

# Insect Reproduction Hampered by Heat

Fewer eggs laid and hatched when temperatures soar above 104 degrees Fahrenheit

Several researchers have shown that insects surviving short-term exposures to temperatures above 104 degrees F resulted in adverse effects on the number of eggs laid by females, hatchability of the

## Pest Management



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eggs, and subsequent development of the immature stages to adulthood.

For example, only 1.3% of the eggs laid by females hatched, when female confused flour beetles were exposed as pupae to 112 degrees for eight hours. But the

egg hatchability was 11%, when month-old virgin adult females were exposed to 112 degrees and mated with unexposed males.

When khapra beetle pupae were exposed to 113 degrees for 48 to 72 hours, the adults emerging from pupae were incapable of propagating a new generation because of complete mortality of larvae hatching from eggs laid by the adults.

When one-, two-, or three-day-old red flour beetle pupae were exposed to 113 degrees for 48 or 72 hours, development of the subsequent generation was completely suppressed, because larvae failed to complete development to the pupal stage.

When two- or three-day-old red flour beetle pupae were exposed to 113 degrees for 48 hours, adult progeny emerging from pupae failed to produce any larvae during a month-long observation period.

When one-day-old pupae were exposed to 113 degrees for 24 hours, an average of 40 live larvae were found after one month, but no larvae were found, if one-day-old pupae were exposed to 113 degrees for 48 or 72 hours.

Most of the work on effects of high temperatures on the red flour beetle

reproduction was conducted at temperatures less than 113 degrees. During heat treatment of mills, the minimum temperature for effective disinfection should be at least 122 degrees.

Very little is known about adverse effects on reproduction of stored-product

degrees would impair the reproductive performance of red flour beetles exposed in the pupal and adult stages. Pupae were selected because adult reproductive system sexual maturity occurs during this stage.

## Tests With Pupae and Adults

Male and female red flour beetle pupae (one-day-old) were exposed for 60 minutes at 122 degrees, and virgin male and female adults (two-weeks-old) of the red flour beetle were exposed to the same temperature for 39 minutes. At these exposures, 50% of the population survives.

Insects that were exposed to 122 degrees were then mated with insects that were not exposed to 122 degrees (control insects). All possible crosses were made, to determine if exposure of males or females to high temperature had a greater influence of the number of eggs laid, egg-to-adult survival, and adult progeny production (detailed experimental protocols and a complete paper will be sent to interested readers).

The four possible reciprocal crosses for pupae or adults were as follows:

- Unexposed female mated with unexposed male.
- Unexposed female mated with exposed male.
- Exposed female mated with unexposed male.
- Exposed female mated with exposed male.

Reproductive effects were measured by rearing these insects on flour from eggs through adulthood.

## Test Results

The number of eggs laid by heat-treated pupae was about 53% less than that of heat-treated adults. In experiments with pupae, there was a 19% decrease in the number of eggs laid when an unexposed female was mated with a heat-treated male compared with the number of eggs laid when an unexposed female was mated with an unexposed male (Figure 1).

When both sexes were unexposed in the pupal stage, about 222 eggs were laid by females in two weeks compared with 80 eggs laid by females, when a heat-treated

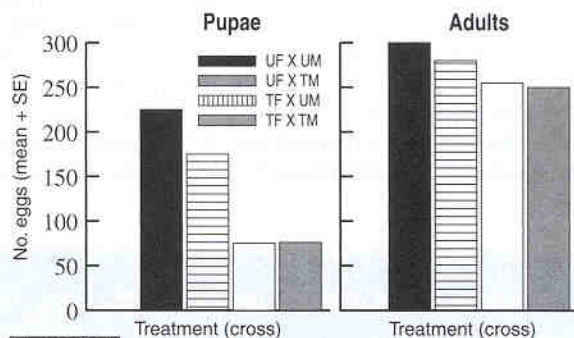


FIGURE 1

Number of eggs laid in 2 weeks in tests with pupae and adults. UF = untreated female; UM = untreated male; TM = heat-treated male; TF = heat-treated female. Bars with means followed by different letters are statistically significant at the 5% level.

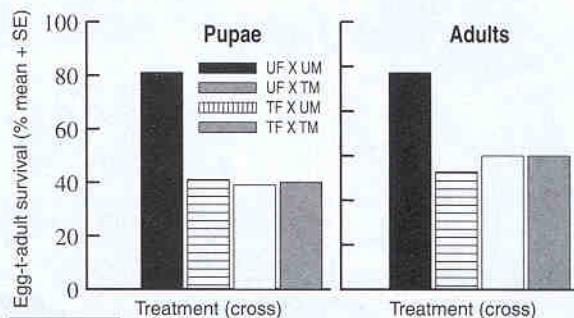


FIGURE 2

Egg-to-adult survival of eggs laid in 2 weeks in tests with pupae and adults. Bars with means followed by different letters are statistically significant at the 5% level.

insects surviving short exposures to high temperatures used during heat treatments.

My PhD student, Rizana Mahroof, determined if short-term exposures to 122

female was mated with an unexposed male, or when both sexes were heat-treated. In contrast, when males were heat-treated in the pupal stage and mated with unexposed females about 179 eggs were laid.

These findings suggest that the adverse effects on egg laying were greater, when females were exposed to 122 degrees than males. A similar trend among treatments was observed in experiments with 2-week-old adults, but the magnitude of differences among the four reciprocal crosses was smaller compared with experiments involving pupae.

This finding suggests that exposure of pupae to 122 degrees had a greater adverse effect on reproduction than exposure of adults. The egg-to-adult survival in tests with heat-treated pupae was 9% less than that of heat-treated adults.

The survival rate of insects where both sexes of pupae were unexposed was about 83% compared with 37% to 42% survival rates observed in the other three reciprocal crosses (Figure 2). Trends in the egg-to-adult survival rate in experiments with 2-week-old adults were similar to those observed for pupae.

Although the number of eggs laid was high in the treatment where an unexposed

female was mated with a heat-treated male, the egg-to-adult survival was severely affected. The trend in the number of adult progeny produced by a pair of males and females in each of the four reciprocal crosses was similar in experiments with pupae or adults.

The largest numbers of adult progeny (244 adults) were produced when unexposed females were mated with unexposed males, whereas the smallest numbers of adult progeny (53 adults) were produced when heat-treated females were mated with heat-treated males.

#### Summary

Exposure of red flour beetle pupae or adults to 122 degrees adversely affected the number of eggs laid and subsequent survival of eggs to adulthood. The magnitude of effects observed was consistently greater when exposure occurred in the pupal stage rather than in the adult stage.

High temperatures disrupt the normal functioning of the reproductive system in both males and females, but females tend to be more vulnerable in some species. Generally, the adverse effects were greater when females of the red flour beetle were exposed to 122 degrees rather


than males. Our results indicated that exposure of red flour beetles to 122 degrees only induces partial sterility.

In some insects, such as the Indianmeal moth, exposure of males to 94 degrees induces complete sterility. How high temperatures affect insect reproduction is not fully understood. The adverse effects of high temperature on red flour beetle reproduction are important for understanding population increases of this pest after a heat treatment.


Pest population buildup after a heat treatment partly depends on the reproductive performance of survivors. In our study, food was not a limiting factor for the red flour beetle. Sanitation of the floor and equipment of mills, before heat treatment, improves effectiveness in killing insects, because food materials are poor conductors of heat and serve to insulate insects from high temperatures. Therefore, the adverse effects observed in the study may be more pronounced in survivors during an actual heat treatment.

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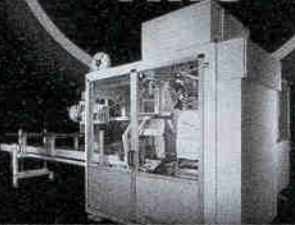


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