

Identification and Management of Bed Bug Infestations in Austere Environments

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Abstract

Military forces have missions that send them all over the globe. With the reemergence of bed bugs worldwide, the possibility of service members encountering them has increased. Special Operations Forces are often sent to locations that may not have Integrated Pest Management (IPM) support. Knowing how to identify and manage a bed bug infestation, with and without proper equipment and supplies, may become necessary in the very near future. It is also important that service members are aware of how bed bugs travel, to prevent their dispersal back to the United States, and into their barracks and homes.

Introduction

The common bed bug (*Cimex lectularius*), the tropical bed bug [*Cimex hemipterus* (Fab.)] (Family: *Cimicidae*) are reemerging worldwide in homes, hotels, barracks and on public transportation after nearly 70 years of relative inactivity. Their rapid disappearance after WWII was due primarily to use of large amounts of pesticides such as DDT (dichlorodiphenyltrichloroethane), organophosphates, and other residual chemical pesticides. Many of these pesticides and their derivatives were banned in the 1970's. Since the 1990's, bed bugs have been reemerging across the globe, especially in developed countries (1). With infestations becoming more frequent, service members and other traveling professionals will likely encounter a bed bug infestation at some point. In those circumstances it is necessary to understand what the threats related to bed bugs are, and how to best manage infestations, sometimes with limited resources or support.

Bed Bug Description

Adult bed bugs are approximately the size of a small apple seed (approx. 3/16" long) (Figure 1). They are brown in color, turning reddish after a blood meal, dorsoventrally flattened (flattened similar to a tick), with six legs and two antennae. Bed bugs lack fully developed wings and cannot jump, but can crawl quickly. Bed bug eggs are white and opaque, and nymphs are lighter in color or clear resembling sesame seeds. All life stages can be observed with the naked eye. Bed bugs have a piercing, sucking mouth parts, composed of a bundle of six stylets that penetrate a host's skin, held together within a sheath, and collectively called a proboscis when not feeding, which can be tucked away underneath the head of the insect. All Hemiptera have a proboscis, however only a few (such as bed bugs and kissing bugs [Family: *Reduviidae*]) are hematophagous (feed on blood). Viewed with the naked eye, bed bugs may resemble ticks, small cockroaches, carpet beetles, or other small crawling insects. (Figure 2) Bed bug infestations sometimes have a distinct odor, often called a "buggy odor" when large numbers are present or the infestation has been present for a long time (9). This odor has also been described as "musty", "stale", or "sweet". This odor has been attributed to the insects' scent glands, and has been associated with "alarm" chemicals (1).



Figure 1: Bed bug on top of a common apple seed. Photo credited to John Obermeyer, Purdue Extension Entomology.



Figure 2: Adult Bed bug. Photo credited to John Obermeyer, Purdue Extension Entomology

Life Cycle

These nocturnal insects have seven different life stages, which include the eggs, five immature instars (juvenile or nymph stages) and the adult stage. (Figure 3) The nymphs need to consume blood (a blood meal), to molt to the next instar. In favorable conditions, a bed bug egg can develop into an adult in as little as 30 days. (5) The time between blood meals can be as few as three days, to as long as a year. Adults can often live from six to 24 months and they have been observed to be able to live over a year without a blood meal. The adult female may lay 200-500 eggs in her lifespan, assuming she survives long enough. Bed bug mating involves a behavior called traumatic insemination. The male bed bug inserts his reproductive organ in to the special in-folded groove in the ventral surface on the bottom of the right side of the females' body. The sperm thus bypasses the females' external genitalia and travels through the hemocoel (the body cavity that contains the insect's version of blood) directly to the ovaries of the female's primary reproductive tract. Often, a female is

mated several times and can die from being repeatedly stabbed (especially if that occurs outside of her special ventral groove) or contracting an infection from having an open wound. After a typical mating, a female can usually continue to lay eggs for 14-20 days. (9)

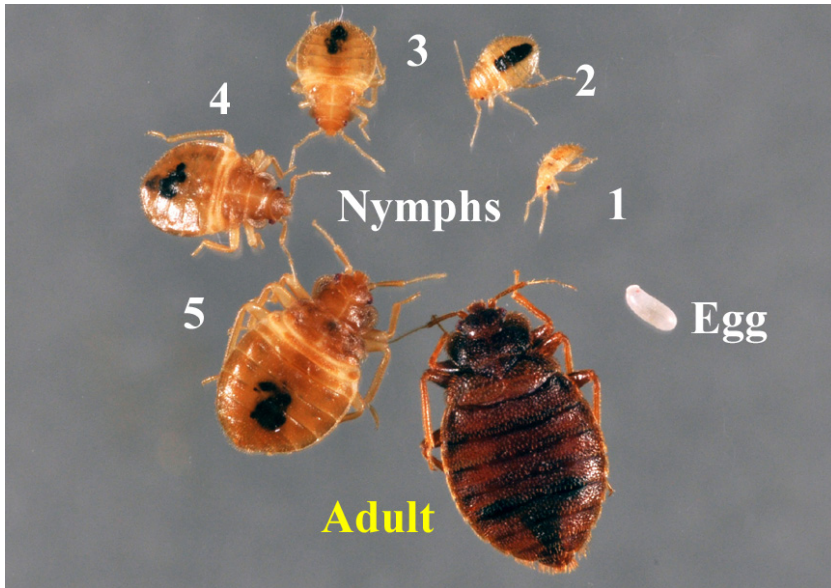


Figure 3: Bed bug life cycle. Photo credited to John Obermeyer, Purdue Extension Entomology

Bed Bug Bites

The common bed bug bites primarily at night. Bed bugs can feed off of humans, or animals. The saliva of these insects contains an anesthetic compound, so the bite is usually painless. Bites may sometimes appear to occur in linear patterns. If aggressively physically disturbed during a feeding attempt, some bed bugs may move a short distance and then bite again. Bites are often not recognized until long after the bite occurs. Bites can become evident in hours, or first appear more than two weeks later. The typical bed bug bite is an erythematous pruritic raised bump, similar in size and appearance to a mosquito bite, and may appear as a maculopapule (7, 10). The reaction to these bites can differ depending on the sensitivity of the individual being bitten. These bites most often occur on unclothed areas. It is possible to have no reaction to bed bug bites, to suffer from prophylactic shock from an allergic reaction, and possibly any given reaction in between. Bed bugs have not been proven to be competent vectors for any human disease pathogen at this time. Bed bugs have been tested and confirmed to have occurring in them under natural conditions a large number of different human pathogens, but they have not been proven to be able to transmit these agents to a human (10). Secondary infection due to scratching, and psychological effects are also reported possible side effects of bed bug bites. Humans experiencing frequent bed bug bites can appear to be nervous or “jumpy” with agitation due to lack of sleep (1). Once an individual learns of a bed bug infestation, even if the infestation is not in their building or sleeping area, they may imagine that they “feel” bugs while lying in bed. (Figure 4 and Figure 5)



Figure 4: Bed bug bite on white male. Photo credited to John Obermeyer, Purdue Extension Entomology



Figure 5: Multiple "older bites" on black male. Photo credited to John Obermeyer, Purdue Extension Entomology

Bat Bugs

Bat bugs, swallow bugs, and a few other bird-feeding bugs (Family: *Cimicidae*) are “cousins” of the common and tropical bed bugs, and several of those species will opportunistically feed on humans when sufficiently hungry. It has been speculated that the bed bug and the bat bugs began evolving separately when humans lived in caves. As humans then began to live in tents and huts they carried some populations of these insects along with them (1). Bat bugs are difficult to distinguish from bed bugs by the naked eye, and only trained individuals can quickly differentiate between them under a microscope (at least 10X magnification is usually needed). The primary readily visible difference between the two is the length of the hairs located on the upper front corners of the pronotum next to the insects' heads. Bat bugs are mainly

associated with bats, though they will feed on humans when hungry. Bat bugs are more likely to be located along the wall close to the ceiling, than closer to the floor. If you find an insect resembling a bed bug, search for bats or nests in the ceiling, roof, or attic. Treatment strategies and techniques for bat bugs or bird-feeding Cimicid bugs, after checking for the roosting bats and/or bird nests is essentially the same as that for bed bugs.

Effects in the United States

The United States has experienced this resurgence of bed bugs in all 50 states. The national cost of bed bug pest control, research, hospital visits, and other economic effects since their reappearance is not currently known. The reason for their resurgence has been attributed to an increase in world travel, pesticide resistance, bans on certain pesticides and immigration. In New York alone, the number of reported bed bug infestations increased by a factor of 20 between 2004 and 2009, rising from 500 to 10,000 (2).

Bed bugs and the Military

The military has a long history of bed bug infestation. Photographs document soldiers reacting to bed bug infestations at Fort Lee (Camp Lee at the time) and educational posters from the 1940s explain how to detect bed bugs. Bed bugs were often found on mattresses, web gear, bed springs, and especially on soldiers' gas masks (3). More recently, bed bugs have been detected at several U.S. Military installations, including Camp Lejeune NC in 2010 (4). The detection of bed bugs in a military setting is both annoying and stressful for service members. Service members will likely have a difficult time sleeping well expecting the presence of insects (1). A bed bug bite is usually painless, with the bite site later growing irritated and pruritic. The stress involved with bed bugs is usually associated with not knowing how to deal with these insects, the time and energy required for their eradication, or the idea of spreading these insects to the residences of friends and family. This stress accompanied with the possible lack of sleep could be detrimental to duty performance and daily living. (Figure 6 and Figure 7)

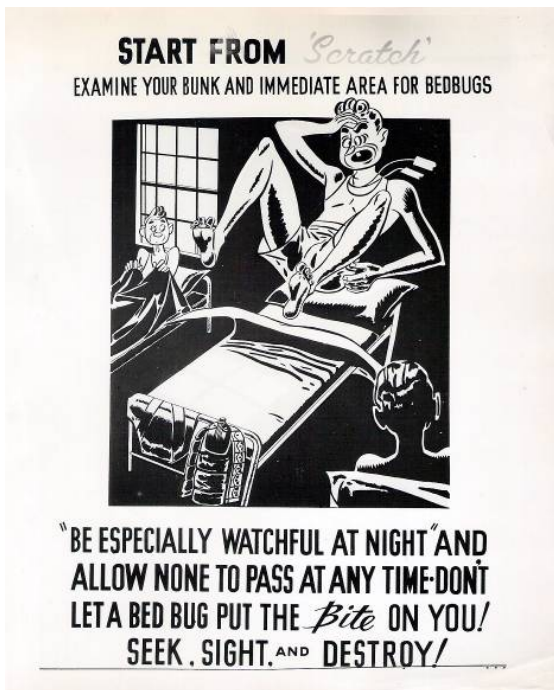


Figure 6: Bed bug poster from the 1940's. Photos courtesy of The Armed Forces Pest Management Board "Evolution of Military Medical Entomology", Eugene J. Gerberg, COL (Ret.)



Figure 7: Method of Detection poster from the 1940's. Photo courtesy of The Armed Forces Pest Management Board "Evolution of Military Medical Entomology", Eugene J. Gerberg, COL (Ret.)

Deployments and TDY (Temporary Duty Travel)

International travel has been cited as one of the reasons for the increasing bed bug problem over the last decade. For service members, travel is often a required element of the service members' missions. Service members may also spend a great deal of time living in hotels, both in the contiguous United States (CONUS) and outside the contiguous United States (OCONUS), which increases the possibility of bringing bed bugs into their homes or barracks. The most common way bed bugs are transferred from one location to another by travelers is luggage transportation. Bed bugs can also be transferred on clothes or shoes.

Prior to traveling, it may be possible to investigate the intended destination on the internet, to find any reports of bed bug infestations. As a precaution, inspect your assigned room for signs of bed bugs. These areas include the mattress, box spring, headboard, furniture, and side tables. Refrain from laying your luggage and clothes on the bed or the floor if at all possible. Many hotels provide luggage stands which you can use to hang up clothes immediately. Dirty laundry can be kept sealed in a plastic bag to prevent bed bugs from infesting clean clothes when you pack for your return home. When you do return from your trip, wash and dry all of your clothes using hot water, and inspect all crevices and seams of your luggage for bed bugs or bed bug eggs. These tasks may seem excessive, but if you have any reason to believe there are bed bugs in your temporary living conditions, these precautions are necessary to prevent spreading the infestation. (Figure 8))



Figure 8: "Rust stains" on mattress. Photo credited to John Obermeyer, Purdue Extension Entomology

Infestation Identification

If you suspect a bed bug infestation, the first step toward eradicating these insects is to determine that they are in fact bed bugs. One of the most helpful ways to make this determination is to visually identify actual bed bugs. Bed bugs can be located on the floor, along the seams of the mattress, along the bed spring, in the springs of military style beds, in a sleeping bag, along the walls and side boards, in curtains, and any number of crevices and cracks near the sleeping area. Bed bugs have flattened bodies enabling them to slip into very small areas. This includes under light switch covers, along molding, and in cracks in the walls. If you can slip your ID card or a credit card into any crevice, a bed bug can hide there.

If you do find a bug during your search, it is helpful to preserve it for later identification. Placing the insect in a plastic zip-lock bag or other seal-able container and then placing it in the freezer, will prevent the insect from escaping, as well as kill it. In a CONUS environment, this measure is particularly important as the Pest Management Professional (PMP) will likely be able to identify the insect. OCONUS, you may or may not have access to a trained PMP. The Army, Navy and Air Force each have professional entomologists, Preventive Medicine personnel, and other resources that may be deployed with you. It may also be possible to mail the insect to them for positive identification. In most instances, it is not illegal to send a dead insect through the mail, however, check your local regulations. Please make sure the insect is dead, but understand that smashed insects may not be able to be identified. Another way to identify a bed bug infestation is by “rust stains” on and under the mattress and sheets. Bed bug feces are reddish brown or black in color, and are excreted after a blood meal. These small, rust colored stains are indicative of bed bug activity. Near these rust stains you may also find very small bed bug eggs, or actual bed bugs. (Figure 10 and Figure 11)



Figure 9: "Rust stains" from a serious infestation of bed bugs. Photos credited to John Obermeyer, Purdue Extension Entomology



Figure 10: Bed bugs, excrement, and eggs on the back of a cabinet. Photo credited to John Obermeyer, Purdue Extension Entomology

CONUS Infestations

In the event of a bed bug infestation in the United States, it is important to report this information to the person in charge of your quarters. Post housing and barracks will have a SOP regarding the treatment of bed bugs. If you are in a hotel, it is important to inform the management, so they can deal with the situation, assign you a different room, or issue a refund. In the event that the home you own is infested, you may face a long and expensive procedure to eliminate bed bugs from your residence. Currently, there are several different ways to eliminate bed bugs from a residence. These include the use of pesticides, heat, bed bug sniffing dogs to locate infestations, and products like mattress covers. Pesticide use is difficult because bed bugs can have resistance. Heaters can be placed in your home to raise the temperature enough to kill bed bugs. A temperature of 120 degrees Fahrenheit for >20 minutes will kill bed bugs (6). However, when washing clothes to kill bed bugs, a water temperature of >140 degrees Fahrenheit has been shown to kill all bed bugs (6). The cost of hiring an exterminator can run from \$1,000 to over \$5,000 to remove bed bugs from a residence (7).

OCONUS Infestations

Outside of the United States, whether on TDY or deployment, bed bug infestations are more difficult to manage for reasons that may include a lack of qualified PMPs, the less than ideal sleeping conditions, an inability to obtain Pest Management equipment, and an inability to dedicate large amounts of time to the situation. However, it is essential for the emotional and psychological well-being of the service members, that bed bug infestations are limited. It is important to remember that bed bugs are easy to kill. Unlike ticks, bed bugs squish easily. After you have collected your first intact specimen, there is no reason you cannot crush every bed bug you see after that point. In the event of positive identification, several steps must be taken to protect the unit and the service members from these insects. Remove clutter and tidy up the living area. Trash or items for disposal should be placed in a plastic bag and sealed before discarding. Clothes and other equipment that can be washed in a machine should be washed in water that is at least 140 degrees F, then dried on the hottest setting for >30 minutes. This includes bedding. Areas that may contain bed bugs must be sealed with caulk, tape, putty, or any other method available to you. Include cracks in walls and seams along the wall, along the base boards, and along the joints in wood. Pay particular attention to areas near and around the bed. Vacuuming is an effective way to eliminate large numbers of bed bugs, but a HEPA filter is recommended. After vacuuming bed bugs, it is important to discard the contents of the vacuum in a sealed plastic bag. The vacuum should then have all removable parts (including the hose and non-mechanical parts) sterilized in hot water. (6) Steam cleaners can be used, if used correctly, to heat the bugs and eggs found on bedding or furniture to a lethal temperature. Tape can also be used to remove bed bugs and bed bug eggs from almost any location. It may be possible to use solar heating to kill bed bugs, by placing your infested items in a sealed black plastic bag and exposing it to the sun. This treatment does not work with large items such as mattresses, and it is not recommended for 100% dis-infestation (8). It is also possible to place smaller items in a plastic bag, and then place them in a freezer. Freezing takes longer than killing with heat and could take several hours to several days to completely kill all the bed bugs and eggs. Mattress covers that completely contain the mattress are recommended to help prevent the mattress from becoming a potential regular resting or harborage site, as well as to impede any surviving bed bugs from escaping the mattress. Bed bugs are not capable of escaping through sealed plastic. The mattress cover should be kept in place for a minimum of six months to a year, as bed bugs have been able to live longer than a year without feeding. The bed should be moved away from the walls, and bedding and blankets should not touch the ground or other furniture item. The posts for the bed can be placed in a passive bed bug trap (a plastic dual walled dish filled with water to contain bed bugs), or in a small plastic container placed in a larger plastic container filled with a small amount of water. (Figure 11) Diatomaceous Earth (D.E.), the powdered form of a sedimentary rock derived from fossilized diatoms, can also be used to kill bed bugs. D.E., a powder of mostly silica, is most useful in dry conditions. When bed bugs walk through this powder, the powder enters

between the joints and the chitinous exoskeleton. The D.E. abrades and cuts through the exoskeleton, much like glass would cut our skin if we walked over it. Insects have a very high sensitivity to fluid loss, and a decreased ability to coagulate and heal. The insect dies over several days, dehydrated. Although this is not a quick method to kill bed bugs, it is effective. This product should be placed along the bed boards, around the bed posts, and in locations bed bugs have been identified or suspected. After two to three days, the D.E. should be vacuumed from anywhere that it could come in contact with humans. D.E. should be treated as a pesticide even though it is non-toxic. D.E. can be harmful to the lungs if inhaled, can irritate the skin, and should not make contact with the eyes. Gloves, mask, and eye-pro should be worn when treating an indoor living environment with D.E. Pesticides have a limited effect on bed bugs depending on their application, the bed bugs resistance, and the amount applied. Sprays that kill other insects will likely also kill bed bugs if applied directly to the insect. Residual pesticides placed in locations the insect may walk over are less effective. It is critical that re-inspection of infested location occur two to three weeks after the initial treatments. This step will indicate the effectiveness of your treatments, and whether further treatment needs to occur.



Figure 11: This is one example of a commercially available bed bug trap. Photo credited to John Obermeyer, Purdue Extension Entomology

The most important aspect of bed bug management is determination. A motivated and single-minded approach to bed bug destruction will offer the best results. Often complacency and neglect result in large infestations, such as those found in less developed countries, or in lower income housing. However it is important to note that anyone can be the victim of a bed bug infestation, and any correlation between bed bugs and personal cleanliness is unfounded.

Conclusion

Bed bug infestations were extremely common at one point in our history and are becoming more common every year. Understanding the life cycle, preventative measure, and treatments, and being able to identify infestations are not common skill sets. There are several measures that can be taken with little or no equipment to manage a bed bug infestation. It is time consuming and can be tedious, but bed bugs are not invincible and can be eliminated with extreme determination, thoroughness, and attention to detail, by a willing and informed individual.

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