# Genetic and Environmental Influences on the Aggregation of Beetles

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## Abstract

**The red flour beetle, or *Tribolium castaneum* (Coleoptera: Tenebrionidae), is a worldwide pest of stored products, particularly feed grains (Baldwin and Faluso 2006). It's tiny body and agile legs allow this beetle to get into tiny niches and contaminate large amounts of stored grains. This beetle cannot feed on intact grains, however thrives on high moisture, cracked or hulled grain which can be a problem in facilities where grain is processed (Gerkin et al 2018). This attraction can lead to an offensive odor, mold growth, and can bring out a grey tint in the grain. It is unknown whether the red flour beetle aggregates based on their environment or due to familiar, genetic pheromones in the air (Johnson). Therefore, the purpose of this research is to place two strains of red flour beetle together and observe their aggregation preferences. The question is will the beetles solely aggregate with their genetic members, or will they associate with the unfamiliar strain. I believe that the beetles will aggregate in response to genetic cues in their environment. The results of this research are necessary to establishing a better way to manage this food storage pest. If the beetles are attracted to genetic pheromones within their environment, then progress can be made to control the pheromone. In turn, this research can help indicate a modified way of controling these beetles.**

## Purpose

The purpose of this research is to find out whether the red flour beetle aggregates due to genetic pheromones or environmental influences.

## Questions, Hypotheses, and Predictions

Question: Will the beetles solely aggregate with their genetic members?

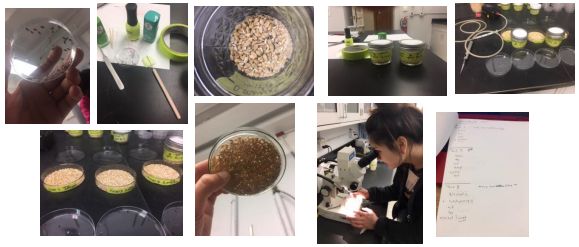
Hypothesis: The red flour beetle will aggregate in response to genetic cues within their environment.

## Study System

The red flour beetle, (*Tribolium castaneum*; Coleoptera: Tenebrionidae), is about 0.1 to 0.3 inches long and of Indo-Australian origin (Baldwin and Faluso 2006). It is commonly found in southern states in the United States, and can also be identified in most tropical and subtropical countries in the world (Mauremootoo). The red flour beetle is reddish-brown in color with a flattish curved-sided body and a pair of antennae that are enlarged in the last three segments. This beetle has chewing mouthparts and six cursorial legs used for running. Regular food sources include rye, wheat, rice, oats, barley, peas, maize, sorghum, lentil, beans, walnuts, and more (Mauremootoo).

## Methods and Experimental Design

To begin this experiment, we used two strains of beetles (Costa Rican and Canadian) that are common pests in farm-food storage. The next step in this project was to split the two strains of beetles in half to have two groups of each strain and then split again to have four groups of beetles in total. After that, we used nail polish to paint the groups of beetles four separate colors: blue and green and yellow and white, respectively. Once the beetles were painted, they were separated into two different petri dishes containing cracked wheat and seven beetles from both strains. Thus, creating two environments of beetles, set up as: blue with yellow and green with white. The beetles were then left alone in their diversified dishes, not be moved again for two weeks. After letting the beetles settle into their assorted environments for a period of time, they were then rearranged into three petri dishes containing five beetles of each color. The final step of this research was to examine the dishes for aggregation between strains on four early mornings before movement started. Examination of the beetles took place by utilizing a microscope to recognize the colored beetles, and a toothpick to find where the beetles were congregated under the cracked wheat.



## Results

After compiling the data and confirming the results, it can be seen that the beetles aggregated the most according to genetic and environmental influences and neither genetic and environmental influences. This would mean that the beetles not only grouped with what was familiar to them, but also branched out to discover what was new in their environment, as well.

Start
10/30

| Trial 1 | Genetic | Environment | Gen. & Env. | Neither G/E | Sum | G | E | G& E | Neither |
|---|---|---|---|---|---|---|---|---|---|
| ybbwww | 5 | 5 | 4 | 7 | 21 | 0.238095 | 0.238095 | 0.190476 | 0.333333 |
| ggb | 2 | 0 | 1 | 0 | 3 | 0.666667 | 0 | 0.333333 | 0 |
| bwgb | 2 | 1 | 1 | 2 | 6 | 0.333333 | 0.166667 | 0.166667 | 0.333333 |
| yygw | 2 | 1 | 1 | 2 | 6 | 0.333333 | 0.166667 | 0.166667 | 0.333333 |
| | | | | | 9 | 0.392857 | 0.142857 | 0.214286 | 0.25 |
| Trail 2 | | | | | | | | | |
| ww | 0 | 0 | 2 | 0 | 2 | 0 | 0 | 1 | 0 |
| bbbg | 3 | 0 | 3 | 0 | 6 | 0.5 | 0 | 0.5 | 0 |
| wwwg | 0 | 3 | 3 | 0 | 6 | 0 | 0.5 | 0.5 | 0 |
| bw | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 |
| | | | | | 3.75 | 0.125 | 0.125 | 0.5 | 0.25 |
| Trail 3 | | | | | | | | | |
| bbbgwwbg | 15 | 13 | 12 | 15 | 55 | 0.272727 | 0.236364 | 0.218182 | 0.272727 |
| gg | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 |
| | | | | | 28 | 0.136364 | 0.118182 | 0.609091 | 0.136364 |
| | | | | | Average | **0.218074** | **0.12868** | **0.441126** | **0.212121** |

Second
day 10/31

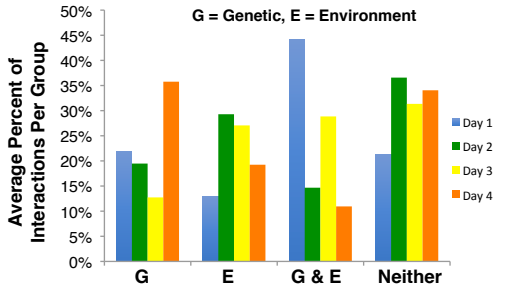
| Trial 1 | Genetic | Environment | Gen. & Env. | Neither G/E | Sum | G | E | G& E | Neither |
|---|---|---|---|---|---|---|---|---|---|
| wb | 0 | 2 | 1 | 0 | 3 | 0 | 0.666667 | 0.333333 | 0 |
| gy | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 |
| bw | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 |
| gwyw | 2 | 2 | 1 | 1 | 6 | 0.333333 | 0.333333 | 0.166667 | 0.166667 |
| | | | | | 2.75 | 0.090333 | 0.25 | 0.125 | 0.541667 |
| Trail 2 | | | | | | | | | |
| wwg | 0 | 2 | 1 | 0 | 3 | 0 | 0.666667 | 0.333333 | 0 |
| bg | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| wb | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 |
| bwy | 1 | 1 | 0 | 1 | 3 | 0.333333 | 0.333333 | 0 | 0.333333 |
| bbbg | 3 | 0 | 3 | 0 | 6 | 0.5 | 0 | 0.5 | 0 |
| gw | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| | | | | | 2.5 | 0.305556 | 0.333333 | 0.138889 | 0.222222 |
| Trail 3 | | | | | | | | | |
| ybbyyww | 5 | 5 | 4 | 7 | 21 | 0.238095 | 0.238095 | 0.190476 | 0.333333 |
| bbgywww | 5 | 5 | 4 | 7 | 21 | 0.238095 | 0.238095 | 0.190476 | 0.333333 |
| wb | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 |
| by | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| wwwy | 3 | 0 | 3 | 0 | 6 | 0.5 | 0 | 0.5 | 0 |
| | | | | | 10 | 0.195238 | 0.295238 | 0.17619 | 0.333333 |
| | | | | | Average | **0.194709** | **0.292857** | **0.146693** | **0.365741** |

Third day
11/1

| Trial 1 | Genetic | Environment | Gen. & Env. | Neither G/E | Sum | G | E | G& E | Neither |
|---|---|---|---|---|---|---|---|---|---|
| bbbgw | 1 | 1 | 3 | 3 | 10 | 0.3 | 0.1 | 0.3 | 0.3 |
| yyywwyb | 5 | 5 | 9 | 1 | 20 | 0.25 | 0.25 | 0.45 | 0.05 |
| ytt | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 |
| | | | | | 10.33333 | 0.183333 | 0.116667 | 0.35 | 0.45 |
| Trail 2 | | | | | | | | | |
| wgwg | 0 | 4 | 2 | 0 | 6 | 0 | 0.666667 | 0.333333 | 0 |
| bbbgwyy | 6 | 10 | 6 | 6 | 28 | 0.214286 | 0.357143 | 0.214286 | 0.214286 |
| | | | | | 17 | 0.107143 | 0.511905 | 0.27381 | 0.107143 |
| Trail 3 | | | | | | | | | |
| gbww | 1 | 2 | 1 | 1 | 5 | 0.2 | 0.4 | 0.2 | 0.2 |
| ww | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 |
| bgww | 1 | 2 | 1 | 2 | 6 | 0.166667 | 0.333333 | 0.166667 | 0.333333 |
| ytt | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 |
| | | | | | 3.25 | 0.091667 | 0.183333 | 0.341667 | 0.383333 |
| | | | | | Average | **0.127381** | **0.270635** | **0.288492** | **0.313492** |

Fourth
day 11/5

| Trial 1 | Genetic | Environment | Gen. & Env. | Neither G/E | Sum | G | E | G& E | Neither |
|---|---|---|---|---|---|---|---|---|---|
| bbggyyww | 16 | 14 | 12 | 14 | 56 | 2.285714 | 0.25 | 0.214286 | 0.25 |
| gw | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| bg | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| ggyy | 0 | 0 | 2 | 4 | 6 | 0 | 0 | 0.333333 | 0.666667 |
| | | | | | 16 | 0.321429 | 0.3125 | 0.136905 | 0.229167 |
| Trail 2 | | | | | | | | | |
| bw | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 |
| bgy | 1 | 1 | 0 | 1 | 3 | 0.333333 | 0.333333 | 0 | 0.333333 |
| wwb | 0 | 0 | 1 | 2 | 3 | 0 | 0 | 0.333333 | 0.666667 |
| gy | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 |
| bwwg | 1 | 2 | 1 | 2 | 6 | 0.166667 | 0.333333 | 0.166667 | 0.333333 |
| ytt | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 |
| yb | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| | | | | | 2.285714 | 0.071429 | 0.238095 | 0.071429 | 0.619048 |
| Trail 3 | | | | | | | | | |
| wwwyyb | 6 | 2 | 4 | 3 | 15 | 0.4 | 0.133333 | 0.266667 | 0.2 |
| bwwb | 0 | 0 | 2 | 4 | 6 | 0 | 0 | 0.333333 | 0.666667 |
| bg | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| wy | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| wy | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| | | | | | 4.8 | 0.68 | 0.026667 | 0.12 | 0.173333 |
| | | | | | Average | **0.357619** | **0.192421** | **0.109444** | **0.340516** |




## Conclusions

The results of this research indicate that the red flour beetle aggregates with others that are geneticly and environmentally similar to them, but they also group randomly with no correlation. Therefore, this information reveals that there is minimal to no structure behind how these beetles group. This data can then be beneficial in showing that there is no social system within groups of this beetle. And thus, guide research further towards finding a solution to this food storage pest.

## Future Directions

Testing the groupings of these strains of beetles for a longer amount of time to see if they favor their own strain. Make an attempt to mimic the pheromone they produce, to then test the beetle's attraction to a large amount. Create a mimic of the pheromone that their predators produce and test if that repels the beetles. Introduce common predator insects to test if that repels the beetles. Try different brands of nail polish on the beetles to see if that affects aggregation. Other factors to modify to test the aggregation of these beetles would be the environment size, the temperature of the environment, or the depth of the cracked wheat for burrowing purposes.

## References

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"Tribolium castaneum - Red Flour Beetle." Edited by John R. Mauremootoo, *BioNET-EAFRINET*, National Museums of Kenya, Tropical Pesticides Research Institute (TPRI).

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