Encasing Mattresses in Black Plastic Will Not Provide Thermal Control of Bed Bugs, *Cimex* spp. (Hemiptera: Cimicidae)

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ABSTRACT The suggestion that bed bug (*Cimex* spp.; Hemiptera: Cimicidae)-infested mattresses wrapped in black plastic and exposed to sunlight will be heated sufficiently to kill the bed bugs was tested. Two types of mattresses were tested: a thin mattress of solid foam rubber and a thick multilayered inner spring mattress. Temperature probes were placed on both upper and lower sides of the mattresses, which were wrapped in black plastic and placed outside on a summer day for >9 h wherein the ambient temperature peaked at 36.5°C. The maximum recorded temperature on the upper (sun-exposed) sides was 85°C for both mattresses, whereas lower side temperatures for the thick mattress never exceeded 35°C, and some areas of the thin mattress failed to exceed 36.5°C. Therefore, with published thermal death points of 40–45°C depending on exposure time, and opportunities for bed bugs to avoid lethal temperatures by retreating from hot zones, this technique seems to be not suitable for bed bug management.

KEY WORDS bed bugs, *Cimex*, black plastic, mattress, control

Currently, the world is in the grip of a bed bug pandemic as indicated by numerous recent reports, involving the bed bug, *Cimex lectularius* L., and the tropical bed bug *Cimex hemipterus* (F.). From the United Kingdom, initial indications of the resurgence were noted when there was annual doubling in the number of bed bug treatments (Boase 2001); later, some parts of London recorded a 10-fold increase in infestations (Boase 2004). Similar observations in the United States have been reported in industry journals and the popular press (Frishman 2000, Lundine 2003, De Marco 2004, McGinnis 2004). For Australia, our laboratory observed a 250% increase in the number of bed bugs submitted for identification during the first 3 yr of the new millennium (Doggett et al. 2004). Local pest control companies noted a similar trend; one Sydney-based company recorded a 700% increase in the number of bed bug treatments over the period from 2001 to April 2004 compared with that from 1997 to 2000 (Doggett et al. 2004), and by 2005 this number had risen to >1,000% (Doggett 2005).

The control of bed bugs has been traditionally achieved through the use of various residual insecticides. Currently, however, there is a limited availability of approved insecticides from different chemical groups and insecticide resistance is well known (Busvine 1958, Myamba et al. 2002, WHO 2006). Because bed bugs commonly infest mattresses, many customers do not want to have their bed or bedding treated with chemicals. Likewise, pest control companies are often reluctant to spray such items for fear of litigation if a customer later develops a reaction to the insecticide. Thus, various nonchemical control methodologies, such as vacuuming (Frishman 2000, Gulmahamad 2002) and steaming (Meek 2003, Wahlberg 2004), are now regularly used for bed bug management.

An often promoted method of control is that infested large items (particularly mattresses) should be wrapped in black plastic and placed on the ground outside in the sun, in the expectation that the heat generated inside the wrapping will be sufficient to kill all stages of the bed bugs (Anon. 2003, Mampe 2004, VDHS 2005); however, to date this method has not been scientifically assessed. Many modern mattresses are multilayered and would seem to have a high degree of thermal inertia, which may protect the bed bugs against lethal temperatures. The aim of this investigation was to assess the likelihood that black plastic encasement could be effective for thermal control of bed bugs on mattresses.

Materials and Methods

The trial was undertaken in Sydney, Australia, on a sunny day in summer (February). Two types of mattresses were tested: one type was a basic single-sized (168- by 112- by 8-cm) solid foam rubber mattress covered in cotton material (designated the thin mattress), whereas the other mattress was a multilayered queen-sized (202- by 160- by 32-cm) inner spring

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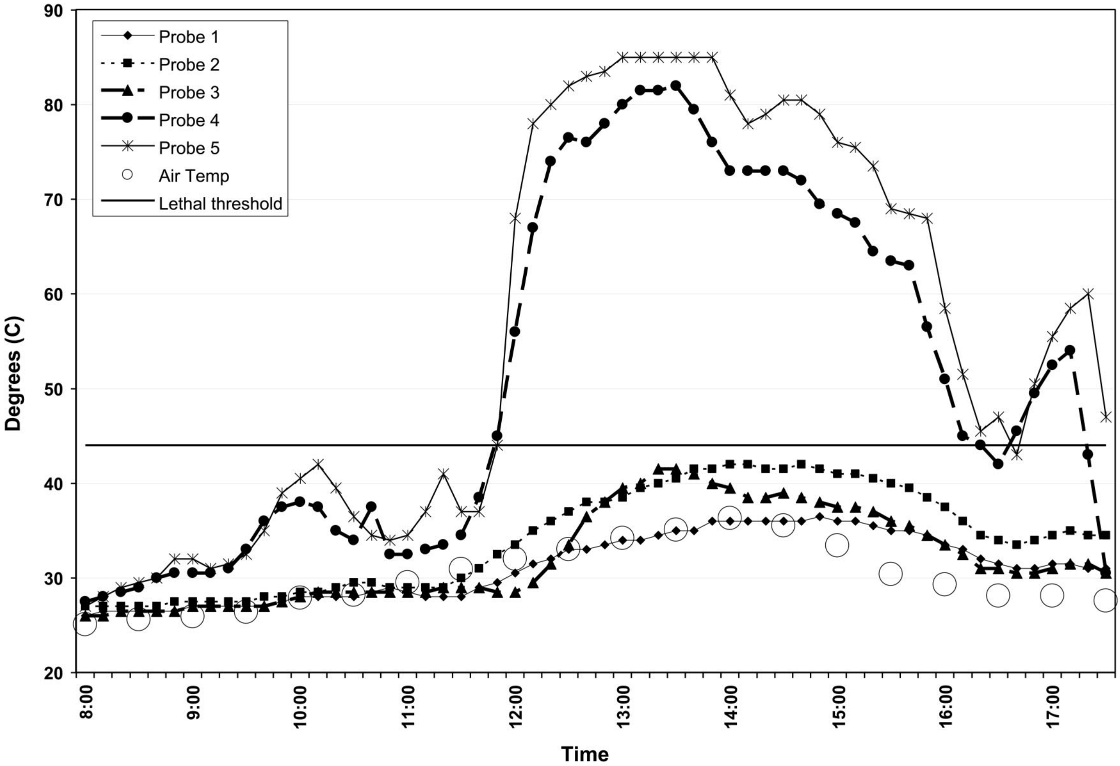

Fig. 1. Data recordings of the temperature loggers on the thin mattress. Loggers 1–3 were placed on the underside, whereas loggers 4 and 5 were placed on the sun-exposed side. The open circles represent ambient temperatures. The line at 44°C is the lethal threshold temperature with a 1-h exposure.

mattress with a padded synthetic fabric layer on top and bottom (designated the thick mattress). The two were selected to compare the difference between a basic cheap mattress, typically used in backpacker accommodation (where bed bug infestations are most common in Australia), and a thicker version, typical of the type in modern homes (where bed bug infestations are increasing).

Because live bed bugs could not be used in the experiment, data loggers (Thermacron Temperature Loggers, OnSolution, Baulkham Hills, NSW, Australia) were attached to the mattresses to record the temperature every 10 min. Logger 1 was placed in the middle of the underside of the thin mattress, while loggers 2 and 3 also were placed underside but on a diagonal and ≈50 cm from each corner. Loggers 4 and 5 were placed on top of the thin mattress on a diagonal and ≈50 cm from each corner. Loggers 6–10 were placed on the thick mattress, with 6 placed in the middle underside, 7 and 8 positioned on the underside similarly to loggers 2 and 3, and loggers 9 and 10 positioned on top as for loggers 4 and 5 on the thin mattress. Both mattresses where wrapped separately in 100-μm-thick black plastic and placed flat in the open where they received sunshine from 0800 to 17:30 hours.

Ambient temperature data were obtained from a nearby Bureau of Meteorology weather station, which recorded air temperature every 30 min. Lethal temperatures for bed bugs were sourced from published data (Johnson 1941).

Results and Discussion

The data from the temperature loggers are recorded in Fig. 1 (thin mattress) and Fig. 2 (thick mattress). For the thin mattress, logger 1 (middle underside) never rose above 36.5°C, whereas loggers 2 and 3 did reach 42°C. The upper surface loggers (4 and 5) reached >80°C, with logger 5 reaching the maximum recordable temperature (85°C). With the thick mattress, the underside loggers recorded almost identical temperatures and never rose >35°C, whereas both upper loggers (9 and 10) reached the maximum recordable temperature of 85°C. There was light cloud cover until ≈1000 hours and thereafter clear blue skies and a nearby tree provided partial shade until 1100 hours for all but temperature logger 10; hence, the earlier rise in temperature. Air temperature remained >30°C from 1130 to 1530 hours and peaked at 36.3°C at 1400 hours.

Bed bugs have a well defined threshold to lethal temperatures. Mellanby (1935), quoted by Johnson (1941), noted that eggs of *C. lectularius* exposed to 45°C for 1 h resulted in 100% mortality, whereas eggs exposed for the same period to 43°C resulted in no

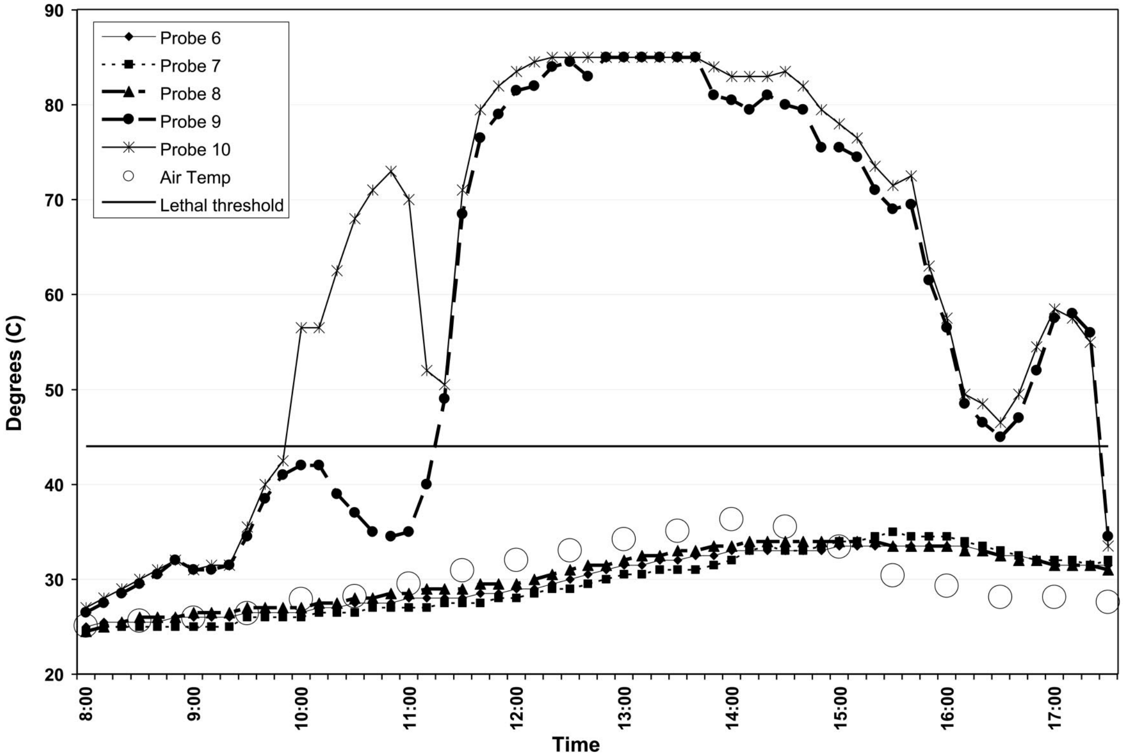

Fig. 2. Data recordings of the temperature loggers on the thick mattress. Loggers 6–8 were placed on the underside, whereas loggers 9 and 10 were placed on the sun-exposed side. The open circles represent ambient temperatures. The line at 44°C is the lethal threshold temperature with a 1-h exposure.

death. For first instars, exposure of 1.5 h to 44°C was 100% lethal, whereas 43°C failed to kill nymphs (Bacot 1914, quoted by Johnson 1941). For adults, Mellanby (1935), quoted by Johnson (1941), found the lethal temperatures were 1°C lower than for eggs and noted that lethal temperatures were lower with longer exposure times, eggs exposed for 24 h at 41°C were all killed, and 100% mortality occurred with adults exposed to 40°C for 24 h. Similarly, Drenski (1928), quoted by Johnson (1941), found that all stages died when exposed for 24 h to 40°C. Therefore, long exposures >40°C and relatively short exposures >44°C can be considered to be lethal.

However, bed bugs are renowned for being sensitive to high temperatures and, when exposed to 40°C, respond quickly by moving to cooler zones (Omori 1941). Thus, the loggers on the nonsun-exposed side were placed in the more protected part of the mattresses. Although the temperature on top of the mattresses reached well above the thermal death point, the high thermal inertia of both mattresses meant that there were always areas cool enough where bed bugs could retreat and survive. Although the process of wrapping items in black plastic and placing them in the sun may work for some objects, these results suggest the process will not be effective for large bulky items such as mattresses.

With the international resurgence of bed bugs, there has been a range of novel control procedures suggested, and it is important that methods are scientifically evaluated before being incorporated into a management program. Recently in Australia, as a world first, a Code of Practice for the Control of Bed Bug Infestations has been developed for the pest management and accommodation industries (Doggett 2006), and studies such as that described herein are being used in its development. The Australian Code of Practice now recommends that black plastic should not be used for bed bug control and that steam, insecticide treatments, or both are the preferred options.

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