How Sex Ratio Influences the Population Dynamics of the Red Flour Beetle

Jazmine Saunders[1,2] and Dr. Jeremy Marshall[1]

[1]Department of Entomology, College of Agriculture, Kansas State University
[2]Department of Biology, College of Arts and Sciences, Kansas State University

Abstract

Sex ratios can influence the population biology of organisms (Wade, M.j. 1984 and Lee, Smith 1978). Sex ratios can also influence the sexual and reproductive fitness of males and females (Michalczyk, Łukasz 2011). I wanted to determine if manipulating the sex ratios would influence the sexual biology of red flour beetles. I tested this using three different male-female ratios and three replicates of each. I found out that the 2:1 male-female ratio had an increased weight and fitness compared to the 1:1 and 5:1 ratios. This means that an increase in ratio will increase the reproductive fitness of red flours beetles to an extent; however, past the 2:1 ratio, it declines near the 1:1 ratio.

Questions, Hypotheses, and Predictions

Question: How does sex ratio influence the population dynamics of the red flour beetle?

Hypothesis: Changing the sex ratio of the red flour beetle will cause an increase in competition and fluctuation in the weight and reproduction.

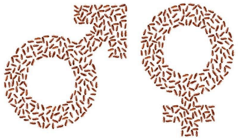
Prediction: I predict that with an increase in mating competition will decrease the weight of the beetles the higher the male to female ratio. Due to the increase in stress and pressure to mate, they will eat less. I also predict that the 1:1 ratio will reproduce more than the 2:1 ratio, and much more than the 5:1 ratio.

Purpose

The purpose of this research is to test the effects of different sex ratios of the flour beetle. With testing the ratios we can determine how much of an impact the different male to female ratios will have on it's competition for food and mating.

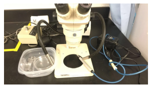
Study System

The red flour beetle (*Tribolium castaneum*) is a known pest in most tropical and subtropical countries that feed on grains and flour. The adult and larvae have chewing mouthparts and feed on the same food. These beetles are small, about 3-4 mm long with segmented antenna that are much shorter than it's body. These beetles are promiscuous which means both sexes can mate multiply. The females can lay up to 400 eggs in her lifetime which is 5-8 months (I had them 4 weeks).

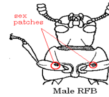


Methods and Experimental Design

In this experiment we separated the beetles into three different ratios: 1:1, 2:1, and 5:1. Each ratio had three replicates each of 18 beetles total with 9 males and 9 females in the first ratio, 12 males and 6 females in the second, and 15 males and 3 females in the last ratio.



They were separated using a microscope, a vacuum holder and their perspective jars. We had to put the beetles over ice because it slows them down and gives us enough time to properly sex them. The only hitch with that is you have to be careful not to let them drown in the condensation.

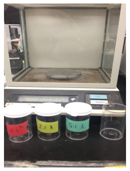


Using the tools mentioned, we could determine which was male or female my the appearance or lack of these "sex patches" on the upper part of their first pair of legs.

The next step was to put the correct male to female ratio in each jar. The red jars are the 1:1 ratios, the green jars are the 2:1 ratios, and the blue jars are the 5:1 ratios. There are three replicates of each and contain 18 beetles. In total there were 162 beetles used in this experiment. The jars were placed in a plastic tub and checked once a week.

After the 4 weeks, I separated the adults from the food and larvae using sieves and a vacuum holder. Each sieve has a different size grate.

The largest sieve has big enough holes to allow the larvae and food to go through while catching all the adults. Once the adults were counted, I removed the top sieve and a smaller sieve would catch some of the larger larvae, and after I've counted the larvae from that sieve I removed it and moved to the next. The same procedure went for the third sieve. The last sieve had no holes and contained the smallest larvae and the food. Each jar was sieved separately and the adults were placed in the appropriate plastic cup while all the larvae and food was put into a tub altogether.

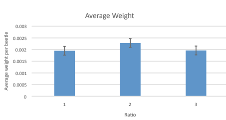


After the all the adult larvae were put into plastic cups, they were weighed. I weighed them by placing the beetles and the cup into the scale and recording that weight in grams. Then I'd put the beetles into an empty cup and weigh the original cup separately and record that weight. To get the weight of the beetles I subtracted the cup weight from the cup and beetle weight. I recorded the weight down to the 0.0001 of a gram because the differences in weight can be minute.

Results

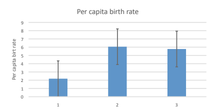
After counting all the larvae from each jar and weighing the adults I put the data into a table and graphed the relevant results. What I found is that the 2:1 ratio had the largest weight and the 1:1 and 5:1 were very similar in average weight. The 5:1 ratio and 2:1 ratios were very similar in per capita birth rate, while the 1:1 ratio had the lowest per capita birth rate.

Group	Ratio 1:1	Ratio 2:1	Ratio 5:1
A	0.00216	0.00175	0.00196
B	0.00189	0.00314	0.001976
C	0.0018	0.00196	0.00195
Average Weight	0.00195	0.00228	0.001962
Standard Deviation of Average Weight			0.000189



This graph shows the ratios: 1:1, 2:1, and 5:1 respectively and their average weight. Included are the error bars that show us the possible fluctuation in numbers. The data are not statistically different ($F_{2,6}=1.07$; $P=0.4005$). However, the data in the 2:1 ratio treatment did tend to be higher.

Group	Ratio 1:1	Ratio 2:1	Ratio 5:1
A	3.11	5.5	7.67
B	1	7.167	7.33
C	2.44	5.5	2.33
Per capita birth rate	2.183333	6.05567	5.77666667
Standard Deviation of Birthrate			2.15966243



In this graph, the error bars show us that the 2:1 and 5:1 ratios are practically the same, while the 1:1 ratio only slightly overlaps. Overall, the data suggest that the 2:1 and 5:1 ratios tend to have higher birth rates ($F_{2,6}=3.81$; $P=0.0854$); although the small sample sizes limit the power of the test.

Conclusions

In conclusion, we can see that the increased competition in the 5:1 ratio didn't have drastic differences compared to the 1:1 ratio like I predicted in my hypothesis. While the 1:1 and the 5:1 ratios fluctuated, it seems that the 2:1 had an "optimum" ratio and had the largest weight and one of the highest per capita birth rates. We can assume based on their biology that every female laid eggs, but due to the low PCB in the 1:1 ratio, we can't assume they were all fertilized. In the article "Effect Of Different Sex Ratios On The Oviposition…" by J.R. Lee and L.B Smith, a similar experiment was done and similar results were found with birth rates. In my data, the less the females present, the higher the birth rate went. In the article they concluded that in ratios with less females, the population growth increases. Sex ratio experiments can help biologists by getting a look into the social dynamics of different packs, herds, or colonies of animals. It can give us insight on to how animals respond or mating stress.

Future Directions

The results from this experiment are close to those found from similar experiments. There are a few things that could account for error in this experiment: the number of adults in two of the groups were 17 due to a death and one beetle flying away. Taking the right precautions for the flight doesn't occur again and although the death might have effected the data, it's a natural occurrence. Two groups also became outliers in this data and produced very low numbers (~10) of larvae. If this experiment were to be done again, I'd take into account the size of the larvae and determine the relevance of reproduction time to the different sex ratios.

The data collected leaves a lot of new questions such as: is there an optimum sex ratio in which red flour beetles could have the best survival, reproduction, and growth rates? An experiment like this would follow the same kind of pattern with different sex ratios, but in order to get a decent look at survival the experiment time would double to four months instead of two; or at least until the second generation started producing larvae. Another question that arises is what would the results be if we allow the larvae to reach adulthood and compare the sex ratios of the second generation. The only stress factor included in my experiment was the different ratio. If another factor was included, such as low food or crowding, how would the results differ? In that experiment I'd keep the ratios done in the previous experiment (three different ratios, with three replicates each) but I'd have each replicates in a different size container, or different food rations. This way we can see how which ratio does better in each container or with the limited amount of food.

References

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Acknowledgements

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