Efficacy of Commercially Available Ultrasonic Pest Repellent Devices to Affect Behavior of Bed Bugs (Hemiptera: Cimicidae)

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ABSTRACT Little is known about the potential for acoustic communication in bed bugs, *Cimex lectularius* L. (Hemiptera: Cimicidae), or the use of sound as cues in host location, although many hemipterans are known to communicate with sound. Most behavioral research has focused on bed bug pheromones that are used in aggregation and as alarm signals. We investigated the influence of sound as a deterrent and as an attractant, either of which could ultimately be used to monitor and control bed bugs. Female bed bugs were tested in two-choice tests with four different commercially available ultrasonic repellent devices. We found that female bed bugs were equally likely to occur in arenas with or without sound produced by ultrasonic devices. These devices did not repel or attract bed bugs during choice trials. However, more bed bugs preferred the middle corridor between the test (sound) and control (no sound) arenas when the sound devices were played. Bed bugs were also more likely to exit the middle corridor during control trials compared with treatment trials with ultrasonic devices. Our results confirm that commercial devices producing ultrasound are not a promising tool for repelling bed bugs.

KEY WORDS bed bug, ultrasound, management, repellency, *Cimex lectularius*

Effective means of monitoring and controlling bed bugs, *Cimex lectularius* L. (Hemiptera: Cimicidae), have eluded researchers and pest management professionals (but see Anderson et al. 2009; Wang et al. 2009, 2011; Weeks et al. 2011). Many of the current approaches for bed bug control rely on chemical means, primarily pyrethroids (Doggett and Russell 2008), that act as neurotoxicants (Costa et al. 2008). These insecticides may have adverse effects on nontarget species (Wolansky and Harrill 2008), and some have resulted in insecticide-resistant strains of bed bugs (Mallis and Miller 1964, Romero et al. 2007). There remains a need for a nontoxic and economical technology to manage this urban pest, as its presence has increased significantly since the late twentieth century in developed countries such as the United States, Australia, and Britain (Boase 2008).

Bed bugs are known to communicate chemically via pheromones that facilitate aggregation, signal sex and age, and serve as alarm signals (Usinger 1966, Siljander et al. 2007, Ryne 2009, Harraca et al. 2010). Bed bugs release alarm signals when disturbed (Levinson et al. 1974), resulting in increased activity and dispersal (Ryne 2009). These same chemicals also serve as honest signals when released by males and nymphs to avoid harmful mating attempts by adult males (Ryne 2009, Harraca et al. 2010). The exploitation of chemical signals in bed bugs may prove fruitful in monitoring and management efforts (Benoit et al. 2009, Haynes et al. 2010).

Bed bugs do rely on sensory modalities other than chemoreception. Vision is used by bed bugs as males quickly orient toward and mount other bed bugs or similar shapes (Rivnay 1933, also from personal observations of bed bug attraction to similar-sized objects such as small microphones). Bed bugs are also positively thigmotactic (Rivnay 1932, Usinger 1966); this response was confirmed in our preliminary bioassays during which bed bugs preferred locations allowing maximum contact with the substrate. However, little is known of bed bug sensitivity to sound. Other blood-sucking hemipterans, such as female reduviid bugs, are known to produce sound via stridulation that functions to discourage unwanted male mating attempts (Roces and Manrique 1996). Many hemipterans use substrate-borne sound to communicate and function in courtship, mating, and species identification (Virant-Doberlet and Cokl 2004).

Alternative means of controlling urban insect pests, including bed bugs, by using ultrasonic frequencies are available and marketed to the public. However, few of these devices have been demonstrated as being effective in repelling insect pests such as mosquitoes, cockroaches, and ants (Schreck et al. 1984, Koehler et al. 1986, Huang et al. 2002) In fact, some ultrasonic devices aggravated the impact of pests by increasing the biting rates of mosquitoes (Andrade and Cabrini 2010). Despite the lack of evidence for the efficacy of

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