Tracking Genetically Modified Mosquitoes (Adapted for HHMI Data Explorer)

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Student Handout
(Adapted for ABLE 2025)

INTRODUCTION

This activity accompanies the BioInteractive video *Genetically Modified Mosquitoes*. In this activity, you will provide questions and explore experiments to examine how releasing genetically modified (GM) mosquitoes impacts wild mosquitoes.

MATERIALS

- access to the video HHMI Data Explorer
- access to the handout "Background_Does Using GM Mosquitoes Work?"
- spreadsheet software

LEARNING OBECTIVES

- Apply understanding of transgenics to ecology and life history of mosquitoes
- Visualize data and interpret results using a line graph and bar graph
- Appreciate the integration of science and society in preventing the spread of a vector-borne human disease

PRE-ACTIVITY

1. Describe your knowledge of or experience with mosquitoes.

2. For what diseases, in humans or other organisms, do mosquitoes act as vectors (carriers)?

3. Watch the video *Genetically Modified Mosquitoes* and record any questions you have. Briefly discuss the video and your questions with a small group of other students.

PART 1: Research Questions

Imagine you and your family have recently moved to a small town on the islands known as Key West off the most southern tip of Florida. Life is good among the white sandy beaches.

Health officials in town are growing concerned, however. News reports from South America suggest that an unusually large number of infants are being born with abnormally small heads, a condition called microcephaly. Health officials have identified the mosquito species *Aedes aegypti* as a vector for the Zika virus that seems to be causing this outbreak. Mosquitoes of this same species have been found living in the Florida Keys. Alarmed city officials want to do everything they can to prevent Zika virus from spreading in Florida.

Some towns in Brazil have used genetically modified (GM) mosquitoes to reduce the size of local mosquito populations, as shown in the video Genetically Modified Mosquitoes. Now officials in Florida are considering releasing GM *Aedes aegypti* mosquitoes in your town. But first they want to know if the method works. Let's look at the evidence.

4. Work with your group to develop one research question that would help determine whether releasing GM mosquitoes into the environment is an effective method for reducing wild mosquito populations in your area. For each research question you develop, fill out a table like the following.

Research question:
Data needed to answer the question:
Brief experimental design for collecting the data:
Predictions for your experiment: (what would the data show if GM mosquitoes are effective in reducing wild mosquito populations?)

5. Read through the handout "Background_Does Using GM Mosquitoes Work?" Compare and contrast the question, experimental design, and the data described in the reading to your research ideas.

PART 2: Data Analysis I – Exploring differences in GM program effectiveness across treated and untreated sites

6. **Results (Dataset Exploration).** Scientists at the company Oxitec completed an experiment in Brazil similar to the one described in the video *Genetically Modified Mosquitoes* (https://youtu.be/zlSTGkDyEfM). The real data results were organized into the spreadsheet named "Mosquito_AD_1.csv" (Take some time to understand and appreciate the data in this dataset). As background, the variables in the "Mosquito_AD_1.csv" spreadsheet are described below:

VARIABLE	DESCRIPTION
Site	Whether the site in reference were untreated sites or treated sites; Treated sites had GM mosquitoes administered
Variable	Whether the site in reference was the control (untreated) site or experimental (treated) site
GMO	Whether GM mosquitoes were administered. Although both untreated and treated sites have before and after designations, only the treated sites had GM mosquitoes administered in the after designation
Month_text	Month in text, categorical form (for bar graphs and box plots)
Month_number	Month in numeric form (for line graphs and scatterplots)
No. traps with eggs (L)	Total number of traps that had at least one mosquito egg in an area (Presence or absence data)
Total no. traps (T)	Total number of traps used in an area
Total no. eggs (E)	Total number of eggs found in traps in an area (Tally data)
Percentage traps with eggs (OI)	Percent number of traps in an area with at least one egg; also referred to as "Ovitrap Index"
Avg no. eggs per trap (AD)	Average number of eggs per trap in an area (also referred to as the Average Density of eggs per trap)

7. **Results (Data Visualization).** Import this spreadsheet into HHMI Data Explorer and generate a **line graph** with months on the *x*-axis (Select "Month_number") and AD on the *y*-axis (Select "Avg no. eggs per trap (AD)") for both untreated and treated areas. Next, set the "Grouping Variable" to "Site," which will display untreated data (control group) and treated data (experimental group) as separate lines on the same graph. **Insert a screenshot of the line graph.**

8. **Results (Data Interpretation).** Based on your **line graph**, describe the main pattern between the untreated site (control group) and treated site (experimental group) from your graph.

9. **Conclusion I.** What are all the possible explanations for these results? (HINT: Are there any assumptions being made about the success of mating by GM mosquitoes? Are there any assumptions being made about the environmental conditions across the sites?)

PART 3: Data Analysis II – Evaluating alternative explanations

10. **Results (Dataset Exploration).** Although there may be a difference in the average density of mosquitoes between the untreated and treated areas, there may be alternative explanations for the difference *other than* the GM mosquito program. For example, perhaps a localized weather event or the presence of a unique predator coincidentally occurred in the treated sites but not the untreated sites. To help eliminate alternative explanations like these, scientists collected subsequent data on the percentage of females that are mating with GM males.

    Here is what we know:

    - In the wild, female mosquitoes can mate with either normal (wild) or GM male mosquitoes.
    - Female mosquitoes who mated with GM males would lay eggs that have larvae that both fluoresce (glow red) and would die due to failure to metamorphose into adult mosquitoes (because they cannot get tetracycline in the wild).
    - Overall, the density of mosquitoes declined at treated sites. If this was caused by GM males (and not for some other reason), then a greater number of females must have mated with GM males than normal mosquitoes - this would result in more eggs being found that hatch into florescent larvae than non-florescent larvae.

    To address these concerns, scientists collected mosquito eggs in the wild, and then, in the lab, these eggs were allowed to hatch into larvae. Larvae were then screened for fluorescence using a fluorescent microscope. The percentage of females mating with GM males was calculated, as summarized in the dataset "Mosquito_MF_2.csv". Review the variables in this dataset based on the table below.

VARIABLE	DESCRIPTION
Site	Whether the site in reference were untreated sites or treated sites; All samples in this dataset were derived from treated sites
Source of Larvae	Larvae collected in the field or Larvae that were collected as eggs which were then hatched out in the lab
Month_text	Month in text, categorical form (for bar graphs and box plots)
Month_number	Month in numeric form (for line graphs and scatterplots)
Number of fluorescent larvae (F)	Total number of larvae that fluoresce; these are GM larvae that result from normal female and GM male mating.
Number of nonfluorescent larvae (N)	Total number of larvae that do not fluoresce; these are normal larvae that result from normal female and normal (non-GM) male mating.
Percentage of fluorescent larvae (M)	Percent number of fluoresce larvae out of all larvae (fluoresce larvae + normal larvae); also referred to as "Mating Fraction" (M)

11. **Results (Data Visualization).** Import this spreadsheet (Mosquito_MF_2.csv) into HHMI Data Explorer and generate a **bar graph** with months on the *x*-axis (Select "Month_text") and AD on the *y*-axis (Select "Percentage of fluorescent larvae (M)"). **Insert a screenshot of the bar graph.**

PART 4. Science and Society – Putting it altogether

12. Knowing what you know about this experiment, write a pretend letter to your local government official about whether GM mosquitoes should or should not be implemented in your neighborhood to control mosquito populations? Why or why not? (In your answer, briefly summarize the evidence (based on the Oxitec data) about whether releasing GM mosquitoes may or may not work in your area.)