Presence and distribution of red flour beetles in a city neighborhood surrounding a grain-cleaning facility

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Abstract

Red flour beetle, *Tribolium castaneum* (Herbst), infestations were found outside and inside several houses in a neighborhood surrounding a grain-cleaning facility in north Minneapolis, Minnesota, USA. There is a railroad yard to the south of the facility. Insect monitoring was done in an area approximately one square mile on all sides of the facility, by placing commercial sticky traps with pheromone lures outside houses to capture red flour beetles. Inside houses, commercial food-baited traps plus pheromone lures were used. Out of the 35 traps inside the facility, 69% captured red flour beetles, with highest captures on the bin floor (33 beetles/trap). Outside the facility, 92% of the 49 traps had beetles, in the railroad yard 41% of the 46 traps and outside the houses 78% of 124 traps had beetles. The actual number of beetles per trap ranged from 0.4-34.3 outside the facility, 0.4-2.2 in railroad yard, and 0.8-22.7 outside the houses. About 78% of 235 traps placed inside the houses captured beetles. Of the 78% of traps with beetles, 48% had 0.1-10 beetles/trap, and 5% had more than 50 beetles/trap. On average, there were 0.1-63.8 beetles/trap/house. Beetles were present in all rooms of the house with highest numbers in the dining room (21 beetles/trap) followed by the kitchen (14.9 beetles/trap). The insect monitoring program documented that beetles were present inside and outside the facility and the houses with very few beetles being present in the railroad yard. The primary source of these beetles in houses appears to be the facility, but continued presence of beetles in various rooms could be due to beetles reproducing on food accumulations in the house. Removal of grain debris next to train tracks and a rigorous sanitation and pest management program including better dust control systems reduced red flour beetle numbers below the complaint level.

Keywords: red flour beetles, outdoor trapping, synanthropic pest

1. Introduction

Residents of a neighborhood in north Minneapolis, Minnesota, USA, were having a tough time dealing with a stored-product insect problem in their houses in 1996. The insect in question was the red flour beetle, *Tribolium castaneum* (Herbst), a species associated with raw and processed grain products, especially floury materials. There was also a grain elevator (more than 80 years old) in the neighborhood. The elevator was a grain-cleaning facility. About 95% barley and 5% wheat grains were cleaned at the facility. Since *T. castaneum* is associated with grain and grain products, the residents were implicating the facility as being the source of these insects. The facility on the other hand denied having any insects. A few frustrated residents approached the City of Minneapolis and local mass media and stories about this insect problem made way into the local press and were reported by two local TV stations.

When the houses with reported *T. castaneum* infestation were visited, a total of 44 residents in the neighborhood reported seeing the insects in their houses. A resident showed insects that she collected in her house 20 years ago. Residents reported seeing insects entering through their

window mesh, and found them throughout their houses, upstairs, downstairs, in the kitchen, bathroom, laundry room, living room, dining room, and in various food products in their pantry.

In the backyard of two of the houses, during an initial visit 3-4 Pherocon 1C trap bottoms or liners (Trécè, Salinas, CA, USA) were placed on the clothesline. The liners were not baited with *T. castaneum* pheromone lures. The purpose was to capture randomly flying *T. castaneum* adults. In two days, 10-12 beetles were captured in each trap. This indicated that these adults were flying outdoors, although the source of these insects was unclear.

In addition to the grain-cleaning facility, there might be other sources for the beetles, such as the accumulations of grain debris and dust on either side of the train tracks that run next to the facility, compost piles in residents' backyards, and dog/pet food in the garage or house. A previous study in UK showed that the red flour beetles flying into houses were coming from populations breeding in a poultry manure heap pile, 6.1 m long and wide and 3.7 m wide, close to the house on a poultry farm in northwest Somerset, where the nearest point to the house was about 18.3 m from the manure pile. The insects were concentrated 10.2 cm below the heap (Jones, 1967). This proved that *T. castaneum* can survive and breed outdoors and can fly from a breeding site.

When the neighborhood issue was brought to the attention of state legislators, members of the House Sub-Committee on Agriculture, Finance, and Rural Development held a public hearing. Besides the legislators and residents, representatives from the Minnesota Department of Agriculture and Food and Drug Administration were present at the hearing. Individuals from the grain-cleaning facility and the facility's corporate office and the railroad company were invited to the meeting. Following the testimony, the legislators asked the facility as well as the railroad company to address the issue, and asked the Minnesota Department of Agriculture to work with all involved parties, including the residents, to investigate and resolve the issue as soon as possible. Furthermore, legislation (House File No. 3853) was passed and approved that gave full authority to the Commissioner of the Department of Agriculture to oversee mitigation of the insect infestation. The Department of Agriculture approved, and funded, a project to investigate the *T. castaneum* infestation. The proposed study began in July and ended in November of 1998.

2. Materials and Methods

2.1. Outdoor trapping

Commercial sticky traps (Trécé, Salinas, CA, USA) baited with the *T. castaneum* aggregation pheromone lures were used to determine the presence and distribution of *T. castaneum* outdoors. The traps were placed in an area approximately one square mile on all sides of the grain-cleaning facility. Around the facility on the outside, there were 49 sticky traps baited with the lures. There were 46 sticky traps with lures distributed throughout the railroad yard. Four sticky traps with lures were placed on the outside of each of the 31 houses surrounding the facility and the railroad yard (houses to the north and south of the facility; total 124 traps). Only the sticky trap bottoms (liners) were placed on the outside of the facility, in the railroad yard, and outside houses surrounding the facility and the railroad yard. To prevent outdoor sticky traps from being affected by wind, the pheromone lure was first tethered to a wire, which was then threaded through the trap.

2.2. Indoor trapping

Inside the grain-cleaning facility, 35 sticky traps baited with the pheromone lures were placed among the five floors. Sticky traps were hung at eye level. Indoor trapping was also done in 26 houses. Residents who had experienced *T. castaneum* infestations inside their houses were

provided with a commercial pitfall traps (Trécé, Salinas, CA, USA) baited with food attractant oil and pheromone lures. This was done to determine the presence and abundance of *T. castaneum* in different rooms of the house. Each resident received 10 traps for placement in different rooms.

The sticky traps outdoors were in place at the facility, railroad yard, and houses for 76, 82, and 36 days, respectively. Traps were examined approximately every 15 days, and were checked 2-5 times between July and October of 1998. Trap lures were changed at monthly intervals. The cardboard traps inside houses were in place for 27-62 days, and were examined only once.

2.3. Data analysis

The adults of *T. castaneum* captured on sticky or in cardboard traps were counted. At each trapping site, the percentage of total traps that captured one or more *T. castaneum* was calculated. Adults captured on sticky and in cardboard traps were expressed as number of beetles captured per trap per 30 days. In case of outdoor trapping, the beetle capture data were subjected to one-way analysis of variance (ANOVA) and means were separated using the Fisher's protected least significant difference (lsd) test at α=0.05 (SAS Institute, 2008) to determine differences in trap catches among the trapping sites. The beetle capture data outside the houses were subjected to two-way ANOVA to determine the differences in trap captures within and among the houses. Trap capture data inside the facility were also subjected to one-way ANOVA and means were separated using the Fisher's protected lsd test at α=0.05 to determine differences in adults captured among the facility floors.

3. Results and Discussion

3.1. Outdoor trapping

Outside the facility, 92% of the 49 traps had beetles, in the railroad yard 41% of 46 traps had beetles, and outside the houses 78% of 124 traps had beetles. This suggested that *T. castaneum* were present on the outside at all three sites, and were distributed more widely on the outside of the facility and around the houses. The actual number of beetles per trap ranged from 0.4-34.3 outside the facility, 0.4-23.0 in the railroad yard, and 0.8-22.7 on the outside of the houses on the north and south side of the facility (Table 1). One-way ANOVA showed that the mean number of adults/trap/30 days varied significantly among the trapping sites (F = 19.72; df = 3, 214; P < 0.0001). The railroad had very few beetles, whereas insect numbers were equally high outside the facility and the houses.

Table 1 Comparison of outdoor trap catches.

Site	Number of traps	Mean ± SE adults/trap/30 days[a]	Range
Houses (north)	100	3.89 ± 0.44a	0.8 - 22.7
Houses (south)	23	2.35 ± 0.57b	
Facility	49	3.65 ± 0.85ab	0.4 - 34.3
Railroad yard	46	0.38 ± 0.08c	0.4 - 2.23

[a]Means followed by different letters are significantly different (P < 0.05, Fisher's protected lsd test).

The beetle captures among the houses differed significantly (F = 3.29; df = 30, 89; P < 0.0001), but not in the four traps placed outside of each house facing the four cardinal directions (F = 0.50; df = 3, 89; P = 0.6861) (Table 2). Interestingly, houses to the south of the facility and the railroad yard also had beetles higher than the railroad yard. If beetles were indeed flying from the facility to the neighborhood south of the facility, the traps in the railroad yard

would have intercepted them. However, this did not happen. These data suggest that the populations of *T. castaneum* found in the neighborhoods may be independent of the facility or that the founding populations may have come from the facility prior to the sampling in the neighborhoods. Trapping at the facility and railroad yard started in July; neighborhood sampling did not begin until August. It is also likely that traps outside the houses were capturing beetles coming from inside the houses. For example, in one of the houses farthest from the facility on the north side, high numbers of beetles were found on traps outside the house. The resident complained about beetles inside the house as well. A careful search of the pantry revealed *T. castaneum* infestation in one-year-old corn grits. Adults of *T. castaneum* have been reported under the bark of trees feeding on rotting materials or molds. The presence of *T. castaneum* in the neighborhoods may be due to the abundant tree cover, which provides adequate bark habitat. Furthermore, during summer months, birdseed and pet food were available for these beetles to infest and reproduce.

Table 2 Influence of trap location outside houses on *T. castaneum* captures.

Trap location	Number of traps	Mean ± SE adults/trap/30 days
NE	31	4.07 ± 0.78
SW	31	3.86 ± 0.83
NW	31	3.27 ± 0.71
SE	30	3.22± 0.72

3.2. Indoor trapping

Out of the 35 traps inside the facility, 69% captured one or more beetles. The mean number of adults/trap/30 days varied significantly among the facility floors (F = 13.37; df = 4, 30; $P < 0.0001$) (Table 3). More beetles were captured on the bin floor (33 beetles/trap), and the lowest numbers were found in the basement area (0.3 beetles/trap).

Table 3 Trap captures inside the grain-cleaning facility.

Floor	Number of traps	Mean ± SE adults/trap/ 30 days[a]	Range in trap catch
Basement (1)	8	0.25 ± 0.17d	0.0 - 1.2
Main (2)	7	3.27 ± 1.15c	0.0 - 5.9
Bin (3)	10	33.04 ± 10.65a	2.8 - 116.8
Distribution (4)	5	11.60 ± 3.67ab	4.0 - 19.3
Scale (5)	5	5.53 ± 2.09bc	0.4 - 11.5

[a]Means followed by different letters are significantly different ($P < 0.05$, Fisher's protected lsd test).

The beetle captures from cardboard traps placed inside the houses were valuable in determining the numbers present and their distribution within houses. Out of the 235 traps inside the houses, only one was in the attic and it did not catch any beetles. About 78% of 235 traps had one or more *T. castaneum* adults. Of the 78% of traps with beetles, 48% of the traps had anywhere from 0.1-10 beetles/trap, and 5% had more than 50 beetles/trap. The number of beetles captured in all 10 traps varied from house to house. The average number of beetles/trap/house ranged from 0.1-63.8. Across all 26 houses, the second floor had the highest number of beetles (16.4 beetles/trap), followed by the ground floor (12.2 beetles/trap), and basement (3.5 beetles/trap). The beetles were present in all rooms of the house. The highest numbers were in the dining room (21 beetles/trap) and the kitchen (14.9 beetles/trap). The bedrooms, bathroom, and living rooms had 7.4-10 beetles/trap. The laundry room had only 5 beetles/trap.

3.3. Meteorological data

The average temperature throughout the study was above 15°C, except during the first week of October. These temperatures are conducive for *T. castaneum* activity and reproduction. It rained on 18 different occasions between July and October; most rainfall was below 1.8 cm, and on one occasion it was over 2.5 cm. Very little is understood about the influence of rainfall on beetle activity. However, rainfall was an important detriment to using traps outdoors. Traps and lures, damaged by the rain, had to be changed immediately. On 20% of the occasions, the wind was blowing in the northwest direction, and 18% of the time it was blowing in the southern direction. About 9-11% of the time, the wind was blowing in all other directions (west, north, northeast, east, southeast, and southwest). The prevailing wind direction did not explain the observed beetle captures in traps placed outdoors.

4. Conclusions

In conclusion, the survey documented that adults of *T. castaneum* were present inside and outside the facility, with very few beetles being present in the railroad yard. The beetles were active outdoors in the residential areas to the north and south of the facility. Beetles were present inside houses in every room. The primary source of these beetles in houses appeared to be the facility, but continued presence of beetles in various rooms could be due to survival and reproduction of the beetles on food debris within the house. Our recommendations were that the facility follow a rigorous pest management program that included repairing damaged doors and windows, screening windows with mesh, sanitation, pest monitoring, and crack and crevice treatment with residual pesticides, fogging with pesticides, and as a last resort fumigation with phosphine. The railroad company immediately cleaned up spilled grain piles next to the railroad tracks. This clean up occurred before the study started and therefore none of the grain piles was sampled to determine if *T. castaneum* were breeding in such piles. The residents were asked to containerize food (pet food, birdseed, flour, etc.) and vacuum every 15 days to remove spilled food particles stuck in the carpet or couches, especially in the kitchen, dining, and living room areas. Finally, better dust control systems installed by the grain-cleaning facility reduced red flour beetle numbers below the complaint levels in 1999.

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