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Efficacy of an Essential Oil-Based Pesticide for Controlling Bed Bug Infestations in Apartment Buildings

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Bed bugs are among the most difficult urban pests to manage, and the resurgence of bed bugs in recent years triggered the development of many insecticide products for bed bug control in the US. EPA-registered active ingredients for bed bug control include pyrethrins and pyrethroids, neonicotinoids, inorganic compounds (such as silicate-based diatomaceous earth), chlorfenapyr, the organophosphate DDVP (dichlorvos), the carbamate propoxur, the growth regulator S-hydroprene, alcohol, and neem oil. The majority of bed bug products are based on pyrethroids, but these have limited field efficacy due to widespread resistance in bed bug populations. Besides EPA registered products, dozens of "minimal risk" pesticide products that fall under FIFRA Section 25(b) have become commercially available. These products contain one or more listed natural materials such as citronella oil, clove oil, or the soap salt lauryl sulfate. These products are not subject to efficacy data requirements by EPA.

Pest management firms can use a variety of materials to control bed bugs, but homeowners or renters find a limited number of bed bug control products registered for non-professional use. All of the synthetic consumer products sold in the US are pyrethrins, pyrethroids, or silicate insecticides. Unfortunately, the efficacy of synthetic consumer products labeled for bed bugs is questionable because most field bed bug populations currently exhibit moderate to high levels of resistance to pyrethroids. Although silicate based products have demonstrated excellent efficacy in published laboratory trials, their field efficacy is unknown. The poor efficacy of the available bed bug control products can lead to chronic infestations, frequent treatments, use of off-label products by consumers, or the spread of the infestation into adjoining premises in multiple occupancy dwellings.

Bed bugs commonly hide on beds and upholstered furniture where

applying insecticides creates opportunities for human-insecticide exposure. Therefore, there is strong interest in insecticides that have low health risks to humans and pets. Dozens of 25(b) products have become available in response to the need for safe treatment of bed bug infested furniture, and these are commonly used by consumers suffering bed bug infestations. Despite their popularity, there is only one previous scientific report documenting the efficacy of 25(b) bed bug sprays. In that study, among 11 products tested in direct spray laboratory assays, only EcoRaider and Bed Bug Patrol (clove oil + peppermint oil + sodium lauryl sulfate) caused >90% mortality; the other nine products caused 0%–61% mortality. No field efficacy data on 25(b) products has previously been published.

In this study, our objectives were to determine the effectiveness of EcoRaider spray in naturally infested apartments, and to determine whether EcoRaider alone or in combination with a synthetic insecticide will provide a similar level of control compared with synthetic insecticide alone. Temprid SC, a synthetic insecticide commonly used for bed bugs by pest management professionals, previously shown to be highly effective against this pest, was selected for comparison in this study. The study was conducted in two high-rise apartment buildings located in Irvington, NJ. Most of the apartments were occupied by senior citizens and did not have air conditioners. Bed bugs collected from apartments prior to the study showed low to medium level resistance to pyrethroids.

Bed bug infested apartments were identified using records from the housing staff and verified with insect interceptors under the legs of beds and upholstered furniture. Twenty four apartments with 9–318 bed bugs were selected. Among the 24 selected units, 14 residents used insecticide sprays before our study (13 used pyrethrins/pyrethroids and one used essential oils), seven residents used electronic pest repellers, and seven residents did not use any pest control products. 80% of mattresses and box springs were encased in plastic or fabric. The 24 apartments were divided into groups based on bed bug counts. Apartments in each group were randomly assigned to one of three treatments: EcoRaider alone, Temprid SC alone, or a combination of the two. We asked all residents to stop using insecticides. We did not include an un-treated control because residents would be reluctant to participate in the study if their apartments were left un-treated for an extended period of time. A comprehensive spray treatment was performed in each of the test apartments at 8–10 days after the pre-count was obtained. For all treatment groups, follow-up visits were conducted biweekly during which a visual inspection of beds and upholstered furniture was conducted to guide additional treatments, which were applied only where live bed bugs were found. The amount of pesticide used was not significantly different between treatments.

In all groups, residents were taught how to recognize, prevent, and control bed bugs. Residents were encouraged to reduce clutter and launder bed sheets and clothing frequently. Insect interceptors installed under bed and sofa legs were inspected after the initial treatment. If bed bugs were not found in interceptors, a thorough visual inspection was conducted to confirm bed bug elimination.

The apartments were thoroughly inspected at 12 weeks. There were no significant differences in the initial bed bug counts among treatment groups. The bed bug counts declined in all groups significantly over 4 to 12 weeks. At 12 weeks, the mean bed bug counts were 9.1 (Treatment I = EcoRaider), 5.9 (II = Temprid), and 14.1 (III = Combination). The mean bed bug count reduction in the three treatments was 92.5, 92.9, and 91.7%, respectively.

At 12 weeks, bed bugs could not be found in 5 apartments, evenly divided between treatments. Eighteen (78%) apartments still had bed bugs based on interceptor counts (mean: 11; range: 1–70), although visual inspections only found bed bugs in 50% of the infested apartments. Interviews with residents whose apartments still had bed bugs show that 76% of them did not feel bites or see bed bugs.

We interviewed residents regarding their pesticide use prior to our treatments, and 89% used at least one type of product for bed bug control, most often pyrethroid sprays. Other self-control products included silicon dioxide dust, essential oils, rubbing alcohol, household cleaning sprays, electronic "pest repellers", and pesticides labeled for other pests. Homeowners commonly use insecticides themselves when they find pests at home, but many of

these treatments are ineffective and over-application is common. Especially when applications are made to beds and sofas, or other furniture where residents rest and bed bugs hide, there are major risks of high pesticide exposure to people. Identifying low-risk and effective alternative insecticides will have immediate benefit to consumers.

The active ingredients in EcoRaider are not unique, but the efficacy of other 25(b) products against bed bugs was substantially lower than EcoRaider in our laboratory tests. This may be due to formulation differences, differences in the cedar oil source, or interactions among the active ingredients which might enable the active ingredients to more effectively penetrate the insect cuticles. Further research on the relative toxicity of essential oils and their interactions will be instrumental in developing more effective products.