INSECT POPULATIONS BEFORE AND AFTER HEAT TREATMENT OF A PILOT FLOUR MILL

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The use of heat for insect control in flourmills is not a new idea. It has been proposed and used in the early 1900s, but the method was no longer preferred after the advent of the fumigants. There is renewed interest in using heat to control insects in mills because of the impending phase out of methyl bromide. Typically, the method involves raising the ambient mill temperature to 50^{o}C or above for 24-36 hours to kill insects within the mill, including machinery.

The Department of Grain Science and Industry's pilot flourmill was heat treated during 1999 with gas, electric, and steam heaters. A continuous trapping program was instituted from the end of June to December 1999 to judge the impact of heat treatments on stored-product insect incidence and abundance. This paper summarizes results from our trapping program.

Methods

The 1st heat treatment was conducted during June 25-27 with gas heaters, the 2nd during August 4-6 with electric heaters, and the 3rd during November 23-26 with steam heaters. Beetle populations were monitored with commercial food-baited traps (Trece, Inc., Salinas, California). Pheromone lures of the cigarette beetle, *Lasioderma serricorne* (F.), Khapra/warehouse beetle, *Trogoderma* species, and confused/red flour beetle, *Tribolium* species were used on each food-baited trap. Separate sticky traps (Trece, Inc.) were used for the almond moth, *Ephestia cautella* (Walker), and the Indianmeal moth, *Plodia interpunctella* (Hübner). In each of the 4 floors of the cleaning house and the flour mill, 10 food-baited and 20 sticky traps (for the 2 moth species) were placed. Trap catches were recorded every 7-14 days. Pheromone lures were replaced every 4-5 weeks. Traps were placed within 1-3 weeks following a heat treatment. Temperatures at the floor level were measured with HOBO data loggers (Onset Computer Corp., Pocasset, Massachussetts).

Results

With gas heaters, it took 12-23 hours across all floors of the mill to reach the target temperature of 50^{o}C, and temperatures above 50^{o}C were maintained for 13-28 hours (Dowdy and Subramanyam 1999, unpublished data). The maximum temperatures

attained varied by floor (53-59^{o}C). With electric heaters, it took 5-21 hours to reach 50^{o}C, and temperatures were above 50^{o}C for 20-27 hours. The maximum temperatures attained were 53-55^{o}C. With steam heaters, it took 12 to 65 hours to reach 50^{o}C, and in some places the temperatures never reached 50^{o}C. The temperatures were above 50^{o}C for 3-58 hours depending on the floor.

The food-baited traps captured 25 species belonging to 6 insect orders. Out of the 17 species of Coleoptera associated with the mill, the red flour beetle, *Tribolium castaneum* (Herbst) was the most abundant, followed by the foreign grain beetle, *Ahasverus advena* (Waltl), and *L. serricorne*. Both *E. cautella* and *P. interpunctella* were captured in sticky traps, irrespective of the lure used, but *P. interpunctella* was the most predominant species in the mill.

The impact of heat on the numbers of 7 stored-product beetles are presented in Table 1. After the gas hat treatment, *A. advena* and *L. serricorne* adults were captured in traps. However, after the electric heat treatment, the traps failed to capture these species. Adults of the sawtoothed grain beetle, *Oryzaephilus surinamensis* (L.) and *Sitophilus* species were captured in traps after each heat treatment. However, the numbers captured were small relative to other species. *Tribolium castaneum* and *Trogoderma* species were not detected after the gas heat treatment, but were captured after the electric heat treatment. The numbers of *Tribolium* continued to rise after the electric heat treatment.

Figure 1 shows the total numbers of all beetle species on a Julian date scale. It appears that traps placed within 1-3 weeks following a heat treatment captured insects in the flour mill and cleaning house.

Males of *E. cautella* and *P. interpunctella* were captured on all sampling occasions (100% occurrence) after the gas heat treatment, and numbers caught during this period were relatively the same. Occurrence of *P. interpunctella* remained at 100% following the electric and steam heat treatments. However, the occurrence of *E. cautella* decreased to 40% in the cleaning house and 60% in the flourmill after the electric heat treatment, and 0% after the steam heat treatment. More *P. interpunctella* were captured in traps after the electric heat treatment when compared with captures after the gas heat treatment (Figure 2). Figure 2 also shows that moths were captured in traps following each heat treatment, although the numbers captured varied.

Discussion

Our results indicated that traps were helpful in providing a relative measure of insect populations in the flourmill before and after heat treatments. However, since traps attract insects from long and short ranges, it may be difficult to accurately gauge the impact of heat on insect populations in the mill. During each heat treatment we observed a lot of dead insects on the floor, which indicated that the heat was indeed effective in killing insects within and outside the mill machinery. It is plausible that insects captured in traps immediately after the heat treatment consisted of adults that survived a heat treatment by seeking refuge within wall voids or grain residues, adults that were brought in on raw

ingredients, or adults that immigrated from outdoors. Therefore, it is important to sample grain and flour residues on the floor and within mill machinery, use visual inspections, sample dead insects on the floor, and use traps to better gauge the degree and duration of insect suppression obtained with heat treatments.

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Table 1. Numbers of important beetle species captured per day after gas, electric, and steam heat treatments.

Species	Insect numbers after heat treatment/trap-sampling day					
	Gas[1]		Electric[2]		Steam[3]	
	CL[4]	FM[5]	CL[4]	FM[5]	CL[4]	FM[5]
Ahasverus advena	2.0	9.1	0.0	0.0	0.0	0.0
Cryptolestes sp.	0.0	0.0	0.4	0.1	0.0	0.0
Lasioderma serricorne	1.0	1.4	0.0	0.0	0.0	0.0
Oryzaephilus surinamensis	0.2	0.1	0.1	1.0	0.3	0.1
Sitophilus sp.	0.1	0.4	0.1	0.0	2.7	0.0
Tribolium sp.	0.0	0.0	5.5	6.4	5.8	1.1
Trogoderma sp.	0.0	0.0	0.0	0.6	0.0	0.0
Total beetle species	3.3	11.0	6.2	8.2	8.8	1.2

[1]36 trap-sampling days.
[2]92 trap-sampling days.
[3]23 trap-sampling days.
[4]CL = Cleaning house.
[5]FM = Flourmill.

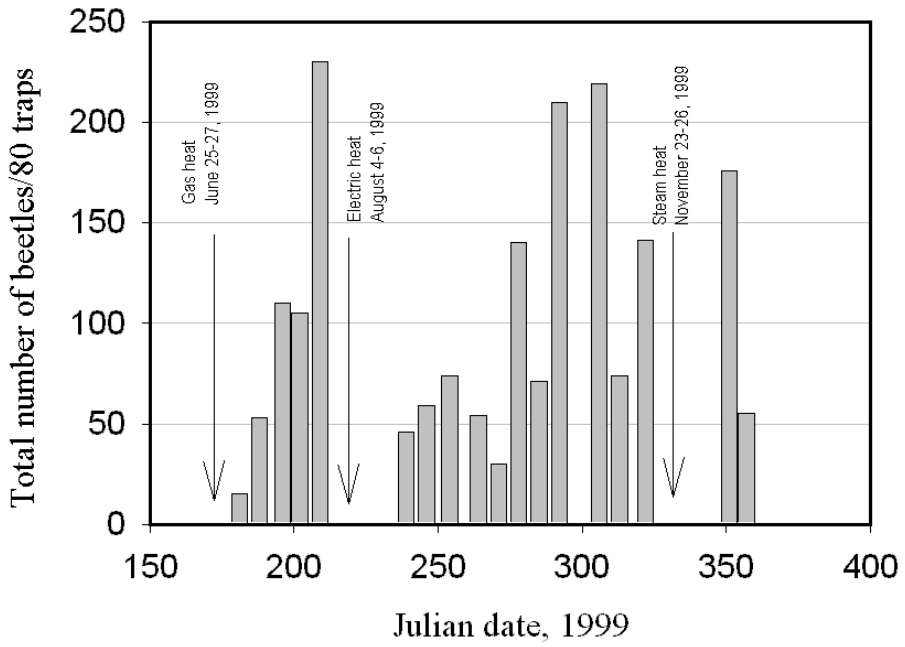

Figure 1. Total number of all beetles captured in food-baited traps on all floors of the pilot flour mill before and after heat treatments, June 23 - December 23, 1999.

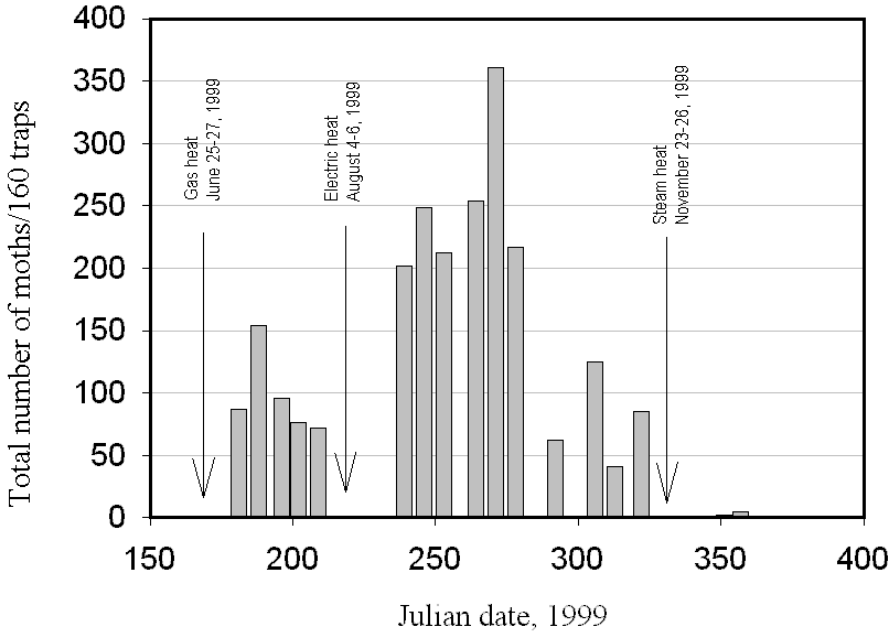

Figure 2. Total number of male moths of *E. cautella* and *P. interpunctella* captured in sticky traps in the pilot flour mill before and after heat treatments, June 23-December 23, 1999.