Information for pest management professionals and pesticide applicators

UC IPM

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Should You Be Worried about Herbicide Resistance?

When a pesticide or pesticides with similar modes of action are repeatedly applied to a site, there is a good chance the pest population will evolve resistance to that type of pesticide and no longer be effectively controlled. Resistance is able to develop because populations of most pests are genetically diverse, and strong pesticide selection pressure will kill susceptible individuals and allow resistant individuals to survive and reproduce.

One place weed populations can evolve herbicide resistance is areas where herbicides are the primary means of weed control such as roadsides, right-of-ways, and canal banks. This is likely due to the herbicide choices that impart both the broad spectrum of weed species controlled and a long residual time. In order to achieve both, a postemergent herbicide that could have some preemergent activity is often used, or a postemergent herbicide is used with a preemergent herbicide but the preemergent may be applied at a high rate to achieve a longer residual period. In addition, many agencies have a specific palette of herbicides they are permitted to use, and this limits one of the ways to delay herbicide resistance—rotation of herbicide modes of action.

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Figure 1. Glyphosate-resistant (left) and susceptible (right) horseweed sprayed with Roundup Weathermax at one, two, and four times the labeled rate. The two plants in front (labeled 0x) were untreated.

Herbicides that are particularly predisposed to promoting plant resistance are those that have what's called a "single site of action." When a compound such as an herbicide affects only one site in the plant (such as a specific location or molecule), it takes only a small genetic change (mutation) at that site to modify how the plant responds. This response is almost always one where the plant is able to tolerate higher rates of herbicide. It is important to understand that the herbicide doesn't change the genetic makeup of a plant; these mutations occur naturally. What the herbicide does is kill all the other plants in the population that don't have that modification. As a result, resistant plants (herbicide-resistant biotypes) are selected, survive, reproduce, and become a larger proportion of the population. When an herbicide is no longer effective at the labeled rates, that population is considered to be resistant to that particular herbicide (Figure 1). This phenomenon is the same as what happens when someone overuses antibiotics and the bacteria in the body become resistant to it.

In some rare cases, plants could evolve to become resistant to two or more herbicides with different modes of action (multiple resistance). This is usually the result of applying herbicides with different modes of action as a mixture over time or applying the second herbicide after resistance to the first herbicide evolved. A more common development is the ability to withstand herbicides

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from different chemical classes. This cross resistance occurs when herbicides have similar sites of action such a sulfonylureas (e.g. SedgeHammer [halosulfuron-methyl]) or imidazolinones (e.g. Stalker [imazapyr]), which both inhibit the same specific enzyme in plants (acetolactate synthase, or ALS).

Worldwide, 200 weed species with 372 biotypes have confirmed herbicide resistance to 21 different herbicide chemistries. In California, three common roadside weeds have verified biotypes resistant to certain herbicides—horseweed (*Conyza canadensis*), hairy fleabane (*C. bonariensis*), and Russian thistle (*Salsola iberica*). If a limited suite of herbicides is used as the only method of weed control rather than an integrated weed management program, there is a good chance resistance will evolve in these species and possibly others.

In California, the first Russian thistle biotypes documented to be resistant to ALS inhibitors occured in 1994. These biotypes are resistant to Telar (chlorsulfuron) and Landmark (sulfometuron-methyl). Horseweed biotypes resistant to glyphosate were found in the Central Valley in 2005, and hairy fleabane glyphosate-resistant biotypes were found two years later. Two years after that, hairy fleabane biotypes were found with multiple resistance to both glyphosate and paraquat.

An integrated weed management plan for roadsides, right-of-ways, canal banks, and similar sites should include the following actions in order to slow the evolution of herbicide resistance:

- Integrate management methods that combine nonchemical weed control such as mowing and cultivation with herbicide treatments.
- Rotate herbicides with different modes of action; for more information see http://www.hracglobal.com/Publications/ClassificationofHerbicideSiteofAction/tabid/222/Default.aspx or http://anrcatalog.ucdavis.edu/pdf/8012.pdf.
- Don't apply herbicides with the same mode of action more than two consecutive times to the same site.
- Herbicides with multiple modes of action can be tank mixed or applied sequentially as long as the herbicides used provide good control of potentially resistant weeds.
- Scout regularly and identify sites where weeds aren't being controlled as expected. These weeds may be resistant, or the herbicide may not have been applied correctly.
- If herbicide resistance is suspected, contact your local UC Cooperative Extension office, since further testing may be warranted. Don't try to control the plants with higher herbicide rates or other herbicides. If these plants must be controlled, use nonchemical methods.

For more information, see UC ANR Publication No. 8012, *Herbicide Resistance: Definition and Management Strategies*, at http://anrcatalog.ucdavis.edu/pdf/8012.pdf.

—Cheryl Wilen, UC Statewide IPM Program, South Coast, cawilen@ucdavis.edu

Ask the Expert!

Q I've been using the same herbicide for years. Sometimes I notice patches of weeds that aren't controlled, even though the label says they should be. What should I be looking for if I think these plants are herbicide resistant?

A First of all, make sure that the herbicide you are using is labeled to control all the weed species on the site at the rates you are applying. It is essential that you properly identify the uncontrolled weeds. Often the "failure" of an herbicide application isn't due to herbicide resistance but to shifts in the weed species present at the location. This happens when most of the susceptible species have been controlled by previous applications, leaving the nonsusceptible or herbicide-tolerant weeds to thrive with less competition. You should also be keeping records of which weeds aren't controlled and where they are. If you find all the labeled weed species in some sections aren't controlled, it is probably a misapplication, either caused by missing the area completely or by poor calibration. However, if most of the labeled weed species are controlled in those sections and there are a few plants of a single species still growing relatively well in that area, you could suspect herbicide resistance. An even stronger indication of herbicide resistance is if you see some relatively uninjured plants growing in very close proximity to dead plants of the same species. If you think you have some herbicide-resistant plants, contact your local UC Cooperative Extension office for assistance.

Q I suspect there is a bed bug infestation in a home. How can I confirm it?

A There are several methods for detecting bed bugs. Thorough visual inspection for bed bugs, cast skins, and fecal spots around the bed frame, mattress, and other possible harborages can be useful when there is a relatively limited area to inspect. However, at the early stage of infestation, the small numbers of bed bugs in a structure could easily go undetected if you solely rely on a visual inspection. There are several commercial bed bug monitors available, categorized as active or passive monitors. Active monitors have one or several different types of lures in the monitor. Heat, carbon dioxide, and attractive odors are good examples of lures. On the other hand, passive monitors don't attract bed bugs into the monitor per se but act as a pitfall trap or harborage, collecting any bed bugs that are passing by. Some of these passive monitors can be quite effective when they are adequately placed in the structure. Properly trained dogs can detect bed bug infestations quite effectively based on the chemical cues associated with bed bug infestation, and this is probably the quickest way to inspect large areas or multiunit structures such as hotel guest rooms or entire apartment complexes in a limited period of time. For more information about bed bug biology and management, see *Pest Notes: Bed Bugs* at http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn7454.html.

Have a question? E-mail it to ucipm@ucdavis.edu.

Using Lure Traps to Reduce Yellowjackets around Picnic Areas

Yellowjackets (Figure 1) are one of the most bothersome pests around picnic areas in parks, at outdoor eating areas such as restaurants, at schools, and on home patios. Effective management tools are limited. Yellowjackets typically nest within 1/4 mile of areas where they are foraging. Yellowjackets commonly construct subterranean nests in abandoned rodent burrows and cavities but will occasionally nest in wall voids or attics of buildings. If the yellowjacket nest can be located, applications of pyrethroid dusts are extremely effective, although care must be taken to avoid stings and appropriate protective clothing (e.g., a full bee suit, gloves, and goggles) must be worn. While destroying the nests can substantially reduce problems, nests frequently can't be found or treated. In these cases, lure traps (Figure 2) can provide some relief.

A demonstration project recently conducted by entomologists at University of California, Riverside provides evidence that local areas such as picnic tables or eating areas can be protected with baited lure traps under some conditions.

Trapping can help reduce the number of localized foraging workers, but traps don't eliminate large populations. Lure traps contain a chemical that attracts yellowjackets into the traps, but the common lure in traps, heptyl butyrate, attracts primarily the western yellowjacket, *Vespula pensylvanica*, the most commonly encountered species in California, and not other species. Meat such as fresh chicken can be added as an attractant and is believed to improve catches of the German yellowjacket, *V. germanica*, and *V. vulgaris*. Replace the bait frequently, because yellowjackets aren't attracted to rotting or dried meat. Also, periodically check the trap to remove dead yellowjackets and make sure workers still are attracted to the trap. Lures need to be replaced periodically, so follow trap directions regarding replacement.

To reduce the number of yellowjackets foraging in specific areas such as patios, picnic tables, concession stands, and trash Dumpsters, place lure traps with hepytl butyrate around the periphery. In large areas such as parks, place traps about 200 feet from the area to be protected and about every 150 feet along the circumference. In backyards, place them along the edge of the property line as far away from the patio or other protected area as possible. It is important to place the traps between the area to be protected and the native landscapes serving as nesting sites to intercept foraging yellowjackets. Typically yellowjackets will forage about 1/4 mile. Figure 3 shows a suggested placement for traps.

J. K. Clark, UC

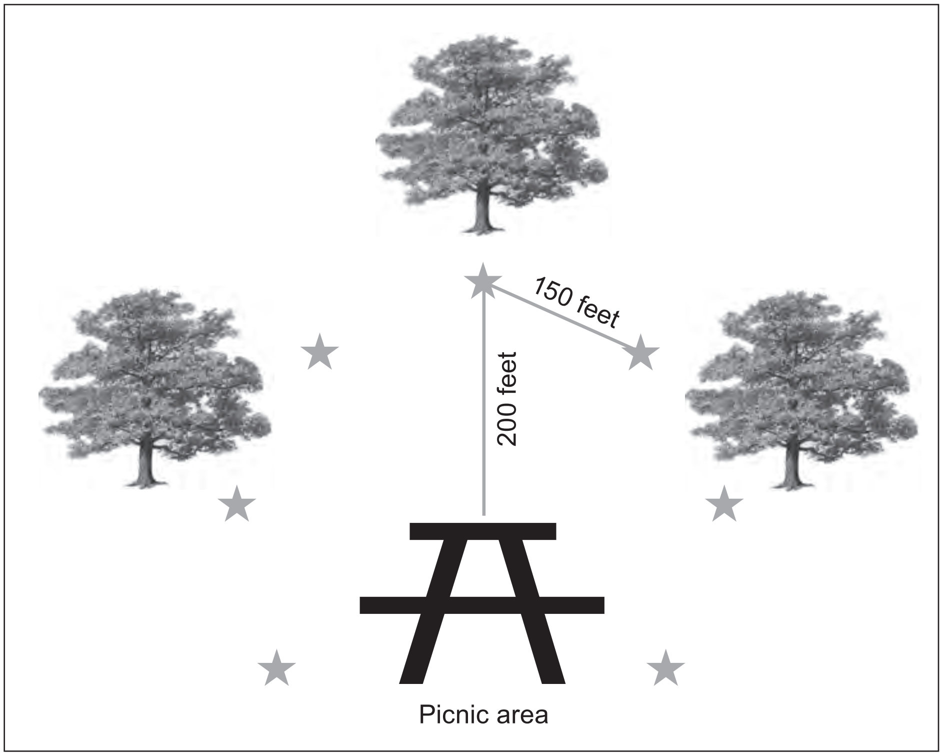
Figure 1. The western yellowjacket, Vespula pensylvanica**.**

J. K. Clark, UC

Figure 2. A lure trap.

For more information, see the *Pest Notes: Yellowjackets and Other Social Wasps* at http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn7450.html.

—Michael Rust, Entomology, UC Riverside, michael.rust@ucr.edu



M. K. Rust, UC Davis

Figure 3. Placement of lure traps, represented by stars, to protect a picnic area in a park. Place the traps about 200 feet from the protected area and about 150 feet apart. In backyards, place the traps around the periphery of the property as far away from the patio or other protected area as possible.

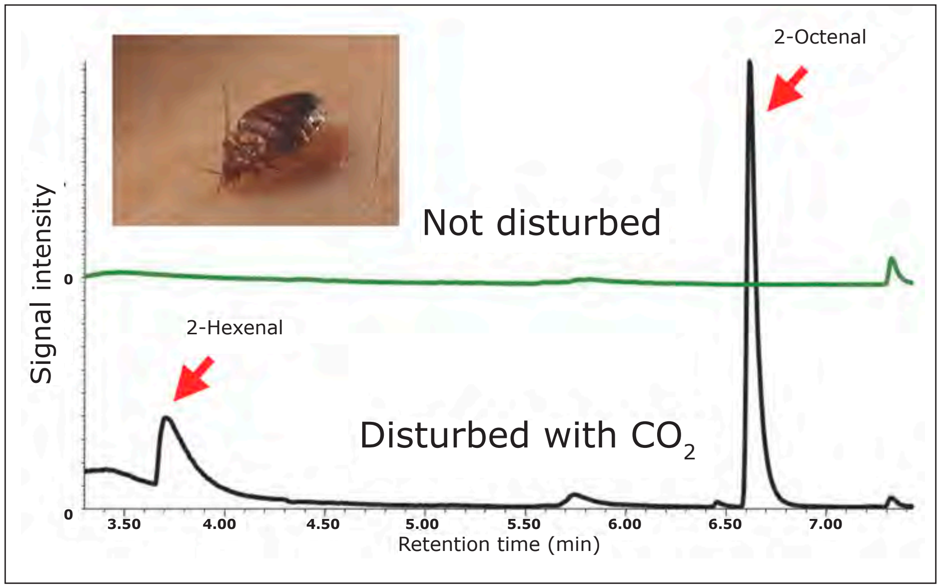
Can We Smell Bed Bugs?

Some people say they can smell bed bugs in an infested structure or house, especially when the infestation level is very high. Their description of bed bug odor might be "sweet-musky," "raspberry-like," or something similar. Because we know that some well-trained dogs can detect hidden bed bugs by sniffing, it might be reasonable to expect that bed bugs produce certain signature odors. In my laboratory, I have been studying bed bug odors to see if they can be used to effectively detect this pest.

Bed bugs certainly have odorous chemicals in their bodies. Anyone who has ever crushed a bed bug between his or her fingertips will notice this fact. Bed bugs belong to the true bug suborder (Heteroptera), which includes many species, such as stink bugs, that emit characteristic volatile chemicals from their scent glands. True bugs, including bed bugs, normally store these volatile chemicals in their glands and release them when attacked by predators or subjected to other kinds of physical stress.

What kinds of volatiles would be emanating from bed bugs?

We used solid phase microextraction (SPME) fiber and gas chromatography-mass spectrometry (GC-MS) to determine if a large population of bed bugs produces some signature odors. The SPME fiber is made with adsorptive material, thus it collects volatile chemicals from the air. We exposed the SPME fiber into a headspace of a jar containing hundreds of bed bugs (adults, nymphs, cast skins, eggs, and fecal spots on the cardboard) for 10 minutes. The SPME fiber was then directly inserted in a GC-MS to analyze the volatiles adsorbed onto the fiber. We found two volatile aldehydes: 2-hexenal and 2-octenal. The SPME fiber and GC-MS method couldn't detect the volatiles when we used a small number of adult bed bugs (10 individuals and no cast skin). However, we found that the bed bugs released the volatiles in much larger amounts when we anaesthetized them with carbon dioxide gas (Figure 1).



D.-H. Choe, UC Riverside

Figure 1. A bed bug volatile collection from a vial containing 10 adult bed bugs using solid phase microextraction (SPME) fiber. The top line (green) shows undisturbed bed bugs, while the bottom line (black) shows bed bugs disturbed by injecting carbon dioxide into the vial. The bed bug volatiles (arrows) are detected only when the insects were disturbed with carbon dioxide.

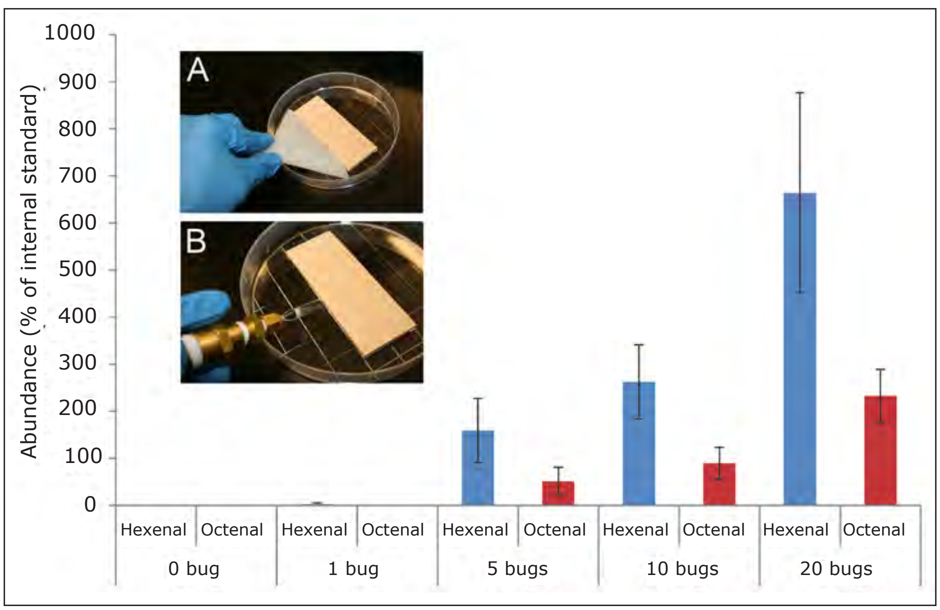


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Figure 2. A bed bug volatile collection from the wooden shelters using charcoal volatile traps with aeration device. Carbon dioxide gas was injected into the experimental shelters, (A), which contain different numbers of bed bugs (0, 1, 5, 10, and 20). Immediately after injecting the gas, (B), we collected volatiles from the shelter with an activated charcoal volatile trap connected to a vacuum. The abundances of the collected volatiles (mean ± SEM) are expressed as percentages of internal standard (n-dodecane, 0.025mg/ml) in methylene chloride that was used for recovering the volatiles from the activated charcoal.

The smell of the bed bug aldehydes is somewhat related to the scent of cilantro, which also contains different kinds of aldehydes. Interestingly, coriander, another name for cilantro, contains the root word "coris," which is the Greek term for bed bug. The bed bug volatiles (2-hexenal and 2-octenal) are behaviorally active pheromones, which at high concentrations function as alarm signals, causing the bed

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Bed Bugs ... continued

bugs to move away from the odor source. At low concentrations, the compounds work as aggregation pheromones, attracting the bed bugs to the odor source.

Can we locate hidden bed bug infestations by detecting these signature volatiles?

To answer this question, we built several wooden shelters to mimic bed bug harborages typically found in residential settings. One, five, ten, and twelve adult bed bugs were released per wooden shelter. Empty wooden shelters served as controls.

Once the bed bugs settled in, we injected carbon dioxide gas into the shelter for 20 seconds to disturb the bed bugs. We collected the volatiles from the shelter with a charcoal volatile trap connected to a vacuum. The charcoal volatile trap was a much more economical alternative to the SPME fiber used in our first experiment and also allowed us to sample relatively large volumes of air with aeration.

The quantitative analysis of the volatiles indicated that the more bed bugs we had in the harborage, the more volatile compounds we detected and the easier it was to find the bugs. One bed bug in the harborage couldn't be detected with this method, but five or more bed bugs would be reliably detected based on the signature volatiles collected (Figure 2).

All nymphal instars (from the first to fifth instar) and adults have these two volatile chemicals stored in their glands. Because bed bugs shed their old skins with their gland linings, these bed bug volatiles are retained in the old cast skins (exuviae) for a while after molting. This phenomenon can be exploited to determine if a cast skin you find at a site is a bed bug cast skin or some other insect's. This method would be particularly useful when the only evidence you have obtained from a suspected infested room or item is a couple of items that look like bed bug cast skins.

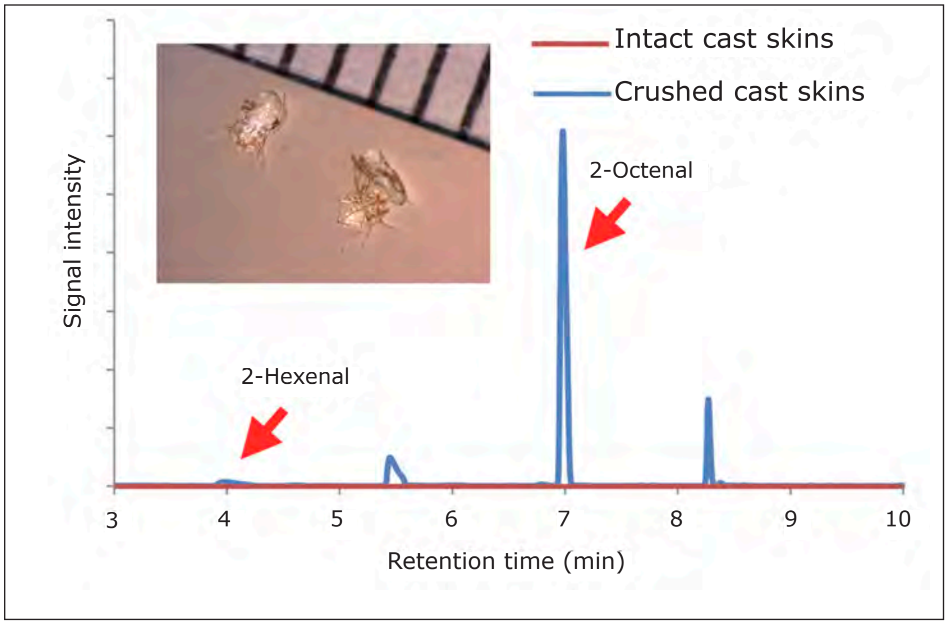

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Figure 3. Bed bug volatiles collected using the solid phase microextraction (SPME) fiber method from three cast skins obtained from first-instar nymphs. The bed bug volatiles (hexenal and octenal) were detected in high amounts only when the cast skins were freshly crushed (the blue line).

How can we determine if these are indeed bed bug cast skins?

Simply crush the item between your fingers and smell it (Figure 3). Because the cast skins of bed bugs retain the volatile aldehydes in enough quantities to be detected by the human nose—even one cast skin from the first-instar nymph, which is only about 1.5-mm long, will do—you should be able to readily determine whether you indeed have cast skins of bed bugs. Of course, you might need to know what those volatiles smell like beforehand. You can easily learn this from crushing live bed bugs of any instar.

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Resource Announcement


REMOVING HONEY BEE SWARMS AND ESTABLISHED HIVES

Integrated Pest Management for Home Gardeners and Landscape Professionals

PEST NOTES Publication 74159

University of California

Large numbers of bees swarming around a home can be unnerving, especially if they establish a hive within the structure.

The new Pest Note *Removing Bee Swarms and Established Hives*, http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn74159.html, provides information on how to safely handle these problems.

To access more than 150 other titles, visit the index at http://www.ipm.ucdavis.edu/PDF/PESTNOTES/index.html.