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A NEW OPTION: LOCALIZED HEAT TREATMENTS

New research out of the University of Florida shows how limited heat treatments of room contents can be effective — as well as affordable and quick— for the control of bed bugs.

Figure 1. Equipment used for localized heat treatment for bed bug control includes oil-filled electrical space heaters, box fans, small desktop fan, tape, electrical extension cord, polystyrene sheathing board insulation and outdoor/indoor consumer digital thermometers.

Bed bugs have been associated with humans for at least the past 3,500 years and have re-emerged recently as an important pest in many urban areas in the United States after being absent as a major pest in the U.S. since World War II. The resurgence of these blood-sucking insects has caused increasing problems, especially on college campuses, in the hospitality industry and in low-income housing. However, bed bugs also have shown up in many well-to-do locales, and have proven themselves as an equal opportunity pest. The number of lawsuits related to bed bugs reported in the news media is a good indication of the increased presence of bed bugs everywhere.

Because bed bugs hide in cracks and crevices, detection and control can be challenging, especially when bed bugs occur on beds, furniture and other objects where the application of chemical pesticides may not be the best choice. Because there is intimate contact between humans and the pesticides applied in these locations, consumers may not be willing to accept a pesticide application to bedding, mattresses and other surfaces that have prolonged human contact. Also, for the pest management industry, even *perceived* risk with no sound basis can represent risk of complaints and lawsuits. That is why a physical control method applied to the room contents (bed, clothing, etc.) can be useful as a tool in the overall control of bed bugs. Such a method can be used to supplement crack and crevice insecticidal applications in an integrated approach that is required for hard-to-control pests such as bed bugs.

ALL ABOUT HEAT. Bed bugs are not more resistant to changes in temperature than other insects, and in fact they seem to be less resistant than some. Temperatures needed to kill bed bugs are below those that would cause damage to furniture and other materials that may be infested with these insects. Therefore, the use of heat for control of bed bugs represents a viable alternative to be used in integrated management.

Heat treatment of a whole room or building is currently used for control of bed bugs as well as many other insects. Temperatures between 112° and 113°F seem to be sufficient to kill bed bugs; therefore, temperatures do not have to be too extreme to eliminate infestation. It is possible that temperature in the upper 90s°F can cause some damage to bed bugs and prevent their development and reproduction. However, by maintaining temperatures well below 160°F or so, bed bug treatment can be accomplished without risking damage to furniture, electronic equipment and other materials that would be included in the treatment.

A quick look at products and services being offered for bed bug control will reveal several that use heat as the killing agent. Most products and services can be classified as whole-structure or whole-room, meaning the total air-space within the structure or room is heated to the desirable level. Sometimes the infested material (furniture, etc.) also may be transferred to a container where the treatment is applied. These containerized heat treatments require the infested material to be moved, which can actually aid in further spread of the infestation. The use of solar radiation as a heat source also has been proposed, although research from Australia threw some cold water on the idea because bed bugs moved to unheated areas and avoided the killing temperatures reached on the sun-exposed sides of encased mattresses.

A NEW METHOD. The cost of the necessary equipment, the energy requirements, treatment duration, and other difficulties related to commercially available whole-room and whole-structure heat treatments have led us to an alternative heat treatment for control of bed bug infestations. We developed and tested an in-room containerized heat treatment for room contents. Such treatment is very similar to the whole-room treatment, but the heat is confined to a much smaller space within the room. This is accomplished by building a box with construction insulation boards around the infested furniture, and confining heater and fans within this box. The furniture is piled in the middle of the room, usually with the bed being piled with whatever else will be heat treated to eliminate bed bugs. Because the volume of air is drastically reduced in relation to the volume of the whole room, and the heat loss is held to a minimum by the insulation material used in the box construction, the heat treatment ends up costing much less than other alternative treatments. The following details how this localized bed bug treatment was done.

The equipment we used included *(see Figure 1 on page 34)*:

Oil-filled electrical space heaters, with no exposed heating elements, were chosen for our application. We used either heaters produced by Pelonis Appliances or DeLonghi, but other heaters may work as well. The important characteristic in these heaters is that they have a built in thermostat that prevents the heater from delivering damaging high temperatures. With no exposed heating elements, and temperature-controlled shut-off, these radiator-type heaters can be put very close to cloth, wood and other material with no risk of fire and damage. We used the maximum setting in these heaters so they would produce the quickest rise in temperature and obtain a quick treatment.

Figure 2. Outdoor/indoor consumer digital thermometers can be used to monitor temperatures within the furniture being heat treated. The display instrument is kept outside the treatment box while the temperature probe attached to a long wire is placed somewhere in the treated contents.

Box fans were placed beside the heaters in order to move the heat quickly away from the heater, and distribute the heated air throughout the treatment box. The fans also were set

Figure 3. The treatment box is built with 4-foot by 8-foot polystyrene (Styrofoam®) boards (four for the sides and two for the top) taped together with 2-inch wide plastic or paper tape.

Figure 4. The room contents are piled in the middle of the room, preferentially on top of the bed or other furniture with legs. Heater and fan combos are placed at opposite corners of the furniture.

at the highest speed, so that the circulation of the heated air was as fast as possible. In fact, we often added an extra fan on top of the furniture to aid in the circulation of the hot air.

Temperature monitoring equipment such as an outdoor/indoor consumer digital thermometer was used to monitor the temperature within the treatment box *(see Figure 2 on page 35)*. These thermometers have a probe (to measure the outdoor temperature) at the end of a long wire, so you know from outside the treatment box what the temperature is inside where the bed bugs are located. We actually kept the body of the thermometer outside the treatment box, and placed the probe at the end of the long wire deep inside the furniture or other material to be treated. This thermometer was used to monitor when the temperature deep inside the treatment had reached the 113°F we were shooting for. Where this probe is placed is probably the most important part of the whole process. The temperature probe should be placed in the location where the heat will have the most difficulty reaching. For instance, in experimental treatments, we would wrap the probe in several layers of blanket and then placed the blanket bundle inside a drawer or cabinet as far away from any heater as possible. This would guarantee that, by the time this probe was indicating the correct bed bug killing temperature, everywhere else in the furniture the temperature would be sufficient to kill the bed bugs. In fact we always used three or more of these temperature-monitoring probes, always placed in locations where heat would arrive with difficulty. Thus, we always had a good indication of when the treatment could be interrupted.

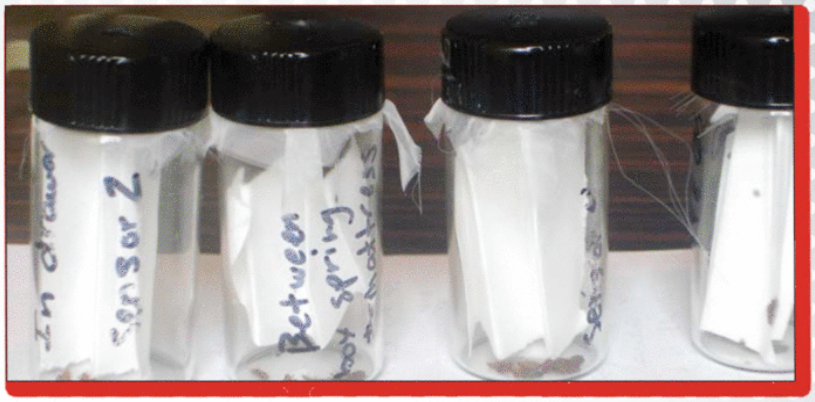

Figure 5. Bed bug vials (with perforated top covered with cloth) can be placed throughout the furniture to serve as proof of efficient treatment.

For experimental purposes, we used quite a few temperature monitors and recorders. These indicated that air temperature within

the treatment box rose very fast and reached the killing levels within 30 to 60 minutes. However, deep inside furniture, bags of clothes, and other articles, the temperature would rise slowly.

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The insulation boards we used to make the treatment box were 4 feet by 8 feet Styrofoam® boards with 2-inch thickness. The treatment box was 8 feet by 8 feet and 4 feet high *(see Figure 3 on page 35)*. Basically, four boards were used as the box's sides and two boards were use as the top for the box. The bottom was the room floor. Everything was held together by 2-inch-wide packing tape. All the seams were taped to provide as tight a seal as possible, and contain as much of the heated air as possible inside the treatment box. To facilitate transportation and moving the foam boards into tight rooms, we have cut some of the boards in half (4 feet by 4 feet) and reassembled them inside the rooms.

Preparation of the rooms for treatment took very little time. The room furniture was grouped at the center of the room *(see Figure 4 on page 35)*. All materials to be treated were placed on top of the furniture. Oil-filled heaters were placed on the floor on opposite corners of the furniture and box fans positioned so that air would blow through the radiator of the heaters. Positioning the heaters at opposite corners increased uniformity of heating within the treatment box. The heaters and fans were turned on and the treatment box was built around the furniture.

For experimental purposes, we placed live bed bugs in vials *(see Figure 5 on page 36)* at different places within the furniture, usually with a temperature probe attached to the vial. Once the treatments were done, the dead bed bugs were a good indication that we had done a good job. Pest management personnel doing similar work may find the use of live insects a good way to demonstrate to doubting clients that the treatment was indeed sufficient to kill the infestation. Doing so also serves as an excellent quality control mechanism.

We terminated treatments when all monitoring temperature probes had reached 113° to 115°F. In the laboratory, we have determined that any temperatures higher than 106°F kill bed bugs, although the length of treatment varies. Bed bugs have to be exposed to 106°F for more than 100 minutes to be killed, while it only takes 10 minutes to kill bed bugs at 113°F. So it is always best to wait 10 minutes after the temperature reaches 113°F before turning the heaters off. In reality, because of the heat accumulated by the bed bugs while the temperature is rising from 106° to 113°F and the time it takes for that temperature change to occur, by the time the temperature reaches 113°F, the bed bugs are dead.

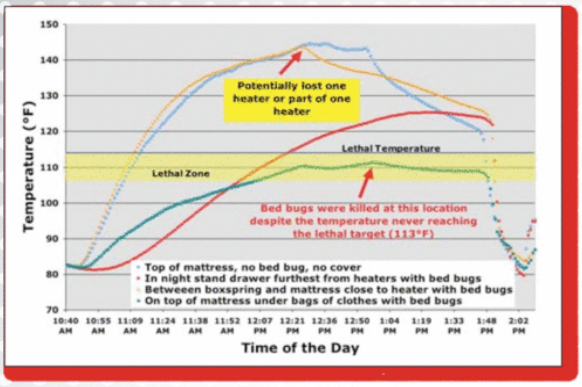

Figure 6. Temperatures measured at different locations within the furniture will rise at different rates, depending on insulation from the heated air within the treatment box. Temperature should be within the lethal zone (106° to 113°F) or above in order to kill the bed bugs. Temperatures only need to be maintained above 113°F for 10 minutes to have complete elimination of bed bugs.

MAKING IT WORK. In our experiments, treatments in carpeted floors needed two to three hours to reach the temperatures to kill the bed bugs while rooms with tile floors needed five to seven hours to reach the same temperatures. This is caused by the greater heat loss through the tiled floor than a floor covered in carpet. Of course, a piece of carpet or foam pads placed on the floor, as the bottom of the treatment box, can prevent this heat loss in rooms with a tile floor.

Another important factor in the treatment timing is air circulation. Poor air circulation and poor distribution of the heaters can cause some pockets of cold air to remain within the treatment box. These pockets of cold air can serve as a refuge where bed bugs can move to escape the killing heat. Highest temperatures are always measured at unprotected locations exposed to the heated air in the treatment box. Lowest temperatures were observed when temperature monitors were placed inside drawers or other insulated locations. Temperatures at exposed locations tended to increase rapidly but stabilize toward the final phase of the treatment when the heaters started to cycle on and off due to temperatures being close to their operating maximum. In contrast, temperatures in locations insulated from the heated air rose very slowly at first then faster toward the end of the heat treatment *(see Figure 6 above)*. Temperatures at these insulated locations continued to rise even after the heaters had been disconnected, especially when the treatment box was not immediately removed. This may offer some opportunity for some energy saving.

Differences between the temperatures at monitored locations and other locations where bed bugs may find refuge may be a problem. Thus, the placement of the temperature-monitoring equipment is a crucial decision during the preparation process. Temperature probes do need to be placed in locations that are well-insulated within the treated furniture, to ensure that lethal temperatures for the bed bugs are reached everywhere before the treatment is interrupted.

Containment and circulation of the heat around the treated material are the most important factors in an efficient heat treatment for bed bug control. The containment provided by the Styrofoam board insulation was sufficient to prevent excessive heat loss and prevent excessive heating of the surrounding room. When heat is contained and circulated efficiently, the air space around the treated furniture increases rapidly. This rapid increase of temperature from outside causes bed bugs to move further inside the furniture, moving away from rising temperatures. The rapid increase of temperature also is likely to quickly immobilize the bed bugs.

Rapid increase in temperature allows treatment to be completed in a short time, well below the 16 hours required for whole-room treatments. Long treatment times cause major disruption in use of the treated structure, require greater energy input and prevent simultaneous application of residual pesticides.

The process discussed here is a method for heat treatment of furniture and other room contents, while providing opportunity for residual pesticide application around the room. Because of the relatively low temperatures required for bed bug elimination, limited heat treatments of room contents using low-cost equipment can be accomplished in less than six hours. When the room contents are grouped in the middle of the room, easy access to the walls, baseboards, carpet corners, and other cracks and crevices facilitate application of residual pesticides. Localized heat treatment can be used in combination with other bed bug control methods with minimal disruption in use of the treated room. **PCT**

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