the future of bed bug

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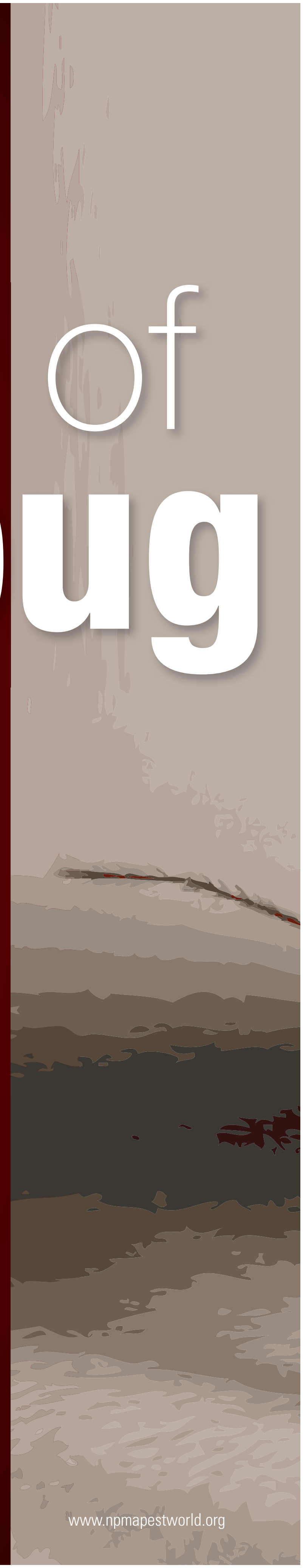
Bed bugs are one of the most commonly discussed urban pests in the United States. Unlike most other urban pests, bed bugs can affect anybody: rich or poor, at work or at home, in clean or in unsanitary environments. Perhaps the most annoying aspect of this pest is that it bites people when they are asleep and hides until the next meal. People are often frustrated and perplexed by the ability of this blood sucker to evade detection, often reaching large numbers without the occupants seeing a single bug.



monitoring

Manufacturers quickly responded to the need for easy bed bug detection by offering various detection tools or services. A search over the internet reveals at least 26 bed bug monitoring tools or techniques (Table 1) are present. The underlying principles of these monitors/techniques fall into four categories: 1) bed bugs seek harborages after feeding; 2) bed bugs are attracted to hosts through chemical lures and heat; 3) bed bugs cannot climb up a smooth hard surface or may get stuck on a sticky substrate; and 4) bed bugs breath, emit unique smell, or posses unique DNA makeup.

Questions arise as a result of the steady influx of new bed bug detection technologies: how effective are they in the field? Can bed bug monitoring be made more effective? How do current monitoring technologies help the day-to-day bed bug management programs?

Studies demonstrated that some bed bug monitors can significantly improve our ability to detect bed bugs and determine the effectiveness of bed bug elimination efforts (Wang et al. 2011, Wang and Cooper 2011a). However, efficacy claims for most detection tools and methods are based upon laboratory results rather than field testing. This is problematic because the behavior of bed bugs is complex and laboratory results often don't translate to what occurs in the natural environment. Thus the response of bed bugs placed in a small confined arena can be very different from those in naturally infested structures. For example, in tests with a device that uses chemical lures to attract bed bugs, traps captured a high percentage of bed bugs in a small arena in the laboratory environment, but failed to detect bed bugs when large numbers of bed bugs are present in naturally infested apartments even though bed bugs were readily seen by a non-trained person (Wang and Cooper, unpublished data). Similarly, some dog detection teams performed very poorly in the field but performed very well during daily training exercises (Wang and Cooper 2011a). The discrepancy between results obtained in controlled environments and real world environments suggests we must re-examine how monitoring tools and techniques should be tested. Without rigorous testing, it is unrealistic to claim a tool/technique is effective.

Passive monitors are relatively inexpensive and easy to use. Pitfall-style devices are designed to be placed under furniture legs. They take advantage of a very important bed bug behavior: bed bugs travel back and forth between furniture and the floor in search of a host or a harborage. Pitfall-style monitors are excellent barriers that protect the human host from bed bug bites. However, as a monitor, their effectiveness varied greatly. The color, surface texture, and the trapping mechanism all have significant effect on the trapping efficacy. We found bed bugs prefer black to white colors. They also prefer fabric to plastic surfaces. A bed bug is more likely to be caught by a pitfall trap than a sticky trap.

The active monitors employ one or several attractants to attract bed bugs to the monitor. It is known that bed bugs follow a combination

TABLE 1. Types of bed bug detection tools and techniques based on internet search (as of October 2011).

Type	Examples	Number
Passive monitor (without lures)	Climbup Insect Interceptor, Bedmoat, BB Alert, Bed Bug Detection System	9
Active monitor (with lures)	NightWatch, Bed Bug Beacon, dry ice trap	12
Detection based on bed bug smells or respiration	Trained dogs, BBD 100, Electronic CO2 detection kit	3
Others	DNA test, camera	2

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of chemical and non-chemical cues to locate the host. NightWatch, CDC3000 (no longer produced), and dry ice monitors were found being able to detect low level infestations in occupied rooms (Wang et al. 2011). Presumably, these monitors would perform even better in vacant rooms where there is no competition with the host. Both Nightwatch and CDC3000 employ CO_2 (pressurized cylinders as source), chemical lure, and heat to attract bed bugs. The dry ice trap only employs CO_2 to attract bed bugs. The fact that dry ice trap was the most effective trap among the three active monitors suggests a sufficient CO2 release rate is the most critical element in an active monitor.

The CO_2 release rates from CDC3000, NightWatch, and dry ice trap are at least 42, 150, and 737 ml/minute, respectively (Wang and Cooper 2011b). Although dry ice trap is highly effective and affordable, it is limited by the availability of dry ice in many areas and the potential risk of accidental

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exposure to children or pets. Pressurized cylinders provide high enough CO_2 release rates, but the system is expensive. Alternative CO_2 sources are being investigated and are employed in some monitors. Among them, sugar and yeast mixtures offer a convenient and safe CO_2 source, but the maximum CO_2 release rate was only 11 ml/minute in our laboratory tests. This rate is insufficient to attract bed bugs from a distance (e.g. a few meters) and explains why these devices can work so well in laboratory arena trials compared to the poor results observed under field conditions. A CO_2 release rate higher than this would require large amount of materials (several kilograms) and become impractical. A possible strategy of overcoming the obstacle of insufficient CO_2 release rate is to place multiple monitors close to bed bug hiding areas. Whether this kind of placement strategy is effective needs to be studied.

Bed bug monitors not only help detect infestations, but also provide important information about bed bug activities and/or their spatial distributions. Pitfall-style monitors, traditionally thought to be a device placed under the legs of beds and furniture can also be an effective tool for monitoring bed bug activity away from sleeping areas (Wang et al. 2010). Figure 1 illustrates the layout of pitfall-style monitors and bed bug counts in the traps after 7 days in a one bed room apartment. This apartment was occupied by one person. Bed bugs had been present in this apartment for at least a year. The existence of bed bugs around the entry door area indicates bed bugs may very likely spread into the hallway of the building. The large numbers of bed bugs off the bed area highlights the need for thorough treatments of the apartment.

Bed bug monitors may potentially be used as a control tool. When they are strategically placed such as under bed and sofa legs and surrounding areas, the monitors may trap the few bed bugs present in a lightly infested environment. Alternatively, insecticides or other killing agents may be placed in or around the monitors to attract and kill bed bugs, thus, reducing the insecticide use and minimizing the environmental impact.

In addition to physical devices, canine scent detection has also emerged as a very popular method for detection of bed bugs particularly for large scale inspections. It is unquestionable that well trained dogs are highly accurate in finding hidden bed bugs in training exercises (Pfiester et al. 2008). However, there is an urgent need to determine the effectiveness of the training methods, evaluation standards, association between training performance and field performances, and factors affecting the field performances. The ultimate criteria for a well trained dog should be high detection rate (correctly alerting to a location where bed bugs are present) and low false positive rate (alerting to a location where bed bugs are absent) under field conditions

As the bed bug monitoring tools/techniques continue to evolve, they will become more widely accepted by both professionals and consumers for bed bug prevention and management. Different types of monitoring methods may coexist to suit the diverse environments and needs from various clientele groups. These monitoring technologies will help detect bed bugs sooner, eliminate bed bugs more easily, and reduce the spread of bed bugs. «

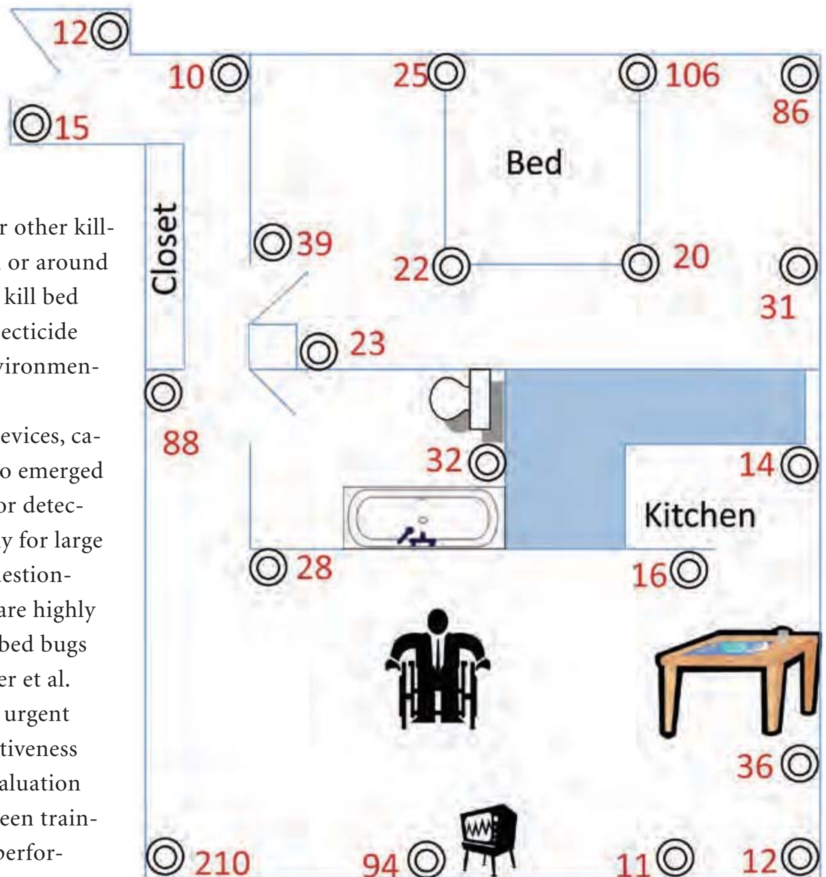

Figure 1. Bed bug counts from pitfall-style monitors (7 day placement) in a one bedroom occupied apartment. Four monitors were placed under the bed legs. Seventeen monitors were placed off the bed in various locations.

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