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Can Fire Shelters Protect Firefighters From Bee and Yellowjacket Stings?*

Richard S. Vetter, Brandy T. Parker, and P. Kirk Visscher

Forest firefighting is inherently dangerous, rife with unpredictable threats to life. As if the fire itself were not sufficiently treacherous, a firefighter who is constructing line or performing mop-up could agitate a colony of stinging insects and be exposed to stings as the insects emerge to defend their colony. The use of chain saws and heavy machinery adds to the problem, first by causing vibrations that irritate honey bees or yellowjacket wasps, and second by preventing the operator from hearing the buzzing insects so stings are the first warning.

Although serious stinging incidents from bees or wasps are rare, this is little consolation to a firefighter surrounded by a tornado of stinging insects. Furthermore, stinging incidents could become more common and dangerous now that Africanized honey bees have become established in southern portions of Texas, New Mexico, Arizona, and California (Visscher et al. 1997). Merrill and Visscher (1995) recently reviewed the significance of Africanized honey bees for fire managers.

When honey bees are aroused defensively, they seek targets that evolution has programmed them to pursue: upright, dark, moving, hirsute mammalian predators.

We were interested in determining the degree of protection offered by firefighter clothing and, in particular, the fire shelter. The best defense when attacked by stinging bees is to run from the area of the nest as rapidly as possible. Any shelter available, such as a building or an enclosed vehicle, can provide protection. However, injury or circumstances such as topography or fire behavior might make it impossible to run away. Therefore, we tested the efficacy of firefighter clothing and the fire shelter in protecting from stings.

Methods

We conducted two types of experiments. In both, we agitated bee colonies to the point where bees emerged in large numbers to defend their nests. In the first set of experiments, we wore Nomex firefighter clothing and sought cover under a fire shelter near the agitated colonies to test the degree of protection this provided from the bees. In the second experiment, we covered bare skin with the fire shelter to test whether it would protect exposed flesh from stings.

In these tests, one of us served (with obvious double entendre) as the "Sting Test Dummy" (SD). At the University of California–Riverside, we maintain research colonies of honey bees, and the person who volunteered as SD is stung about 200 times annually in the course of normal beekeeping operations. Aside from pain, he has only minor reactions to bee stings. As a precaution, several emergency epinephrine kits (EpiPens®) were made available, and before the experiments, an observer was instructed on their use. As figure 1

Figure 1—*The Sting Test Dummy wearing firefighter gear and pith helmet/bee veil. Photo: P. Kirk Visscher, University of California–Riverside, Department of Entomology, 1997.*

Rick Vetter is a staff research associate, Brandy Parker is a laboratory assistant, and Kirk Visscher is an associate professor in the Department of Entomology at the University of California–Riverside.

* The views expressed in this article are those of the authors. Readers should not construe them to be advice from the U.S. Department of Agriculture (USDA) or the Forest Service. Those individuals who anticipate being close to hymenoptera should seek advice from their physician. In addition, the naming of products is for the convenience of the reader and should not be misconstrued as an official endorsement by the USDA or the Forest Service.

shows, the SD wore Nomex clothing, leather gloves, web gear, and a hose pack. In addition, he wore a conventional beekeeper's pith helmet/bee veil to protect his face and neck, the most dangerous sites for stings.

In the first experiment, we deployed the fire shelter before initiating each test. Although predeployment did not truly mimic field conditions, we chose it to limit the number of stings to the SD, because several colonies were tested in a single day. We judged efficacy by the behavior of the bees before and after the SD was under the fire shelter and not by the total number of stings received before getting under the shelter.

We tested colonies consisting of at least two 10-frame Langstroth honey supers, with an estimated population of between 20,000 and 40,000 honey bees each. Four colonies were tested on one day and a fifth 2 weeks later. We began the test by prying loose the cover of a beehive, but leaving it in place. Then the SD beat vigorously three times on top of the hive cover with a long-handled shovel (fig. 2) and flipped the hive cover off to allow more defending bees to emerge from the colony in a short time. Next, the SD shook the hive by inserting the shovel beneath it and pumping up and down vigorously 10 times (fig. 3). This was typically sufficient to irritate the bees.

Figure 2—*Beating on the top of the hive to agitate the bees. The fire shelter is already deployed and out of the picture. Photo: P. Kirk Visscher, University of California–Riverside, Department of Entomology, Riverside, CA, 1997.*

Figure 3—*After removing the lid, the whole hive is rocked to agitate the bees. Photo: P. Kirk Visscher, University of California–Riverside, Department of Entomology, Riverside, CA, 1997.*

After 10 pumpings of the shovel or when the SD felt the first sting, he quickly got under the fire shelter located about 3 feet (0.9 m) from the hive entrance (fig. 4). Inside the shelter, he lay prone on the ground and attempted to get the edges of the shelter flat against the ground to prevent bees from entering (fig. 5). In some tests, the SD thrashed about under the shelter to emulate the movements of a firefighter trying to remove stings or kill bees inside the shelter. This action tested whether such movements drew more defensive attacks by the bees (since movement is one of the cues that defending bees use to locate an intruder). If not much stinging had occurred, the SD lifted a small edge of the shelter to see whether defending bees would fly into the darkened interior of the shelter.

An observer garbed in beekeeper's protective clothing watched the

Figure 4—*The Sting Test Dummy getting under the fire shelter. Note that there are many bees coming out of the hive, and several bees are stinging the left arm through the Nomex shirt. Photo: P. Kirk Visscher, University of California–Riverside, Department of Entomology, Riverside, CA, 1997.*

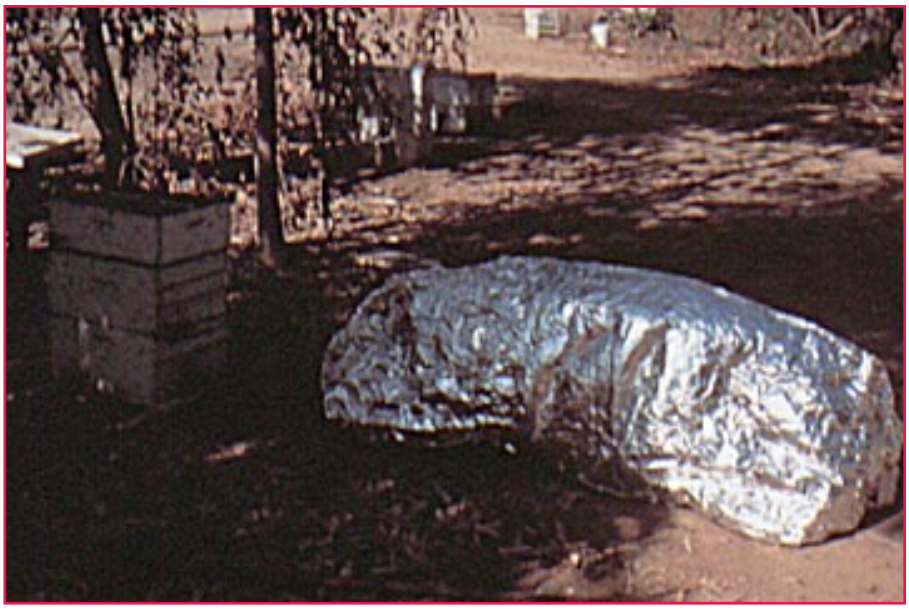

Figure 5—*The Sting Test Dummy is safely under the fire shelter. Note that bees are still flying around the area, but none are attacking the fire shelter. Photo: P. Kirk Visscher, University of California–Riverside, Department of Entomology, Riverside, CA, 1997.*

test from about 30 feet (9 m) away, making observations of the bees on the outside of the shelter and timing the experiment. The observer signaled to the SD when the bees were no longer defensive and the hive appeared to have settled down. Timing of the test started with the first shovel attack and ended when the bees were no longer flying around in an agitated manner. Inside the shelter, the SD observed the behavior of bees that entered the shelter.

Where possible, we recorded the number of stings felt by the SD before getting under the shelter. At the completion of the test, the SD moved away from the colony and removed the firefighter gear. Then we recorded the number of stings detectable as welts on his skin (fig. 6).

A second experiment tested whether bees could or would sting through the material of the fire shelter. Two weeks after first testing colony 4, we agitated it again, and the SD stood nearby with beekeeper protective clothing on his upper body and with the shelter wrapped in a single layer around his bare legs (fig. 7). We recorded the behavior of the bees toward the shelter material and compared it with their behavior toward the veil and jacket. The test lasted 11-1/2 minutes, until the colony's defensive response decreased to near zero.

Results

In the first set of tests, colonies 1, 2, and 3 were not very defensive. The SD received no stings during the agitation phase, and only one, two, and zero stings, respectively, while under the shelter. These were from bees that crawled under the shelter or were brought in when the SD initially got under the shelter. The stings resulted because the bees were trapped between the ground and the body, and not because they actively pursued the SD inside the shelter. All three colonies returned to normal in 3 to 5 minutes.

Colony 4 was the most demonstrative and most convincingly showed the efficacy of the shelter. During the agitation phase, nine stings were delivered (four to the left biceps, two to the right wrist, one to the thigh, and one to each knee), all within about 10 seconds. While under the shelter, one bee crawled

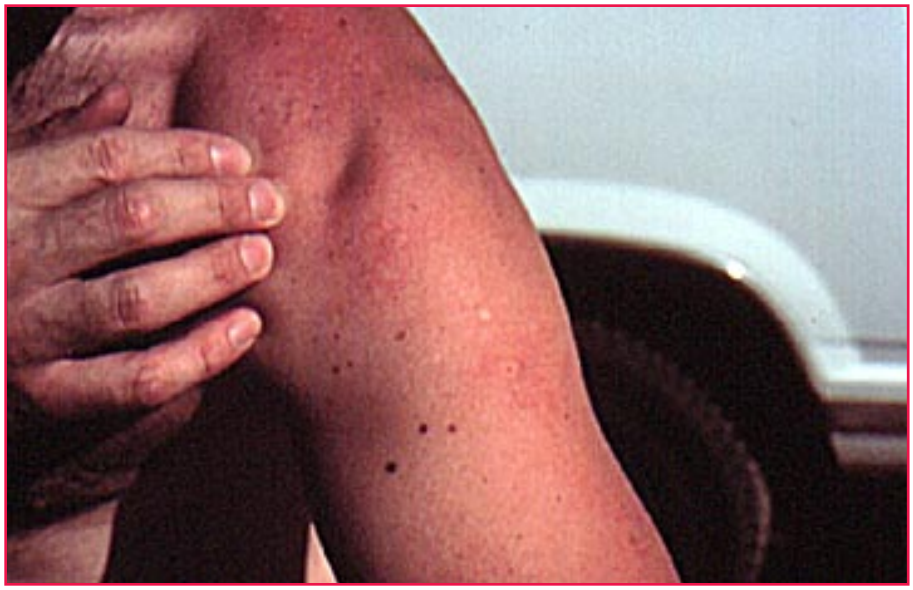

Figure 6—*Two sting welts inflicted on the arm (the raised weals with red centers). Photo: P. Kirk Visscher, University of California–Riverside, Department of Entomology, Riverside, CA, 1997.*

Figure 7—*The Sting Test Dummy is wearing shorts and pressing bare legs against the fire shelter to test its ability to ward off stings. Notice that the bees are concentrated on the head area and ignore the silver fire shelter. Photo: P. Kirk Visscher, University of California–Riverside, Department of Entomology, Riverside, CA, 1997.*

under a glove and stung the wrist, and another got under the veil and delivered a sting to the pinna of the ear. This colony settled back to normal within 3-1/2 minutes.

Colony 5 was very defensive, delivering 19 stings: 7 to the forearms (6 to the left forearm, 1 to the right); 8 to the upper arms (6 to the left arm, 2 to the right); 2 to the left thorax; 1 to the left rib cage; and 1 to the buttocks. Unfortunately, due to the large number of stings and the distraction of getting under the shelter, we could not determine precisely how many stings were delivered before and after the SD entered the shelter. In fact, the SD initially believed that he had been stung no more than 6 to 8 times in all, and was surprised to discover 19 welts on his body after emerging from the shelter. Although several stings did occur when the bees landed on the Nomex shirt after the SD got under the shelter, stinging inside the shelter stopped precipitously. This colony settled back to normal in 4-3/4 minutes.

In the first experiment with the five colonies, the observer noticed bees outside the shelter flying about looking for the offending stimulus. They mostly searched the dark edge of the shelter shadow and did not attack the silver surface of the shelter. This was also evident to the SD inside the shelter, who heard no sound of bees colliding with the shelter from the outside. Bees inside the shelter spent much of their time at the top, attracted to the light coming through the pinholes; they were apparently trying to escape. Otherwise, they mostly crawled on the SD's clothing. Bees made little attempt to sting the SD in the dark interior of the shelter unless they were trapped.

In the second experiment, with the shelter wrapped around the SD's legs, the bees emerged from the hive and readily attacked the upper half of the SD's body. They made virtually no defensive attacks on the legs covered by the shelter. No stings were inflicted during this experiment, and the bees settled down after 11-1/2 minutes.

Discussion

In the rare event that a firefighter is attacked by honey bees and cannot retreat from the area, the fire shelter can provide useful, potentially life-saving protection from additional stings. The shelter removes the firefighter from the view of agitated bees, and they do not respond to the shelter itself as an object to be attacked. Bees brought under the shelter during deployment mostly change their behavior from attack to escape.

Shelter Deployment. The most important protective feature of the fire shelter is its coloration, not its thickness. When honey bees are aroused defensively, they seek targets that evolution has programmed them to pursue: upright, dark, moving, hirsute mammalian predators. Because its color and texture do not match this profile,

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the shelter is largely ignored by defending bees. The white clothing worn by beekeepers provides protection for a similar reason.

The bees searched the dark shadow of the shelter and entered the shelter when the margin was breached. However, after entering the shelter, most bees aborted their attacks and went to the top of the shelter to escape. This parallels our experience of fleeing into a dark shed to escape harassing bees and seeing many of the bees cease attack and fly out the door.

This suggests that the shelter is most effective against stings when it is fully deployed to minimize crevices and shadows, and when it is horizontal (rather than wrapped around an erect firefighter). Our experiments showed this in two ways. First, colonies 4 and 5 delivered 24 stings through the yellow shirt (possibly because defending bees were attracted to the dark straps of the web gear) and only 4 through the darker green pants. Second, when the SD was lying flat under the shelter, the bees settled down in about 4 minutes. But when the SD stood upright with the shelter wrapped around his legs, bees continued to harass him after 11 minutes (although they focused on his head, not on his shelter-wrapped legs).

Sting Treatment. One trait peculiar to honey bees is that their sting is designed to detach in mammalian flesh, where it emits an alarm pheromone (isopentyl acetate, which smells like bananas). This signals other bees to join the attack and marks the area of the sting as vulnerable. The detached sting also continues to pump venom into the flesh. After entering the shelter, a firefighter should attempt to remove any stings to minimize the quantity of venom injected. Contrary to conventional medical wisdom, the method used to remove a sting does not affect the venom injected, but even seconds of delay can be harmful (Visscher et al. 1996). Therefore, rubbing the area of the sting (through the clothing if necessary), pinching the sting out, and scraping it off with a fingernail are all effective methods of removal.

Many of the bees that enter the shelter as it is deployed might already have stung and offer no further threat. Others will mostly attempt to escape, but will sting if trapped against skin or clothing. The bees can be safely crushed with a gloved hand, but should not be struck at, because this could lift the shelter off the ground and allow more bees to enter.

Attacks from honey bees will always be rare, and death from bee stings even rarer. The number of honey bee stings necessary to kill half of those who die from bee stings (the median lethal dose, or LD_{50}—a commonly used measure for the toxicity of all types of venom, pesticides, and other chemical substances) has been estimated to be from 500 to 1,200 (Merrill and Visscher 1995, Vetter and Visscher [In press]). Because the initial stings would probably be enough to alert even the most focused firefighter, most would be able to flee the area before receiving a life-threatening number of stings. However, for incapacitated firefighters, protection is necessary to prevent large numbers of stings. Fortunately, the fire shelters carried by wildland firefighters are quite effective in this regard, and—if promptly deployed—can make the difference between survival and death.

For those allergic to bee venom, even one sting can set off an anaphylactic response. In the minority of these cases, death can result (usually within 1 hour) from swelling of respiratory passages or a precipitous drop in blood pressure. Hypersensitive people typically understand their vulnerability and should always carry anaphylaxis emergency treatment kits (such as Ana-kits® or EpiPens®), both on the firelines and off. Injection of epinephrine can usually reverse the life-threatening symptoms.

Africanized Honey Bees and Yellowjacket Wasps. In our experiments, we used European honey bees to simulate defensive attacks against a firefighter. With Africanized honey bees, a firefighter should expect the defensive attack to involve more defenders and last longer, and the bees to chase a fleeing firefighter farther. If a fire shelter were deployed to protect from Africanized bees, we would expect it to be effective. However, the bees would be more likely to enter if there were openings between the shelter and the ground, and to continue their defensive attacks after having

entered the shelter when it was first deployed.

Yellowjacket wasps are also a potential problem for firefighters. Wasp stings—unlike honey bee stings—do not normally detach. Therefore, each wasp can sting several times (possibly in rapid succession), fly off, and return for another attack. As with bees, some people are dangerously sensitive to yellowjacket stings (Flanagan and Fadich 1996). Because the venom components and allergens in wasp venom are different from those in honey bee venom, people who are hypersensitive to bees are not necessarily hypersensitive to wasps (and vice versa). Wasps are potentially more dangerous than bees because fewer stings are capable of causing death through kidney damage (Levick and Braitberg 1996).

Yellowjackets, unlike honey bees, do not store provisions for winter. They appear to be more active late in the warm season because the populations in their annual nests peak at this time of year, not because they are collecting food for winter. Even though yellowjackets searching for food might be drawn to the color yellow, the yellow Nomex shirts worn by firefighters are not likely to provoke attack, because both yellowjackets and bees target the upright, moving mammalian form when defending their nests, not objects that are yellow. Yellowjackets use their venom only to defend themselves or their homes; they subdue their prey by mauling with their mandibles, not by stinging. People can be stung regardless of shirt color, and those wearing dark objects (such as the pack straps in this study) are more likely to be stung than those wearing lighter colors (Visscher and Vetter 1995).

Recommendations for Firefighters

When attacked by honey bees or yellowjacket wasps:

1. If at all possible, run away from the nest as quickly as you can.
2. If running away is impossible due to injury, fire conditions, or topography, then deploy a fire shelter to drastically reduce the number of stings. Get your head and neck under the shelter as quickly as possible, and try to lie flat. Then cover the rest of your body.
3. Flatten down the edges of the shelter along the ground to prevent additional insects from entering.
4. If stung by honey bees, remove stings by rubbing your hands over exposed skin. Remove stings in clothing by rubbing or pulling on the cloth.
5. Use gloved hands to crush any insects inside the shelter.
6. After the bees or yellowjackets settle down (which will take several minutes to an hour, depending on the degree of their agitation), move away from the nest, using the shelter as protection from any remaining defenders.

As always, knowledge of how to respond correctly in an emergency is the best insurance of survival. In most circumstances, timely escape is best; but when escape is impossible, the fire shelter can provide significant protection from stings. The fire shelter now has a new, potentially life-saving application.

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