PCT PEST CONTROL TECHNOLOGY

DETECTION TOOLS AND TECHNIQUES

By Changlu Wang and Richard Cooper

Effective bed bug monitors are badly needed to save money, provide peace of mind and nip bed bug infestations in the bud. Here, types of monitoring tools and techniques and their effectiveness are discussed.

No other urban pests have aroused so much public attention as bed bugs in the year 2010 in the U.S. This insidious pest has emerged as the most challenging urban pest. New York City Department of Housing Preservation and Development documented an increase from 537 to 12,768 reported cases in 5 boroughs during 2004-2010. In February 2010, we surveyed nine public housing authorities in New Jersey. Five of them reported an increase in bed bug infestations since 2008. More alarmingly, bed bugs are beginning to appear in offices, schools, theatres, stores and other public places on a more frequent basis.

The challenges in bed bug control are multifold. Perhaps the greatest challenge is to detect the presence of bed bugs when their numbers are small. Bed bugs are difficult to find and are often hiding in inaccessible areas. An effective bed bug monitor is badly needed to save money, provide peace of mind and nip bed bug infestations in the bud.

Many bed bug monitoring tools have been developed since 2008, yet few have been scientifically tested and proven effective. Here we discuss the types of monitoring tools, technique and their effectiveness.

PASSIVE MONITORS. The number and type of passive monitors continues to change with new devices becoming commercially available on a regular basis. Passive monitors trap bed bugs with glue or a pitfall design. Among these, we found ClimbUp Insect Interceptors worked the best. Its prototype, a set of two plastic bowls, effectively detected low-level infestations that were not detected by visual inspections (Wang et al. 2009ab).

Advantages of using ClimbUp interceptors are: 1) improves detection accuracy compared with visual inspections; 2) saves monitoring cost; 3) requires less skill and experience than visual inspections; 4) reduces bed bugs as they confine bugs inside the interceptors and eventually kill the bugs; and 5) reduces bed bug bites immediately as they reduce the number of bed bugs in the room that successfully access the human host.

Disadvantages of ClimbUp interceptors are: 1) presence of the device may alert the guests in hotels; 2) does not completely prevent bed bugs from accessing sleeping and resting areas for blood meal; 3) may need several days or longer to detect the presence of low number of bed bugs; 4) inner well is prone to breaking under weight of furniture when carpet is present; and 5) requires maintenance (cleaning and relubrication) on regular basis.

We found the following tips are helpful when using ClimbUp interceptors: 1) eliminate as many bugs as possible on beds and upholstered furniture before installing interceptors because bed bugs already on furniture may not go to the interceptors; 2) eliminate alternate paths for bugs by pulling beds and upholstered furniture away from walls and do not allow linens, dust ruffles, etc., to touch floor; 3) install interceptors for at least seven days to detect low-level infestations; 4) clean and reapply talc powder every one to two weeks to keep interceptors fully functional; 5) use a hand-held magnifier to help identify small nymphs trapped in the interceptors.

ACTIVE MONITORS. A number of bed bug monitors that contain chemical(s) and/or chemical lures have been developed for detecting bed bugs. Some examples include CDC3000 (Cimex Science, Portland, Ore.), NightWatch (BioSensory, Putnam, Conn.), dry ice trap (http://njaes.rutgers.edu/pubs/publication.asp?pid=FS1117), Bed Bug Beacon (Packtite/Nuvenco, Laporte, Colo.) and BB Alert Active (MidMos Solutions, West Midlands, UK).

In late 2009, we evaluated CDC3000, NightWatch and a dry ice trap in a high-rise apartment building *(see Figure 1 on page 74)*. Three experiments were conducted. In Experiment I, three heavily infested apartments were identified. Brief visual inspections found at least 426 bed bugs in each apartment. Immediately after visual inspection, the three types of monitors were randomly assigned to the three apartments. The monitors were installed around the infested area (sofa, bed or piles of clothing) in each apartment between 1:00 p.m. and 6:00 p.m. The monitors were examined the following day (about 24 h later). Each monitor was then placed in a different apartment on each of the next two days. On each day, the monitors were examined and reset in the afternoon.

In Experiment II, 15 lightly infested apartments were used. These apartments had fewer than 35 bed bugs based on visual inspections and interceptor counts (one week deployment of interceptors). Five CDC3000, five NightWatch and five dry ice traps were randomly assigned to the 15 selected apartments. The number of trapped bed bugs was recorded the following day. The experiment was continued for two more days. On each day, the three types of monitors were rotated among the apartments so that every apartment received each type of monitor during the three-day period. NightWatch monitors were programmed to release carbon dioxide (CO_2) immediately after installation.

In Experiment III, we evaluated the daily trapping pattern of NightWatch in eight lightly infested apartments (a subsample of the apartments from Experiment II). A NightWatch was placed beside the infested furniture (bed or sofa) in each apartment. All NightWatch monitors employed 567 g (20-ounce) CO_2 cylinders, which allowed the monitors to operate for

Figure 1. Three tested active bed bug monitors; 1) CDC 3000, 2) NightWatch and 3) dry ice trap.

four consecutive nights. The monitors were programmed to begin releasing CO_2 at 10:00 p.m. to 6:00 a.m. each day per manufacturer's instructions.

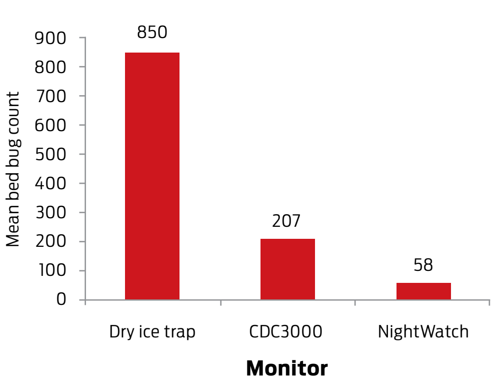
Results show that the homemade dry ice trap was the most effective monitor both in apartments with heavy and light bed bug infestations *(see Figure 2 below)*. All monitors were able to detect bed bugs in lightly infested apartments. The number of low-level infestations detected over 24 hours by the CDC 3000 was significantly greater than those detected by the NightWatch. However, unlike the CDC 3000, the NightWatch is designed to operate for four to seven consecutive days.

In our third experiment, the NightWatch detected bed bugs in five apartments on the first day. It trapped bed bugs from an additional apartment the following day, indicating multiple day trapping is beneficial in detecting a light infestation. Bed bugs only come out looking for a host every three to seven days (Reinhardt et al. 2010). Thus monitors that work continuously for two or more days may be more likely to capture bugs in low-level infestations as individuals seek a blood meal.

We installed ClimbUp interceptors for seven days in the apartments before and after the Experiments II and III. The interceptors caught similar number of bed bugs as the dry ice trap, demonstrating that employment of ClimbUp interceptors for seven days can be as effective as installing any of the active monitoring devices tested.

DETECTION DOGS. In recent years, bed bug detection dogs have become an increasingly more common method employed by companies to provide detection service. Pfiester et al. (2008) reports specially trained dogs are effective in detecting bed bugs in controlled environments. However, there are no field data documenting the reliability of dog detection in real world field settings.

During June-July 2011, we evaluated the effectiveness of seven canine detection firms in detecting bed bugs in apartments. The purpose was to evaluate the accuracy of trained dogs in identifying bed bug infestations. The companies selected were experienced firms that have been providing canine scent



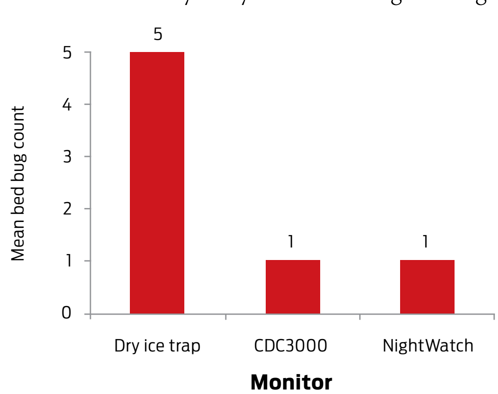


Figure 2. Effectiveness of three bed bug monitors in detecting bed bugs in apartments with heavy infestation (left) and light infestation (right).

detection services for at least one year. Five of the seven firms had been providing commercial services for three or more years, the other two firms have been in business between one and two years. Each of the firms boasted advertising claims of 90 percent or greater accuracy.

We asked each firm to inspect 24 apartments. The apartments were either studio or one-bedroom units occupied by seniors. The canine scent firms charged between $500 and $1,000 to inspect 24 apartments. Time to complete the inspection ranged from one hour and 40 minutes to four hours and 10 minutes. The average time to complete the inspection was 2.5 hours. None of the firms were aware that their inspection results were being evaluated.

Forty-eight apartments were selected from three high-rise apartment buildings. These apartments were known to have live bed bugs, had bed bugs previously that were believed to have been eliminated, or never had bed bugs based on historical data and monitoring of the units prior to the dog inspections. The apartments were divided into two similar groups (24 apartments per group). Group I had 12 known infestations. Group II had nine known infestations. Four dog teams inspected group I. Three dog teams inspected group II. The inspections were completed within a four-day period.

Each apartment was inspected by three or four different canine detection firms. The detection rate (an infested apartment that was correctly alerted during inspection) by dogs ranged from 11-83%, with an average of 43%. The false positive rate (alerted by dogs but no bed bugs were found in the apartments by visual inspection and/or ClimbUp interceptors) ranged from 0-38%. The two companies that charged the most ($1,000) and had been in business for more than three years had very low detection rates (25% and 30%). False alerts were also high for the same two companies. Interestingly, we found the accuracy of the canine detection was not related with the level of bed bug infestations. Three apartments with large number of bed bugs were not alerted by all dog teams which serviced the apartments.

Prior to the dog inspections, an average of 15 ClimbUp interceptors were installed in 62 apartments for 14 days. Bed bug activity was confirmed in 18 apartments. The number of bugs in the 18 infested apartments, based on ClimbUp interceptors (14-day installation period), ranged from 1 to 73 bugs with a median count of 6.5 bugs per apartment. An additional three apartments where dogs alerted were subsequently confirmed as having bed bug activity. Two out of three additional units where dogs alerted were identified during the 14 day post monitoring period, with ClimbUps bringing the total detection rate of ClimbUps to 95% (20 out of 21 infestations). One infested apartment was not identified by ClimbUp interceptors, but was confirmed by thorough visual inspection (only one bug was found).

These results highlight the great degree of variability between detection firms and the need for rigorous ongoing testing and evaluation of dogs using scientifically proven methods. More research is needed to investigate the factors affecting the performance of canine detection and establish standard methods to evaluate the reliability of canine detection services. The current performance of trained dogs as revealed from this study is far from being satisfactory.

Despite these results, if properly trained and maintained, canine detection is helpful for conducting large-scale inspections where other methods are not practical (e.g. entire hotels, college dorms) or in non-traditional settings, such as office buildings, movie theaters, retail stores, etc., where speed and efficiency is required.

SELECTING AND USING MONITORS.

There are a number of factors that go into deciding which monitoring method(s) are the most appropriate for a given situation. Some of the major factors to consider are:

1. Cost and scope of area to be monitored. All of the monitoring devices available have the ability to work at short range (attract bugs within several meters) or capture bugs by random chance. Thus, at least one active monitor or multiple passive monitors are necessary to monitor a small area (e.g., single bedroom). Currently, active monitors vary in cost from about $50 to $600 plus supplies required for ongoing maintenance. Passive monitors range from under $1 to $30 each. Canine scent detection can run from several hundred dollars to thousands of dollars depending upon the scope of the area to be inspected. Cost can become a major factor when determining what device/method is most appropriate. For example, active monitors can be deployed effectively to monitor several hotel guest rooms but not the entire hotel. Likewise, several suspected work cubicles can be monitored but monitoring of an entire office building would likely be cost prohibitive. Canine scent detection, using a high-quality firm, is the only economically viable method at the current time for conducting large-scale inspections, particularly when the areas are not traditional residential settings and can be used to narrow down the focus to a few areas of specific concern which can be further monitored using either active or passive monitors, or a combination of the two types.

2. Is electricity readily available in areas to be monitored? Many of the active monitors require electricity, which can be a limiting factor or may require running extension cords for proper placement of the monitors.

3. Can the detection method be carried out over a period of time (days) or does it need to occur over a period of 24 hours or less? Most of the passive monitors are designed to detect bed bugs over a period of time (days, weeks, even months). Other monitors like the ClimbUp Interceptors, NightWatch and Bed Bug Beacon are designed to detect bed bugs over several days to a week. Bed bug sniffing dogs, on the other hand, provide immediate results.

4. Are the aesthetics or visibility of the monitoring effort a concern? There is great variability in the size, and professional look among the detection tools currently available.

5. Is the area to be monitored occupied or vacant? Passive monitors are best suited for use in occupied areas to intercept bed bugs as they forage for a blood meal, but may not be as reliable in vacant dwellings where no host is present (additional research needs to be done to evaluate this). Active monitors on the other hand attempt to mimic a host and thus may provide better results for vacant areas. Dog detection should be equally effective in both occupied and unoccupied dwellings and often requires occupants to leave the room during the inspection.

6. Is the monitoring effort a one-time

event or ongoing? Some monitoring methods may be cost effective for one-time monitoring but not for ongoing monitoring efforts. The ongoing maintenance costs associated with different tools and methods needs to be considered.

7. How critical are the results? Are the monitors simply an aid to help identify a problem or is the goal to have the highest degree of effectiveness to detect a low-level bed bug infestation? Inexpensive passive monitors can be incorporated into long-term monitoring programs in hotels or other settings where housekeeping or maintenance personnel are trained to inspect the devices regularly. The reliability of these types of devices, however, is unclear at the present time. Additionally, because no one monitor is completely reliable, multiple methods, including visual inspection, is always recommended to aid the detection of few bed bugs present.

DISCUSSIONS. Deploying bed bug monitors can help detect bed bugs and evaluate treatment results, reduce labor cost associated with inspections and improve bed bug elimination result by early detection of bed bugs.

We hypothesize that using monitors also may reduce the need for pesticide use in situations where bed bugs are detected very early on before newly introduced bugs have an opportunity to become established. In apartments with only a few bed bugs, using a combination of monitors and non-chemical treatments may be sufficient to eliminate the few bugs present in a room, thus avoiding or minimizing the use of chemicals.

It remains unclear what percentage of bed bugs are responding to bed bug monitors each night and whether trapping alone can trap out the bed bugs in an environment within a short period of time. Understanding bed bug behavior and ecology and developing more effective monitors will be valuable for future bed bug management.

Canine scent detection is most well suited for large-scale inspections that cannot be monitored or visually inspected in a cost-effective manner. Canine scent detection is also well suited for inspecting complex environments where visual inspection is unlikely to be effective. However, variability in the accuracy of canine scent detection is great among canine scent firms. Additional studies are necessary to gain a better understanding of the factors that influence the accuracy of an inspection and to provide guidance for maintaining a quality canine scent program.

SUMMARY. Bed bug monitors are valuable tools in bed bug management. ClimbUp Insect Interceptor and dry ice trap and NightWatch are the most effective monitors known at the present time. Dry ice traps are not commercially available and their use should be limited to areas not likely to be tampered by pets or young children to avoid possible injury from dry ice. Properly trained dogs have the potential to identify low-level bed bug infestations, but overall their reliability is low based on field results in this study. Their accuracy needs to be evaluated periodically in a scientifically proven method.

Very low level bed bug infestations can be detected by increasing the number of trapping days using ClimbUp Insect Interceptors. To date, no single monitoring tool or method provides 100 percent accuracy. A combination of visual inspection and other monitoring tools/methods will provide the best evaluation on bed bug infestation level and distribution.

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