THE USE OF HEAT FOR CONTROL OF CHRONIC GERMAN COCKROACH INFESTATIONS IN FOOD SERVICE FACILITIES – A FRESH START

B. C. ZEICHNER, D. F. WOOD JR. & A. L. HOCH
U.S. Army Centre for Health Promotion and Preventive Medicine, Aberdeen Proving Ground, Maryland, USA

Abstract—Chronic, unacceptable, insecticide resistant German cockroach (*Blattella germanica*) populations exist in some of the U.S. Army's food service facilities. We have conducted field trials using heat to control German cockroaches in food service facilities. The process used involved: caulking holes in walls, turning off all electrical equipment, sealing exhaust vents, applying an insect growth regulator (IGR), and heating the facility with direct fired propane heaters to a target temperature of 46°C (115°F) for 45 minutes. Heat was applied for 4 to 6 hours or until no cockroach movement was observed. Temperatures frequently reached 65°C (150°F) at the ceiling while some areas at floor level remained below 46°C (115°F). Cockroaches which congregated in relatively cool spots were vacuumed during the process. Following heating, a residual insecticide and IGR were applied to control those cockroaches surviving the heat treatment and vacuuming. In one of the worst infestations treated, the pre-treatment trap index was 46. The trap index 1-week post treatment was 4.1, representing a 91 percent reduction. At 1-month post treatment, it was 0.3, the lowest levels recorded in this facility in 1.5 years. The trap index remained well below 2.0 (the threshold for residual pesticide treatment) for 11 months with no additional pesticide applications, other than the placement of one to two dozen bait stations on three separate occasions in the dishwashing and serving areas. Food service personnel who constantly battle cockroach infestations are interested in this process since it offers long-term population reduction.

INTRODUCTION

The U. S. Army maintains many food service facilities which typically serve 3 meals a day, 7 days a week. Many are operating in buildings constructed during the middle part of this century, and cockroach (*Blattella germanica*) control has been a constant challenge. Moderate to high levels of physiological resistance to insecticides has developed in some of the cockroach populations infesting these facilities. One installation in particular was unable to control cockroaches in about a dozen of its fifty 50 food service facilities. Four strains were collected and tested for resistance using the glass jar tarsal contact method (Rust *et al.*, 1993). These strains were the most resistant of 45 strains collected Army wide from 1989-1992 and were resistant to almost all of the residual adulticides. Behavioural resistance to a microencapsulated organophosphate was also found using the choice box method (Rust *et al.*, 1993). Due to the resistance levels and cockroach infestation history, it was decided that an alternative to conventional control methods was needed. Heat, when lethal temperatures are reached, has proven to be an effective technique for killing the various life stages of stored product pests (Shepard, 1984) and termites (Forbes and Ebling, 1987). Heat is also being used by a few pest control companies to control cockroaches. Isothermics Inc., a pest control company located in California, has the U.S. patent for the use of sublethal temperatures 43°C, (110°F) and boric acid to control cockroaches (Quarles, 1993). The Topp Construction Services Inc. produces chambers for thermal control of cockroaches in equipment such as water coolers.

METHODS

Facilities Treated

The facilities treated to date have been one-story structures with concrete subflooring and concrete block walls. They ranged in size from 465 to 930 m^2 (5,000 to 10,000 ft^2) and served 200 to 700 soldiers per meal, 3 meals per day, 7 days a week.

The opinions or assertions herein are the views of the author(s) and are not to be construed as official or as reflecting the views of the Department of the Army or the Department of Defense.

Proceedings of the Second International Conference on Urban Pests.
K.B. Wildey (editor). 1996

Facility Preparation

All perishables were removed including spices, fruits, vegetables, and bread, as well as food from refrigerators and freezers since all electrical equipment was turned off to keep the motors and wiring from overheating. Large walk-in freezers/refrigerators were kept operating if their compressors were located to the exterior of the building or area being heated. Wax candles, chocolates, and any other heat sensitive items were removed from the heated areas. Flammable liquids, aerosol, containers, and compressed gas cylinders (e.g., the carbon dioxide cylinders used at the soda fountains and fire suppression systems) were removed from the areas prior to heating. In addition, big screen televisions, computers, and computer disketts were removed to prevent heat related problems. The gas supply to the building was turned off prior to the thermal procedure.

Most facilities had a chemical fire-suppression system for gas range hoods located in the kitchen area. The presurized canisters associated with the ranges were typically fire rated to withstand temperatures up to 49°C (120°F) while the fusible elements of the fire suppression system located in the exhaust system are designed to activate at 127°C (260°F). If the gas cylinders were not removed, they were protected from the heat by wrapping them with an insulating foam approximately 5 cm (2 inches) thick. Thermocouples were placed in the insulating material next to the canisters to ensure that the rated temperature, 49°C (120°F), was not exceeded during the thermal process.

The exhaust hoods of gas ranges and other venting ducts were sealed by covering the exit vents with plastic sheeting to prevent excessive heat loss. In addition, the heating/air conditioning system was shut off to those areas heated to reduce heat loss.

Any small items that could be easily removed from the floor were elevated to another location, so that cockroaches could not find a relatively cool, dead air space beneath them and survive the heat.

No attempt was made to heat the wall voids or crawl space. Therefore, it was critical that all holes in the walls and floor were sealed thoroughly to prevent safe harborages and escape routes for cockroaches. Floor drains could harbor cockroaches, so they were flushed with hot water to kill or wash away any cockroaches within them. Those floor drains equipped with a metal screening cap were wrapped with aluminum foil or plastic wrap to prevent cockroaches from entering them. Adhesive tape was used to seal drains without screening caps.

The day prior to the heat treatment, Gentrol™, E.C.(65.7% hydroprene), an insect growth regulator, was applied in accordance with label directions (7.5 ml Gentrol™ diluted in 3.8 liters water) as a spot and crack and crevice application. Gentrol's™ is chemically stable to 60°C (140°F); such temperatures were generally not reached at the floor levels during the heating process. Therefore, Gentrol™ complements this process well.

Temperature-sensing thermocouple wires connected to a data logger were placed at strategic sites throughout the facility to monitor the temperatures generated during the heating process (temperatures were measured and automatically recorded every 10 min during the heating process). The ceiling temperatures were sampled since that area was generally the hottest. The other sites sampled were at the floor level and in the lowest available equipment harborages, since these were the most difficult areas to heat.

Dead air spaces, such as dry food store rooms, utility closets, and office areas were slow to heat if a heating duct was not directed into the area. If these rooms were connected to the heated area and were not part of the overall thermal control effort, then steps were taken to prevent cockroaches from escaping to these cool areas during the treatment. Escape barriers were made by placing double-sided sticky tape (Mr. Sticky™) across the floor and up the door jams, so the cockroaches became entrapped as they tried to escape to the cooler areas.

In those facilities where the ceramic floor tile is not firmly cemented, to the concrete floor, it is possible that the heat will cause air to expand underneath the tiles and lift them from the floor, thus, cracking them in the process. To minimize this problem, the floor was sounded with a rubber mallet to identify those areas where the tiles were loose from the floor and 3.2 mm (1/8 inch) holes were drilled through the grout between the tiles to vent the air as it heated.

All refrigerator doors were kept closed during the heating process to prevent damage to the plastic door seals. Past experience has shown, that older models of a few freezers/refrigerators with

Gentrol is a registered trademark of Zoecon.
Mr. Sticky is a registered trademark of Lo Tox Products International.

door panels pressure-fitted together (as opposed to being welded together) and insulated with foam may become distorted due to foam expansion caused by heat. Freezers or refrigerators with this type of construction were removed from those heated areas.

Direct fired propane heaters have been used for the last 14 buildings treated. These heaters were easily handled, portable, safe to operate, and required only seven amps of electricity and produced up to 400,000 BTUs per hour. Heated air was delivered through 0.45 m (18 inch) diameter flexible ducts at approximately 31 k/hr (19 miles per hour), which produced good mixing and air circulation within the facility. Normally, air-handling ducts were not extended beyond 7.6–11 m (25–36 ft) from the heaters. Beyond that length, the heaters would shut off because of excessive back pressure. The heaters are not designed to operate in high temperatures, so they were placed outside the heated area where they were connected to propane tanks.

Application of Heat

To ensure that the target temperature –46°C (115°F) for 45 min – was reached and maintained, one heater was used for each 168 to 224 m^3 (6,000 to 8,000 ft^3) of space. Heaters were adjusted to produce temperatures of 78°C (175°F), or less, at the heater. In general, the longer the heater duct run, the lower the exit-air temperature at the end of the duct. For example, a heater temperature of 79°C (175°F) generally produced an outlet air temperature of approximately 65–67°C (150–155°F) which represents a 13–11 (25–20) degree decrease. Normally, following 2 hours of heating a facility, cockroaches began exiting equipment and common harborage areas and congregated in the cooler parts of the room. When cockroach congregations were observed, thermal control personnel vacuumed them. Special back-pack styled vacuum cleaners equipped with a hepa filter and high temperature switches were used for this process.

Following the inital vacuuming, the heating ducts were systematically shifted every 30 to 45 minutes to ensure that all areas of the facility reached the target temperature. Prior to each duct movement, all cockroach clusters were vacuumed. When cockroaches were no longer observed in significant numbers, heating was ceased, and a final inspection was conducted to remove any remaining cockroaches.

Once heating and vacuuming ceased, a residual adulticide mixed with Gentrol™ was applied in accordance with label directions. The residual adulticide used was either cyfluthrin, chlorpyrifos, or propetamphos. In no instance was an adulticide used post-thermal that had not been used previously in pre-thermal treatments. The same is true for Gentrol™ which had been used prior to thermal control. Therefore, the dramatic population reductions cannot be attributed to pesticide applications alone. Bait stations containing hydramethylnon were placed and maintained in the receiving area to minimize reinfestation from incoming commodities harboring cockroaches.

Cockroach Surveillance

Cockroach populations within the facilities treated were surveyed by the installation Preventive Medicine personnel. Routinely, 12 to 18 sticky traps were placed at strategic sites at floor level during monthly sanitation inspections. A biased sampling plan was employed by placing traps in areas of suspected cockroach infestation. If a trap site consistently failed to capture cockroaches, that site was terminated and another trap location was selected. Based on this sampling plan, a trap index of 2 or more cockroaches per trap per night was established as the threshold which triggered a thorough pesticide application including the use of residuals, dust, and baits. If the trap index was less than 2, then dust and/or baits were applied in selected areas at the surveyor's discretion. All pesticide applications, both before and after heat application, were performed by the installation pest control team using their standard operating procedures.

RESULTS

Cockroach Population Levels and Treatment History

Detailed results are presented for four representative buildings in Figures 1 through 4. These figures graph the number of cockroaches per trap per night and show when the pesticide applications were

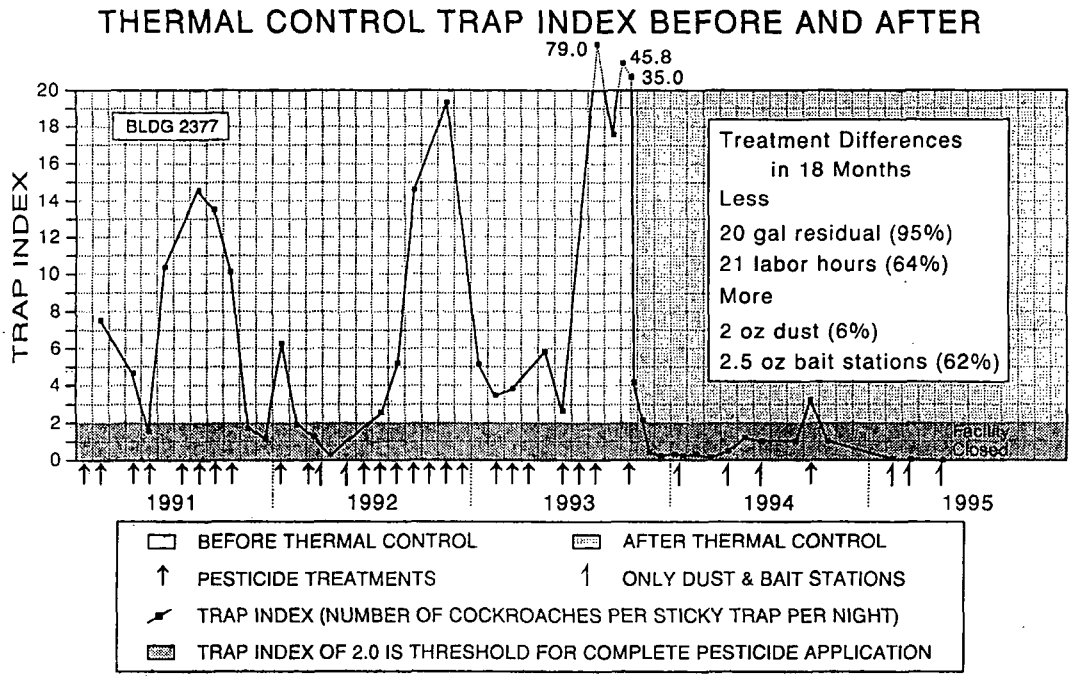

Figure 1

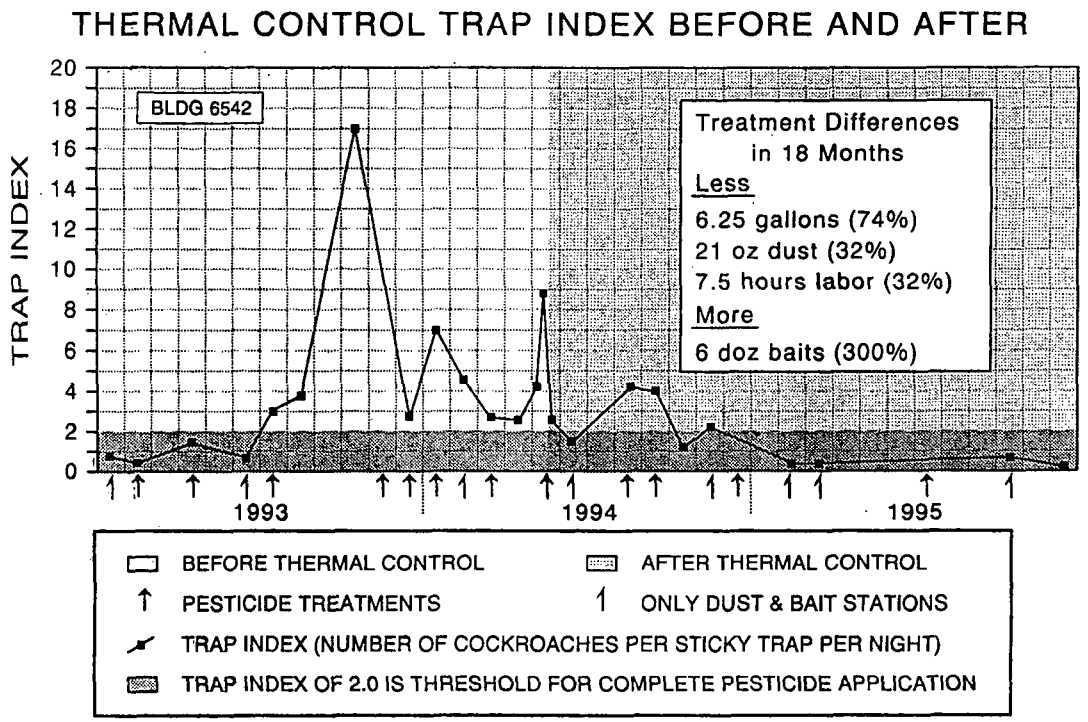

Figure 2

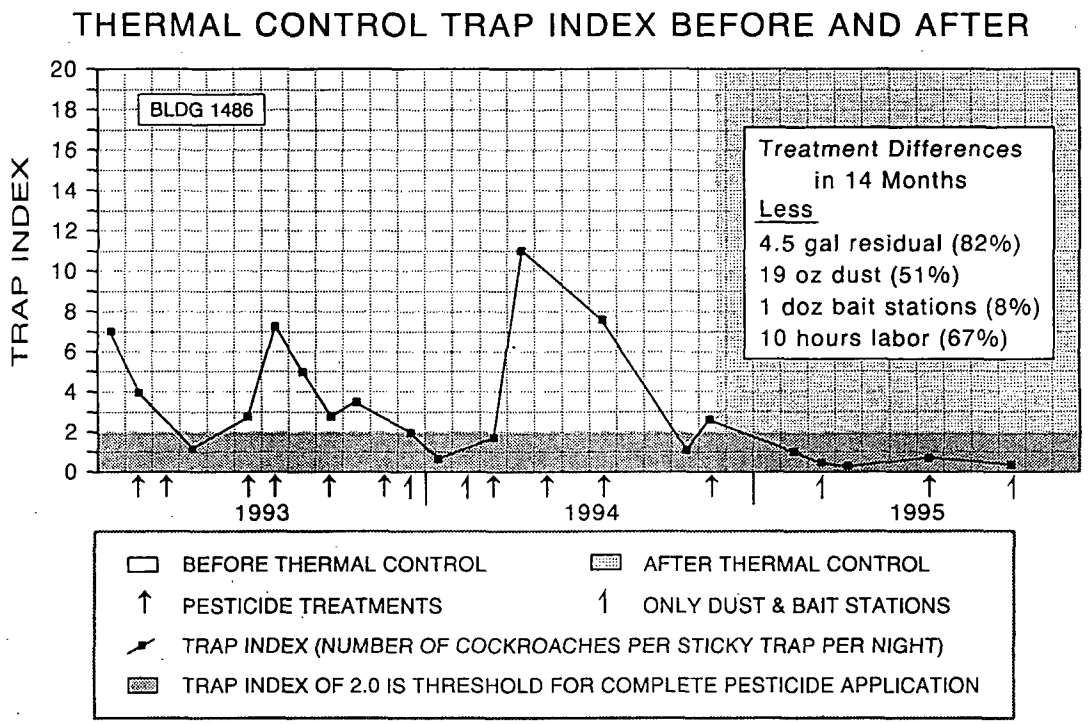

Figure 3

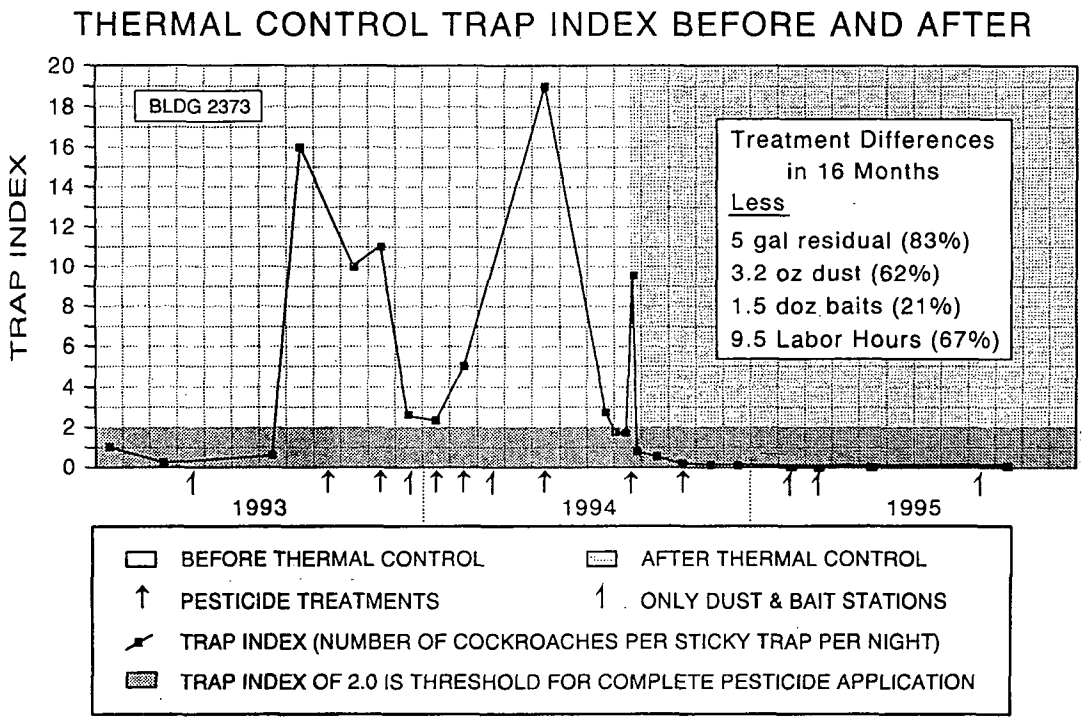

Figure 4

made before and after thermal control. Also, data for each facility are displayed indicating the difference in the quantity of insecticide applied for equal periods of time pre- and post-thermal control.

In Building 2377 (Figure 1), the trap index pre- and post-thermal control was 44 and 35 cockroaches/trap, respectively. It was not uncommon to find relatively high trap indexes immediately following a thermal treatment. In part, the high trap indexes recorded may be attributed to the displacement of cockroaches from their normal harborages down to the floor where the traps were located. By 2-weeks post treatment, the cockroach population dropped below a trap index of 2 and remained at this level for all but 1 of the 18 months since the thermal control. Since thermal control treatment, only one application of residual insecticide was made, as opposed to 14 applications during the 18 months prior to thermal treatment. This represents a 75.7 liter (20 gal) reduction of insecticide spray. During this period, 1 to 2 dozen bait stations were placed in the facility on seven separate occasions.

In Building 6542 (Figure 2), the trap index reached 4.1 three months post-thermal treatment. This was the only facility where a growth regulator was not used in conjunction with the thermal control. Following the application of a residual insecticide and growth regulator, 3- and 4-months post thermal control, the trap index decreased and has remained below 1.0 for all of 1995 with a few applications of dust, 1–2 dozen bait stations, and one application of an insect growth regulator in December 1995. Despite these pesticide applications, there was still a 75 percent reduction in residual insecticide spray and a 32 percent reduction in insecticide dust and labor hours.

The results of thermal control in Building 1486 are graphed in Figure 3. The trap index has remained well below 2.0 for the 14 months since thermal control was used, with significant reductions in the quanity of pesticides used (82 percent less insecticide spray, 51 percent less dust) and labor hours (67 percent less). The only pesticide treatments have been prophylactic applications of dust and baits on two occasions and one insect growth regulator application.

Results of thermal control in Building 2373 are graphed in Figure 4. The trap index the morning after thermal control was over five times higher than the day before. However, within 2 weeks it dropped to 0.5, within 2 months to 0.1, and has remained below that level for the last 14 months. In the 16 months since thermal control, only one prophylactic application of an insect growth regulator and four prophylactic applications of dust and 12–30 bait stations have been made.

Customer Satisfaction

Two written questionnaires were distributed and returned from each of 10 treated food service facilities. We asked, "Of what concern to you is the presence of cockroaches?", 83 percent responded that they were a major concern. When asked, "Should the method be offered to other facilities that request it?", 19 responded "yes" and one responded "not sure." Based on the results of this survey and our contacts with food service personnel, we believe that there is a high degree of interest in thermal control among the Army food service community.

DISCUSSION

The greatest advantage of heat is its penetration into the cockroach harbourage sites within the treatment area, exposing them to lethal temperatures or mechanical removal. Many of these harborages may be either hidden from pest control technicians or difficult to treat with pesticides. In addition, thermal control removes the vast majority of cockroaches in a single treatment. With proper heat application, cockroaches either die within their harborages or escape to the floor where they may contact the insect growth regulator and/or be vacuumed. Thus, all segments of the cockroach population are affected. Even though this method does not entirely eliminate cockroach infestations, routine trap surveillance clearly demonstrates that thermal control combined with minimal pesticide applications can significantly reduce them. To date, cockroach populations have remained low for up to 18 months and will continue to be monitored.

In summary, even though thermal control treatments require considerable planning, a relatively high initial capital investment, are labor intensive, and may damage small areas of the

floor tile, it does provide dramatic long-term reduction of insecticide resistant German cockroach populations. Our questionnaire indicates that Army food service personnel who constantly battle cockroach infestations are very interested in this methodology.

ACKNOWLEDGMENTS

Many individuals have contributed to the development of this methodology, making the field trials possible, as well as the collecting and recording of trap data. In particular, I would like to acknowledge Mr. Bob Ruddell, CPT Chad Riccelli, Mr. Al Freeland, and Mr. Bill Grimes of Fort Knox, Kentucky USA.

REFERENCES

Forbes, C. F. and Ebeling, W. (1987). Update: Use of Heat for Elimination of Structural Pests, The IPM Practitioner., **IX**(8): 1–5

Rust, M. K., Reierson, D. A., and Zeichner, B. C. (1993). Relationship between insecticide resistance and performance in choice tests of field-collected German Cockroaches (Dictyoptera: Blattellidae). *J. Econ. Entomol.*, **86**(4): 1124–1130.

Sheppard, K. O. (1984). Heat sterilization (superheating) as a control for stored-grain pests in a food plant. In Insect Management for Food Storage and Processing edited by F. J. Baur, Published by American Association of Cereal Chemist, Saint Paul, Minnesota.

Quarles, W. (June 1994). Is it me or is it getting hot in here?, *Pest Control Technology.* Volume **22**(6).

Proceedings of the Second International Conference on Urban Pests.
K.B. Wildey (editor). 1996