

AN OVERVIEW OF BED BUG (HEMIPTERA: CIMICIDAE) TREATMENT IN THE UNITED STATES: USING SCIENCE TO CREATE PROGRESSIVE PROTOCOLS

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Abstract For the past 15 years bed bugs, *Cimex lectularius*, have been aggressively spreading across the United States and pushed professionals to create bed bug treatment protocols with voids in basic research on many control options. The first response to this problem was to use pesticides as the backbone to a bed bug treatment protocol but research quickly detected high levels of resistance within field populations, which forced professionals to evaluate non-chemical options to assist in the control of this pest. Due to the speed at which bed bugs have spread, as well as the resistance issues they present, both academia and the pest control industry has been forced to find alternatives on how to slow their spread and control them properly. This session will look at the past 15 years of bed bug control in the United States and review the history of treatment protocols during that time. Using research conducted over the past decade, different options to control bed bugs will be evaluated. Some treatment tools that will be covered include pesticides, bed encasements, monitors, steamers, amongst others and the value each provide to efficiently and effectively control bed bugs will be discussed.

Key words Bed bugs, preparation, clutter, pesticides, resistance, monitors.

INTRODUCTION

Bed bugs have been a pest of human beings since they transitioned from hunter gatherers living in caves to more stable living environments such as farming communities and more traditional residential settings. They have been noted in North America since European settlers and explorers first landed there in the 1600's but have been documented living with humans in Greece as early as 400 BC (Usinger, 1966; Potter, 2011; Koganemaru and Miller, 2013). Bed bugs continued to spread and infest homes throughout the world until shortly after World War II when residual pesticides such as DDT were introduced to the commercial marketplace. These pesticides were both easy to apply and had strong residual properties, where they would remain active within households for months or years after application. This provided simple and affordable bed bug control for many developed communities across the world and drove bed bugs from a significant pest within homes to a mythic monster that was the subject of fairy-tales and nursery rhymes often told to children as the fell asleep within their beds (Usinger, 1966; Cooper, 2011). Within the past 20 years, an increase in the presence of bed bugs has been noted worldwide. In addition to infesting traditional residential settings, bed bugs have been noted in commercial environments such as offices, schools, hospitals, public transportation, movie theaters, amongst others (Potter, 2006; Potter et al., 2015). Along with an increase in the presence of bed bugs, a high-level of synthetic pyrethroid resistance has been noted in bed bug infestations, which has presented significant challenges to pest control professionals as they have developed protocols to eliminate this pest (Davies et al., 2012; Dang et al., 2013). Resistance to pyrethroids have forced pest management

professionals to search for other methods to assist in the control of bed bugs. Such methods that have been evaluated and adopted by professionals include but are not limited to: bed encasements, vacuums, steam/non-chemical tools for contact kill and monitors (Pinto et al., 2007; NPMA, 2011; Doggett, 2013). The following will review the past 15-20 years of bed bug management in the United States and discuss currently accepted control practices for bed bugs as well as effective and efficient service protocols for the elimination of infestations.

RESISTANCE TO PESTICIDES: USING LIQUID RESIDUALS AS A LAST RESORT

As mentioned above, pesticide resistance has been noted at high-levels within bed bug infestations collected from the field. One study found that 88% of bed bug populations collected from across the United States tested positive for target-site mutations, which suggests probable pyrethroid resistance (Zhu et al, 2010). Another study found that bed bugs collected from an infestation in Virginia were more than 300-times less susceptible to certain synthetic pyrethroids compared to a laboratory strain collected more than 30 years ago (Moore and Miller, 2009). These two studies, amongst many others, illustrate significant and widespread resistance to pyrethroids in the United States. Although widespread resistance had been found in field infestations across the United State, liquid residual pesticides remain one of the most popular choices for bed bug control amongst pest management professionals, being used by 99% of pest management professionals (Potter et al, 2015). Some studies have demonstrated positive effects from certain synthetic pyrethroid products, especially those that have unique formulations that have proven to be effective against bed bugs (Romero et al, 2009). In addition, studies have found that products containing neonicotinoids may demonstrate a high-rate of contact kill along with some residual effect when applied on certain substrates (Potter et al., 2012). These studies suggest that using a liquid residual may provide some value as part of a bed bug control protocol but due to the resistance noted in field infestations they should not alone be relied upon to control infestations and the residual effect on bed bugs should be questioned.

DUST PESTICIDE: CRACKS AND CREVICES

Bed bugs have long been noted to hide in cracks and crevices to avoid detection and provide safe harborage (Usinger, 1966). Due to this behavior, dust pesticides to treat cracks and crevices and occasionally applied in more accessible areas (according to label directions) may be one of the most effective options for bed bug control. Through the last 15 years pest management professionals in the United States have had moderate to high level of success using a wide variety of dusts to treat crack and crevices for bed bugs. The biggest issue associated with dust pesticides have not been the effectiveness but instead have been complications with application equipment and that equipment not creating a misapplication “cloud” at the point of treatment. Dusts that are considered low-impact to the environment that use silica or diatomaceous earth as the active ingredient have been demonstrated to be effective for treating cracks and crevices. Also, dusts that contain active ingredients such as deltamethrin or cyfluthrin (amongst others) have been shown to have a positive effect on bed bugs (Wang et al, 2013; Potter et al., 2014). Dust pesticides should be used to treat all cracks and crevices where bed bugs are thought to be hiding. Once most dusts have been applied to a crack or crevice they will remain active for several weeks or months after application. This extended efficacy of treatment seals and prevents many cracks and crevices from being infested in the future as well as placing bed bugs still infesting the home under additional stress. Treating cracks and crevices with dust also shortens the length of future follow-up services since most cracks do not need to be treated more than once.

MATTRESSES AND BOX SPRINGS: TREATING BEDS

Mattresses, and particularly box springs, have proven to be one of the most significant areas to be treated in a bed bug infestation, as well as one of the most challenging (Cooper, 2011). Before the introduction of bed encasements around 2006, most pest management professionals were using pesticides to treat both the mattress and box spring. Due to the limitless amounts of hiding places often found inside box springs, encasements have been widely accepted by the pest control industry as an appropriate method to treat both mattresses and box springs. Surveys have found that up to 84% of pest management professionals use encasements to assist in the treatment of infested bedding (Potter et al., 2015). In addition to assisting with the treatment of hiding places associated with mattress and box springs, encasements also provide value to pest management professionals by shortening follow-up services, easing the detection of bed bugs, protecting new bedding, salvaging old bedding, as well as many other benefits. Other methods to treat bedding include laundering items in a hot dry cycle, vacuums, and non-chemical contact kill tools such as steamers, as well as pesticide impregnated bedding covers. The frequency with which these tools are used often differs by pest control companies as well as the extent of the infestation. Dryers, vacuums and non-chemical contact kill tools are often used to kill and remove bed bugs from infested bedding as well as those hiding on and within the bed itself (Pinto et al., 2007; NPMA, 2011; Doggett, 2013). The value pesticide impregnated bedding covers provide to a bed bug management protocol have been debated over the past 15 years but research in the last 5 years conducted at several universities have suggested that the covers may have more value than first thought (Jones et al., 2015; Kells and Hymel, 2016). While research has suggested that the liners may have more impact than first thought, pesticide impregnated covers are still only being used by about 9% of the pest control industry compared with 84% which use bed encasements (Potter et al., 2015).

KILLING BED BUGS ON CONTACT: VACUUMS, STEAMERS, AND OTHERS

Due to the high-levels of pesticide resistance noted in field infestations, professionals have adopted several different tools to kill bed bugs on contact. Vacuums are one method that pest management professionals are using to remove bed bugs that are visible on the surfaces of furniture. Vacuums are being used by approximately 62% of pest management professionals when treating for bed bugs. Another tool often used to kill bed bugs on contact is steamers. Steamers often generate temperatures in excess of 180°F (82°C), which will kill bed bugs and their eggs on contact. Steam also penetrates pleats and folds within upholstered furniture where bed bugs are often hiding. These pleats and folds are often difficult to remove bed bugs from as they are often small and tight, and vacuums and other control tools fail to access the bugs hiding within them. Steamers will penetrate through several millimeters of fabric killing any bed bugs or eggs contained within them (Pinto et al., 2007; NPMA, 2011; Doggett, 2013).

Other tools that are being used to kill bed bugs on contact include flash-freeze technology such as Cryonite, all-natural sprays and hot dry cycles. While the value and consistency of flash-freeze technology has been debated in several forums, one study did claim to successfully treat a homeless shelter for bed bugs within two treatments (Brown and Laughlin, 2012). The efficacy of all-natural sprays have been heavily debated for the past 10 years with many being found to be completely ineffective for bed bug control. A study at Rutgers University did find that while several were ineffective for bed bug control there are a few all-natural sprays available that did kill close to 100% of bed bugs treated within 10 days of application (Singh et al., 2013). Lastly, bed bugs and their eggs will be sufficiently killed by a hot dry cycle and has proven to be a great option for the treatment of items that can be laundered (Naylor and Boase, 2010).

BED BUG MONITORS: CAN THEY ASSIST IN TREATMENT?

While monitors have long been thought of as devices used to detect the presence of bed bugs, since 2007 several have been evaluated as part of a bed bug treatment protocol. The value monitors may provide within a treatment protocol include: reducing the number of bed bugs infesting the home by capturing bugs between services, providing additional information on where bed bugs may be infesting by using where bugs were captured to suggest the direction they may be originating from and reducing the stress placed on residents sleeping within the bed as well as the number of bites received by capturing bed bugs as they search for hosts. This additional information providing by monitors installed during service can reduce both the time and expense associated with eliminating the infestation (Pinto et al., 2007; Koganemaru and Miller, 2013).

Several monitors have been evaluated over the past 10 years with the majority of published research focusing on interception devices. Interception devices are pitfall traps that capture bed bugs as they move around an environment. Research has indicated that interception devices can be effective at reducing populations of bed bugs as well as detecting movement of bed bugs from one location to another (Cooper et al, 2015b; Cooper et al., 2015c; Wang et al., 2011). The conclusion of these studies is that interception devices can provide great value as part of a bed bug treatment protocol in addition to their ability to detect infestations. Beyond interception devices, glueboards and other bed bug monitors have been evaluated for both their ability to detect bed bug infestations as well as their ability to capture bugs (Boase et al., 2012; Vaidyanathan and Feldlaufer, 2013). The effectiveness of these products can vary greatly and published research, cost and operational time should be considered when an individual product is considered for use within a bed bug treatment protocol.

CLUTTER AND BED BUG PREPARATION FOR SERVICE

From emptying closets of clothes to stripping beds of bedding, what is often required of residents to prepare their home for bed bug treatment has been a heated topic within the pest control industry for the past 15 years. When the bed bug resurgence began most pest management professionals were recommending clients strip their beds of bedding, move furniture away from walls, empty closets and dressers of furniture and launder those items, amongst many others. Getting residents to cooperate with bed bug prep lists is often an uphill battle that many pest control professionals blame for difficult-to-eliminate infestations. These preparations are often provided to every client being treated for bed bugs and one of the more frustrating topics for pest management professionals is “how do we handle clients that don’t prepare the home for bed bug treatment?” In addition to bed bug prep work being a volatile topic amongst pest management professionals, it has also been the source of many arguments between residents, property management and pest control technicians (Pinto et al., 2007). Recent research though has shed light on the topic and suggested that many of these recommendations may not be necessary to solve 95% or more bed bug infestations (Wang et al, 2014; Cooper et al, 2015a). In addition to extensive bed bug preparation lists being unnecessary to control many infestations, there is also concern raised that residents conducting extensive preps may be moving bed bugs around the home and thus complicating treatment moving forward. Many recommendations on bed bug preparation being made now revolve around asking residents to prepare areas where bed bug evidence is noted instead of emptying and moving furniture as a requirement on all services regardless of evidence.

THE FUTURE OF BED BUG MANAGEMENT

Recommendations on bed bug treatment protocols currently revolve around using a multi-faceted approach to address pesticide resistance amongst bed bugs. Both structural heat and fumigation have been identified as methods to eliminate bed bugs in a single treatment but neither has proven to be cost-effective to the majority of the United States and the rest of the World. That being said, research has demonstrated that an integrated approach to bed bug control can be efficient and effective, especially if infestations are detected early-on. Pest management professionals should not be relying on pesticides alone to control infestations and instead should be taking a multi-faceted approach to bed bug management. Over the next decade protocols should continue to become streamlined and thus reduce the cost associated with bed bug management. In addition, research should demonstrate the impact residents and societal structure can have on the spread of bed bugs and how approaches and protocols should differ based upon the clients being treated for bed bugs.

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