixing precise volumetric amount of fipronil SC into batches of four 85-g cans of chicken as described above. A maximum of 3 cans of chicken were prepared at any given time. Bait was spooned into pre-weighed 2-oz plastic salsa cups to about 3/4 full, weighed to determine the amount of bait per cup, capped, and refrigerated until taken to the field. One salsa cup of each concentration of fipronil was placed out in six bait stations for 48 hours on September 3.

The spa was monitored on a regular basis until October 6, 2008.

Bait trials in Mariposa County. - Field trials to control yellowjackets with various bait actives were made in September 2008 at a series of rural residences east of Modesto, CA in Mariposa County in the western foothills of the Sierra Nevada Mountains. Dr. William Donahue, Sierra Laboratories, Inc. Modesto CA, was the cooperating field director of this portion of the project. During his research with ants at the residences over the last few years, several homeowners complained bitterly to him about the annoyances of yellowjackets and asked that they be included in any yellowjacket control trials in which he might be involved. Many homeowners were unable to hold parties or cook outside because of the abundance and severity of the yellowjacket problem. They reported that during the summer months hundreds of foraging yellowjackets descend on nearly any meat they bring outdoors. Stings were common. Dr. Donahue confirmed with traps that *V. pensylvanica* was the major pest species.

Species, abundance, and protein foraging. The control trials were conducted at rural residences. The residences included in the study were selected by Donahue. Criteria for study included a.) the presence of many foraging yellowjackets, b.) a preponderance of *V. pensylvanica*, and c.) protein foraging, specifically canned chicken. Aerial-nesting species (*Dolichovespula*) and species such as *V. vulgaris* and *V. germanica* do not respond well to heptyl butyrate and do not forage protein as do *V. pensylvanica*. Presence and abundance was determined with 4 of our standard sentinel heptyl butyrate monitor traps (Fig. 2). The traps were hung about 30-50 yards apart from low branches of trees or fenceposts. The sentinel traps were left in place for 7 days at which time trapped yellowjackets were removed, counted and identified. Trapping confirmed species and abundance and served as a precount for each residence. Only residences with at least 25 yellowjackets/trap/day were included in the study.

Donahue qualitatively confirmed protein foraging at each residence by observing foraging at salsa cups of fresh canned chicken blank in custom hardware cloth cages (Fig. 5, bottom) he suspended from low branches or fence posts between traps. Only residences where Donahue observed at least 15 foragers/cup/minute at blank chicken were included in the study. The cages were also used to dispense bait.

Baits. Our acceptance trials in southern California in 2006-07 indicated that Swanson's canned chicken and Friskies brand Ocean Whitefish Dinner cat food were the most preferred of 17 protein foods tested. Dr. Donahue reported that in preliminary tests in 2007 he had significant yellowjacket foraging on tuna and canned chicken. Because we had the most consistent take with canned chicken and Donahue also had good take, canned chicken was used as the bait matrix in the trials in Maricopa County.

We prepared a series of baits for Donahue to use in the trials. Refrigerated bait was shipped on cold packs in Styrofoam containers to Sierra Laboratories via overnight delivery. The cold baits were refrigerated until they were used, usually within 1 or 2 days.

The baits were prepared using insecticide concentrate mixed with canned Swanson's white chicken. The AI in the baits ranged from 0.025 to 0.05% (wt/wt solid or wt/vol liquid) chorfenapyr, dinotefuran, fipronil, indoxacarb, and chlorantraniliprole. A weighed or precise volumetric amount of insecticide was mixed into batches of four 85-g cans of chicken. A maximum of 3 cans of chicken was prepared at any given time. Bait was spooned into pre-weighed 2-oz plastic salsa cups to about 3/4 full, weighed to determine the amount of bait per cup, capped, and refrigerated until shipped later the same day. The AI variables examined in this study are shown in Table 3.

Baiting, consumption and efficacy. Six dispenser cages were hung around the property of each residence where the yellowjacket criteria had been met. The cages were hung in the general vicinity of the monitor traps. Two salsa cups of bait were placed in each cage mid-morning and yellowjackets were allowed to forage *ad libitum* for 5 days at which time the cups of bait were removed from the cages and weighed on an electrobalance to determine the amount foraged. The bait dried and became unpalatable to yellowjackets by day 5. Consumption was calculated from the difference in original bait weight and the final weight compared to the average evaporative weight-loss of controls. The monitoring traps were removed for the baiting period and were replaced afterwards.

Efficacy was calculated as the % reduction (i.e. % suppression) of the total number of yellowjackets trapped before in sentinel traps compared to the number trapped in the same traps after baiting. Trapped yellowjackets were counted and discarded before baiting began. Counts were combined for the 3 traps per property. Trapping reflects the number of yellowjackets in the area and we assumed that a reduction in the number of yellowjackets trapped was attributable to the bait. Trapping was done 1 and 2 weeks post-bait.

Results

Glen Eden. The fipronil 0.025% bait provided outstanding control with 93.5% reductions in the number of yellowjackets trapped at week 1 (Table 3). Initially, 0.025% dinotefuran bait provided knockdown of foragers, but the numbers of foragers began increasing by day 7. This was very similar to its performance in previous studies At FarNiente Vineyards in Napa Valley in 2007. It is extremely fast acting and this concentration was probably still too high. The baiting had a much larger area wide effect causing a significant reduction in the number of yellowjackets trapped at the untreated site (pool). The indoxacarb and chlorfenapyr baits did not provide control of the yellowjackets.

Glen Ivy Hot Springs. Baiting with fipronil baits resulted in significant reductions (ca. 85-90%) in the number of yellowjackets trapped near the baiting stations (Traps 1-4, Appendix I, Table 1). A similar reduction in the number of foraging yellowjackets was also observed in the untreated areas across the spa (traps 5-8). This similar area-wide effect was observed at Glen Eden.

Mariposa County. Suppression of yellowjackets around individual homes in Maricopa County is summarized in Table 5. As in previous years, bait containing fipronil was very effective, 0.025 to 0.05% bait providing > 90% suppression of foraging yellowjackets within a week. BD1 was an internal comparative standard inserted into the study by Dr. Donahue. He used a 0.05% fipronil bait mix using fresh ground chicken that he prepared himself. He included this as an internal standard because he had good results with this

Table 3. Suppression of yellowjacket foraging and the average number of yellowjackets per trap (%reduction) before and after baiting at Glen Eden.

Treatment	Baiting Dates	Pre-count 1 week	Avg. no. trapped (% reduction) Day 2-3	Day 5	Day 7
Indoxacarb, 0.05%	8/6-8/8	238	65 (72.9)	123 (48.4)	324 (0.0)
Chlorfenapyr, 0.05%		202	124 (38.4)	69 (65.8)	308 (0.0)
Untreated		415	333 (19.8)	357 (14.0)	594 (0.0)
Indoxacarb,0.05%	8/15-8/18	284	109 (61.6)	123 (56.8)	286 (0.0)
Chlorfenapyr, 0.05%		285	121 (57.5)	152 (46.8)	362 (0.0)
Untreated		770	375 (51.4)	458 (40.6)	888 (0.0)
Dinotefuran, 0.025%	8/25-8/27	250	57 (77.2)	22 (91.4)	64 (74.5)
Fipronil, 0.025%		231	33 (85.7)	10 (95.4)	15 (93.5)
Untreated		630	138 (78.2)	110 (82.4)	82 (87.0)

mix in 2007 and he wanted a baseline bait to which he could compare results. Fipronil was effective in our studies in 2006 and 2007 too. The good results we obtained with some of our bait preparations would probably have been even better if more bait dispensers had been used over a wider area around each residence.

Dinotefuran, 0.001% also provided good control whereas 0.01% did not. As suggested in our foraging studies with dinotefuran in late 2007, dinotefuran is very toxic to foragers. The 0.01% rate killed foragers that took bait before they recruited others to the bait. It provided kill too quickly and extinguished foraging at the bait. The 0.001% rate, on the other hand, was close to a rate that allowed foraging and recruitment. A lower rate may be even more effective.

Chlorantraniliprole belongs to a new class of insecticide, anthrailic diamides and the 0.05% rate provided reasonably good control (i.e. 88.5%) at 1 week but the 0.005%

rate did not. Chlorantraniliprole is obviously not as biologically active against yellowjackets as is fipronil and dinotefuran. However, more research should be done with different concentrations. Although indoxacarb has performed well in controlling other insect pests, it did not perform well in these tests.

Chlorfenapyr and indoxacarb did not provide good control. This may in part be due to an insufficient number of foragers when the bait was dispensed. Based on trap counts, there were only 12 yellowjackets per trap/day where 0.05% chlorfenapyr was tested, and 9 per trap/day where 0.005% indoxacarb was tested. According to our research in 2006-07, more foragers are needed to effectively recruit and repeatedly take morsels of bait to nests before the bait dries. Maximum effect would be achieved with greater foraging intensity. Additional tests should be made with these AIs to confirm whether or not they are effective in yellowjacket bait.

Table 4. Suppression of the number of yellowjackets trapped near or away from the bait stations at Glen Ivy Hot Springs by 0.0025, 0.005, and 0.025% fipronil baits during September 2008.

	Avg. Precounts/trap/day		Avg. Trap Counts/trap/day post baiting				
Traps	Wk 1	Wk 2	day 5	day 12	day 19	day 26	day 33
near							
1&2	50.4	52.0	7.6	16.9	17.3	11.6	5.7
3&4	29.2	28.4	7.6	11.6	12.9	14.4	6.1
away							
5&6	34.9	42.1	11.2	13.0	15.3	14.4	6.1
7&8	33.7	33.6	7.2	10.1	16.1	14.4	3.9

Table 5. The suppression with bait of foraging western yellowjackets, *Vespula pensylvanica*, at rural residential sites in Mariposa County, CA in September 2008.

				% Reduction[a]	
Site	AI	Rate (%)	Before[b]	1 wk	3 wks
1	Fipronil	0.025	647 (30.8)	93.5	90.1
2	"	0.005	397 (18.9)	58.9	69.0
3	"	0.0025	944 (45.0)	92.6	95.9
BD1	Fipronil, Donahue ck	0.05	1029 (49.0)	94.9	78.3
4	Chlorfenapyr	0.05	251 (12.0)	29.5	45.8
5	Indoxacarb	0.05	901 (42.9)	41.1	77.1
6	"	0.005	195 (9.3)	33.8	0.0
7	Dinotefuran	0.01	435 (20.7)	55.4	17.9
8	"	0.001	418 (19.9)	86.1	80.4
9	Chlorantraniliprole	0.05	583 (27.8)	88.5	48.2
10	"	0.005	700 (33.3)	52.6	44.7
11	Unbaited control	-	870 (41.4)	0.0	42.1

[a] % Reduction based on total number captured in 7 days in 3 heptyl butyrate traps/site.
[b] Total number of yellowjackets (per trap/day) in 7 days in 3 heptyl butyrate traps/site.

2009 Research

We found in preliminary trials conducted near the end of the season in 2008 that some new toxicants such as dinotefuran were active against yellowjackets. Initial results were promising, but the season ended before we could determine their suitability in a bait. In 2009, we looked more closely at the effectiveness of these new toxicants. Based on our finding in 2008 that the effectiveness of baiting not only depends on a mix of an acceptable bait base (i.e. Swanson's chicken) and a biologically active toxicant (i.e. fipronil), but also on a sufficient number of foraging yellowjackets to carry the bait to their colony, we did not conduct bait trials in 2009 unless we were capturing at least 20 yellowjackets per trap per day at the test site. Although it is conceptually desirable to control yellowjackets early in the season when there are only a few of the around, we showed that baiting was ineffectual when there are only a few foragers. Monitor traps may indicate when there are sufficient yellowjackets for baiting to be effective.

Commercial yellowjacket traps are available to the public and to PMPs. We showed previously that strategic, intensive trapping may temporarily suppress the number of yellowjackets in a specific area. As in 2008, we evaluated some new traps in 2009 to determine if they might effectively complement baiting. Besides suppression, traps may be used for monitoring bait efficacy, and we highly recommend using trap counts to determine when to bait and to determine baiting success. The manufacturers of some newer traps claim significantly greater attractivity with their lure and better trap designs to retain captured wasps. We evaluated traps with the thought that a series of tremendously effective efficient traps may have an additive effect on baiting, additionally suppressing the number of foraging yellowjackets in a limited area. Such traps would also be particularly useful if they effectively captured queens or if they detected invasive species such as the German yellowjacket, *V. germanica*. One trap we evaluated had some good characteristics in terms of being practical and usable and it did catch significantly more yellowjackets than others we tested. We doubt, however, that the increased catch provided any relevant measure of control. Unfortunately, to-date we have not found any tremendously effective trap, most commercial traps with heptyl butyrate lure being nearly equally effective. Their utility tends to be a matter of cost, ease of maintenance, and reusability.

Bait efficacy and distance effect. As in 2008, we conducted bait trials for control in 2009 at Glen Eden Resort, Corona, CA. Initial monitoring was done for a week commencing 18 June. Depending on location, two to four of our standard sentinel heptyl butyrate wet traps with 70% antifreeze collecting fluid (Fig. 2) were placed at 6 separated locations covering the extent of the resort property. The initial 5 locations were: Tom’s Place, Dog Run, Dry Wash, Chapel, and Pool (Appendix I, Fig. 1). Location 6, Sky View, was added in response to a request from Western Exterminator. As long as we had multiple replicates fairly close together, we felt comfortable using as few as 2 traps to monitor a location. We hung traps about 50 feet apart, suspended on wire hangers 4 to 6 feet from the ground from trees or shrubs. Based on published information concerning the presumed foraging distance of *V. pensylvanica*, we assumed that each location (e.g. Tom's Place versus the Dog Run) was far enough from the others that we could consider each an independent test site being monitored with 4 traps.

First baiting in 2009 at Glen Eden was made 14 July. Average trap catch was 12 to 20 wasps/trap/day about double the number of wasps being caught by that date in 2008. The number being caught per trap/day indicated there were enough foragers to effectively take bait to their nest and for us to determine baiting efficacy. Efficacy was determined as the difference between trap catch before and after baiting. Using canned Swanson's chicken as the bait matrix, Tom's Place was baited with 0.05% chlorfenapyr and Dry Creek (opposite end of the property) was baited with 0.025% fipronil. At each location, we suspended 5 bait dispenser cages (Fig. 5, bottom) containing three 2-oz salsa cups of bait (15 total) about 15 to 20 yards apart from low branches of trees and shrubs. As in 2008, we prepared the bait in chicken minced to a thick slurry with a Quisinart 21-oz capacity mini food processor (model DLC-1SS). Yellowjackets foraged some of each bait, but not all the bait was taken and there was some dry bait remaining in each cup the following day.

Yellowjackets reportedly forage about 1/4 mile (1,320 feet) from their nest. Since the Dry Wash and Tom's Place are >1,900 feet apart, we assumed that baiting with 0.05% chlorfenapyr at Dry Wash would be independent of baiting with 0.025% fipronil at Tom's Place. It is unlikely that baiting at the Dry Wash affected nests near Tom's Place, >2,500 feet away. Baiting reduced the number of yellowjackets within days and, as shown in Table 1 (Appendix I), the effects occurred within days and persisted for weeks. Baiting with 0.025% fipronil at the Dry Wash reduced the number of yellowjackets there and at Sky View, 630 feet away. Fipronil bait reduced populations by 84.6% and control lasted longer than 8 weeks. Baiting with 0.05% chlorfenapyr reduced the number, albeit not as markedly as fipronil, at Tom's Place and at the Dog Run, 675 feet away. Both treatments apparently reduced the number of yellowjackets foraging near the Pool, 960 feet away. This indicated that depending on the location of the nests, terrain and prevailing winds, baiting may have a collateral effect over about 650 feet. The upper limit of bait effectiveness was about 800 to 900 feet.

Dinotefuran as a bait toxicant. Because dinotefuran is so exceptionally active against yellowjackets, we were encouraged by the possibility of using it in yellowjacket bait. However, in preliminary baiting trials in Napa in 2007 and in trials in Maricopa County in 2008, dinotefuran bait provided only marginally good results. The 0.001% rate was more effective than 0.01%. We theorized that 0.01% was repellent or killed foragers before they returned to the nest enough time to affect control.

We did multiple baiting with dinotefuran in Swanson chicken at Glen Eden and Silent Valley RV Park in 2009. Foraging on dinotefuran bait extinguished within about 30 minutes. Dinotefuran is so toxic to yellowjackets that foragers touching or handling bait died within minutes, thus not giving them the opportunity to recruit others or continue their foraging. As suggested by our observations of foragers alighting and handling dinotefuran bait, heptyl butyrate traps showed that populations baited with 0.05%, 0.025%, or 0.0125% dinotefuran were affected within a day. However, the traps also showed that populations rebounded to pretreatment levels within 2 weeks. We

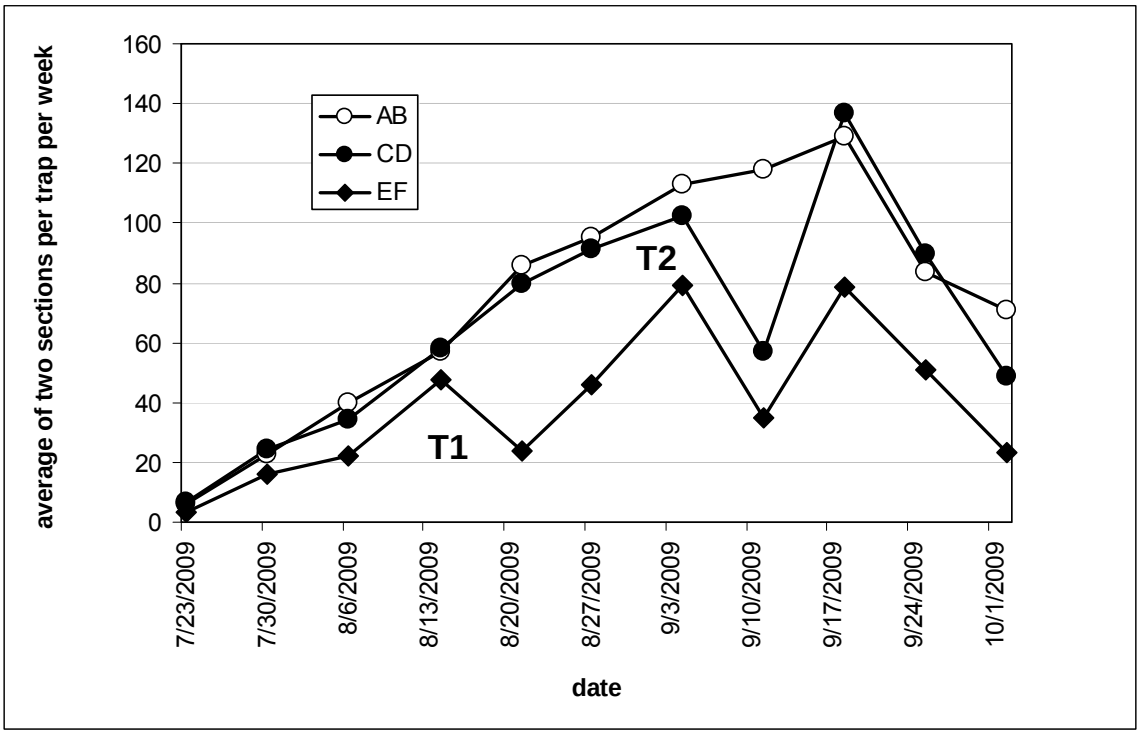

Fig. 16. Rebound effect of *V. pensylvanica* populations at Silent Valley Club within 2 weeks after treatment of section EF with 0.025% dinotefuran bait (T1) and after treatment of CD *and* EF (T2). Section AB not treated. Based on heptyl butyrate trap catch.

observed this rebounding effect at Glen Eden and Silent Valley, independent of concentration. The rebounding effect illustrated in Fig. 16 where camp section EF at Silent Valley Club was baited (T1) and rebounded. Rebounding also occurred later after both camp sections EF and CD were baited. Section AB was never baited and its population did not decline until late in the season from natural senescence. Dinotefuran was unable to depress the yellowjacket population to a relevant extent or for more than 2 weeks.

Traps. As in 2008, we examined various traps and trap designs as possible additives to a bait control strategy. None were highly effective, and no trap selectively captured large numbers of queens. A queen-trapping strategy remains elusive.

In June 2009 we evaluated a new Sterling Rescue (Spokane, WA) WHY bottom-entry heptyl butyrate rigid plastic trap in preliminary, unreplicated trials. We have used conventional Sterling traps as monitors for several years at many of our trials. But because the new WHY trap is expensive and difficult to set up and maintain, we abandoned the idea of using the new traps as monitors in our trials later this year. Like other Sterling traps, a positive feature of this trap is that it may be emptied and reused, thus potentially reducing its overall cost.

We also evaluated the new Contech (Victoria, BC) yellowjacket trap in 2009 (Fig. 17). This is a side-entry heptyl butyrate flexible bag trap that was easy to use and more

effective than our standard UCR heptyl butyrate trap. Contech traps are flexible, transparent, water-filled plastic bag-type traps with a circular opening offset from each other near the center of each side. Attractant is added to the water added to the bag. A negative feature of the Contech trap is that it should probably be emptied every week or so because trapped wasps tend to begin to spoil in the water, producing a rotting odor. The odor was not very noticeable within a week but, depending on temperature, was more pronounced within 10 to 14 days.

In a trial in September at UCR and in replicated trials at Silent Valley RV Park, the Contech trap consistently captured more yellowjackets than did our standard UCR trap. Of the hundreds of yellowjackets caught, the Contech trap captured 62% compared to 38% with the UCR trap. The Contech flexible bag trap may be a useful monitoring

Fig. 17. Contech 2009 side-entry heptyl butyrate flexible bag trap.

tool for determining when baiting should begin and for evaluating the efficacy of baiting treatments. If used strategically and intensively, Contech traps may have an additive effect on a yellowjacket baiting strategy. Sterling and other kinds of dry traps are effective at attracting and capturing yellowjackets, but live trapped wasps tend to dismember others in the trap. This makes it difficult to count the number trapped as is done for monitoring purposes. Depending on price and availability, the PMP may wish to consider the Contech trap.

As reported previously, small amounts of fipronil thoroughly mixed into an acceptable protein bait base provided excellent control of scavenging foraging western yellowjackets, *V. pensylvanica*. This year, however, we found that as low as 0.025% (wt/wt) fipronil bait provided nearly 90% control. Control persisted > 2 months. Chlorfenapyr, 0.05% provided a modicum of control, but not the high level of fipronil.

Effective baiting reduced the number of yellowjackets over a wide area. Depending on the number of nests and foragers and the native food supply, fipronil bait was effective over a distance of 500 to 600 feet, about 0.21 miles. This is close to the 0.25-mile foraging range reported in the literature, and helps explain why yellowjackets were controlled in areas hundreds of feet away although we did not bait those areas. Invading yellowjackets from the periphery may be more effectively controlled if we had used more bait stations closer together

In 2009 we refined our understanding of dinotefuran as a yellowjacket bait ingredient. Although dinotefuran has good environmental characteristics that make it potentially desirable for inclusion in a yellowjacket bait, it was too fast-acting to allow for suitable foraging, recruitment, and dispersal of the dinotefuran in the nest. As a consequence, populations fed dinotefuran bait rebounded to pre-bait levels within 2 weeks. Foragers could not deliver enough dinotefuran to the nest for it to be effective for long. Lower rates of dinotefuran were not as effective because very low rates that were palatable to foragers were not toxic to brood. Besides being toxic when ingested, fipronil has a surface-active (contact) effect. As among ants, termites, and others, lethal amounts of fipronil may be transferred among yellowjackets as they handle fipronil bait. Dinotefuran did not exhibit the strong horizontal transfer effect of fipronil.

Acknowledgments

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APPENDIX I

g. 1. Diagram of the Glen Eden RV Park and the areas monitored and baited.

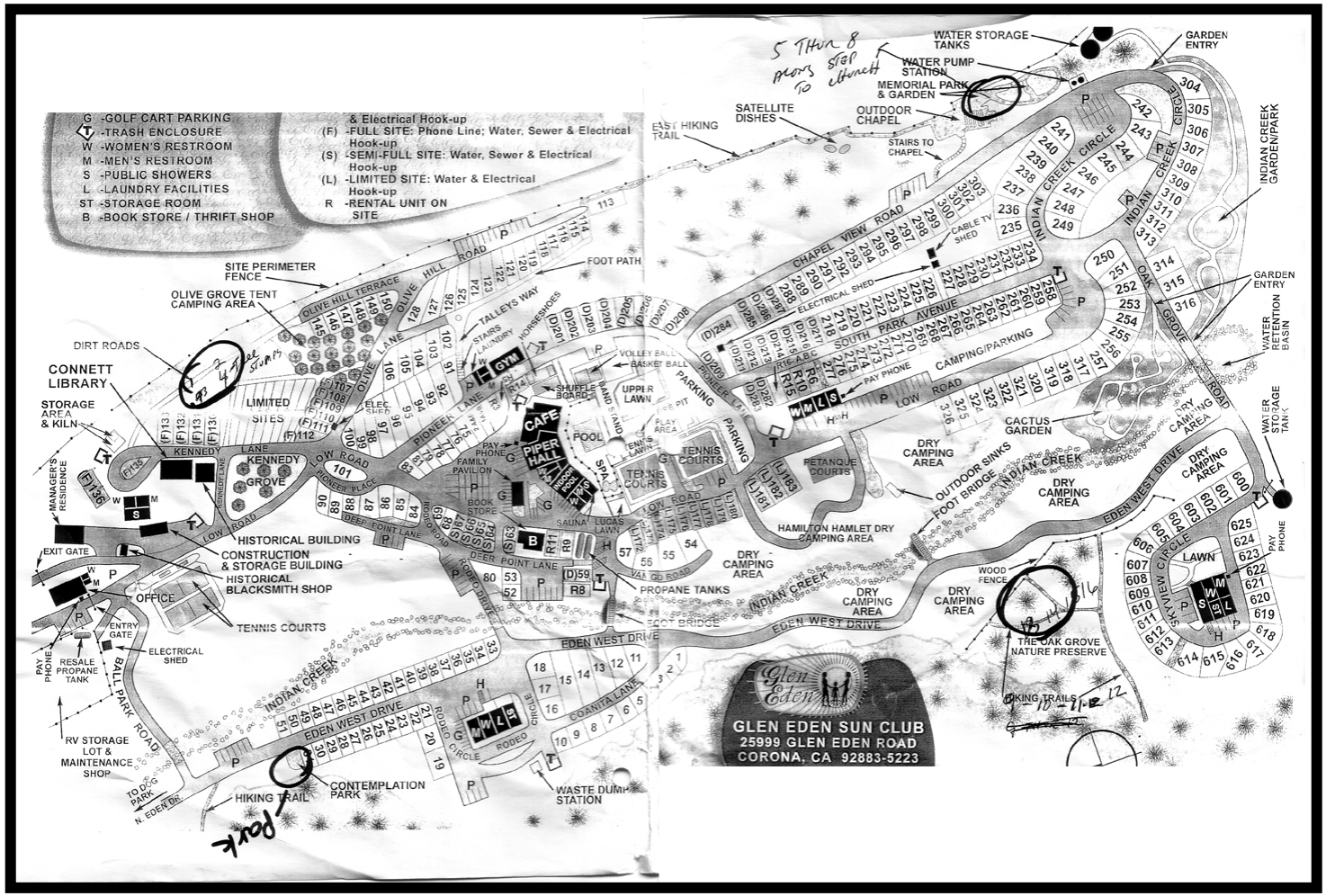

Table 1. Efficacy and distance effect of yellowjacket bait at Glen Eden Park in 2009.

Bait[a]	Location	Distance[b]	Before[c]	Avg. % reduction at week post-bait				
				1	2	4	6	8
0.025% fipronil	Dry Wash		40.8	89.7	84.9	83.9	86.0	78.4
	Sky View	0	75.1	81.9	85.6	84.0	81.4	85.4
		630						
0.05% chlorfenapyr	Tom's Place		40.6	28.3	18.6	69.4	77.5	90.5
	Dog Run	0	77.3	56.7	37.7	67.4	88.0	92.2
		675						
Unbaited	Pool		57.7	47.8	46.7	69.5	58.8	71.6
		960						

[a] % AI (wt/wt) in Swanson's canned chicken.

[b] Distance (ft.) that unbaited Sky View, Dog Run, and Pool are from baited location. Pool located at approximate center of 2200 by 850-ft bait-treated area.

[c] Average number of wasps per trap/day in 3 to 4 heptyl butyrate monitor traps before baiting. Pre-bait monitoring 10-14 July 2009; baits installed 14 July 2009.
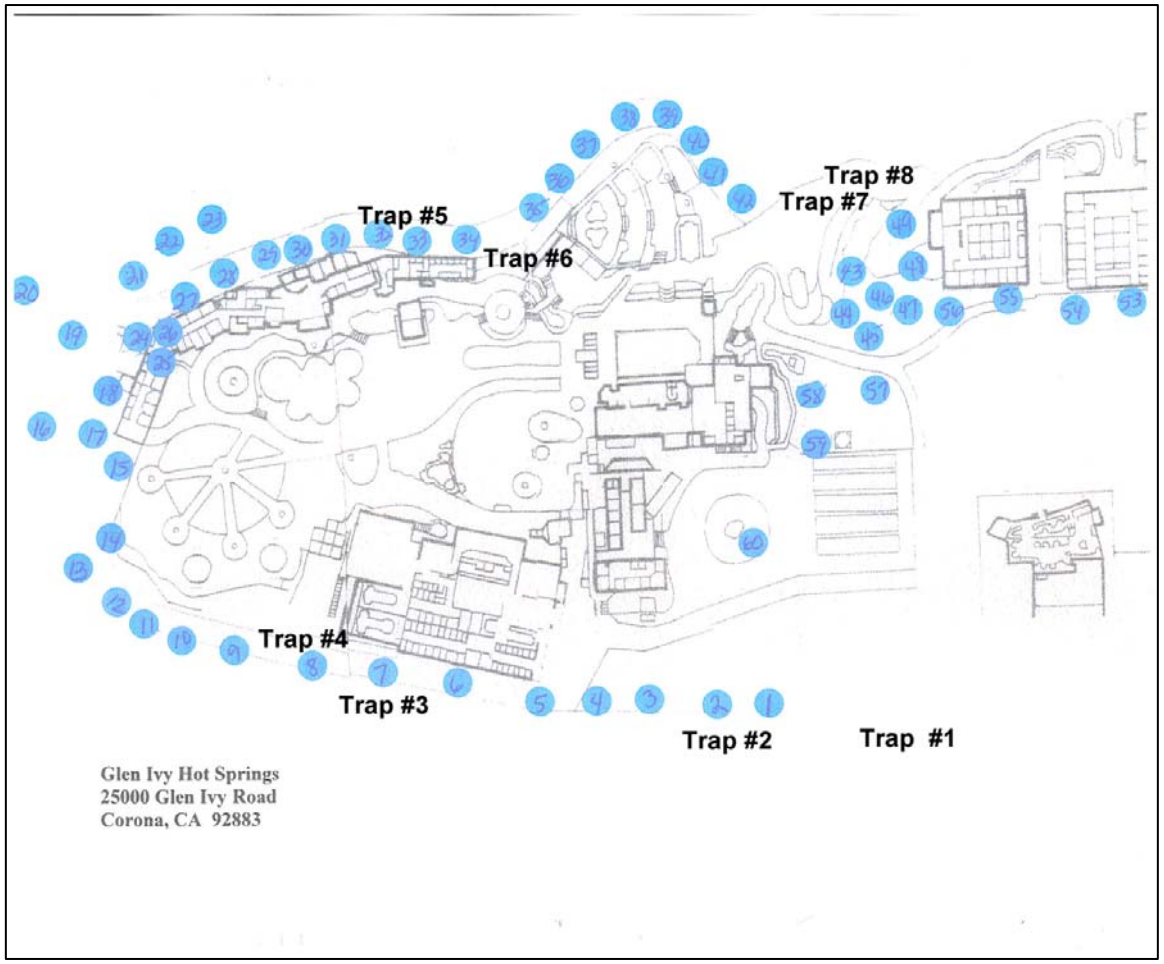
Fig. 2. Diagram of Glen Ivy Hot Springs and the location of monitoring traps and bait stations. Blue dots represent the location of Sterling traps monitored by our cooperating PMP. Our 8 trap sites are indicated. Red triangles represent the bait stations.