ScienceLIVE

What the Bees Need: Pollinator Nesting Phenology

Grades: 6-12

Summary:

This ScienceLIVE lesson brings real native pollinator data into your classroom! Students will improve their graphing and quantitative skills by exploring citizen science-generated data from the University of Colorado's Bees' Needs program. The lesson explores the phenology, or timing, of native pollinator nesting behavior and the environmental factors that trigger this behavior. It also incorporates the concepts of variation in populations and natural selection, as well as the effect climate change is having on species-environment relationships.

Learning Goals:

After completing this lesson, students will be able to:

- Develop hypotheses that are appropriate to a scientific question
- Graph and summarize data in Google Spreadsheets (or MS Excel)
- Explain the meaning of patterns seen in a graph
- Describe why species phenology is variable across species, based in the concept of limiting factors
- Understand how selection pressures can select for advantageous traits in a population
- Predict the potential impacts of climate change on pollinator nest behavior

STANDARDS:

Next Generation Science Standards Addressed*:

Middle School:

- MS-LS4-6. Natural selection.
- LS4.C: Adaptation.
- Crosscutting Concepts: Graphs, charts, and images can be used to identify patterns in data.

High School:

- HS-LS2-2. Factors affecting biodiversity and populations in ecosystems.
- HS-LS3-3. Variation and distribution of expressed traits in a population.
- HS-LS4-2. Evolution.
- HS-LS4-3. Advantageous heritable traits.
- HS-LS4-4. Natural selection.
    - LS4.C: Adaptation
- HS-LS4-5. Changes in environmental conditions can lead to: increase in species, new species, extinction.

Common Core State Standards:

Middle School:

- Mathematics: 6.SP.A.2 Understand that a set of data collected to answer a statistical question has a distribution which can be described by its center, spread, and overall shape. (MS-LS1-4),(MS-LS1-5)

High School:

- SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

PREREQUISITE KNOWLEDGE:

- This lesson is designed to give students practice graphing and summarizing data. Depending on your class's background, revisiting independent (x) and dependent (y) variables as well the concept of an average, minimum, and maximum may be helpful prior to this exercise.

MATERIALS:

- This is a computer-based lesson that should be conducted in a computer lab in which students can work in groups of 2-3. The lesson uses Google Spreadsheets so a Google account is necessary to use the data. Access data here.
- Students will receive a worksheet and a guide to graphing and calculating summary statistics.
- All materials are available online at http://www.science-live.org/teachers/beesneeds.html
- If your school's internet capabilities aren't ideal for this kind of lesson, contact us at erbp@colorado.edu for an alternate version of the exercise (NOTE: The alternate version still requires computer access, but not in-class internet.)

*See Appendix for full descriptions of each standard

THE LESSON:

STEP 1: Show the class the ScienceLIVE Bees' Needs video

- Watch HD version online at: http://vimeo.com/112350478

STEP 2: What do bees need?

SETUP: There are four focal pollinator species featured in this lesson (members of the Genera Anthrax, Isodontia, Megachile, and Osmia; do not assign Hylaeus – it is used for an extension question later in the exercise). Given the computer-based nature of this activity, we recommend having students work on the graphing and data parts in groups of no more than 2 or 3. Groups with the same assigned species can come together before reporting to the full class, develop consensus answers, and then send a representative for that species to put values on the board.

Part 1: Initial Hypotheses: Why do some pollinators nest earlier than others?

- Have students develop initial hypotheses about factors that might affect pollinator nesting behavior.
- If your group needs more information on bee/wasp nesting to develop their hypotheses, descriptions and photos of nesting behavior can be found at http://www.science-live.org/bees/about/nesting.html
- Students will record their hypotheses on their worksheets, but have some students share their main hypotheses and write them on the board.

Part 2: Graphing and Summarizing Nest Dates

- Students will follow the directions on their worksheets to graph nest dates and calculate summary statistics (average, minimum, maximum), entering the statistics in tables on their worksheets. If you would like to demonstrate the graphing and summary process, the Hylaeus data is a good option. There is already a graph made for you in the Hylaeus sheet, intended for Part 4 of this lesson, but you can delete that graph and create one as a demonstration, if you would like. Just be sure the pre-made graph is accessible to students when they download the Google Spreadsheet.
- Check each group's graph and summary statistics vs. the ANSWER KEY provided to ensure all went well in the graphing process.
- If more than one group is working on each species, have them convene as a "Species Team" to compare graphs and summary statistics. Once they come to a consensus on the latter, have them send a representative to the board to post their statistics in a table like this (see ANSWER KEY for correct answers):

Species	Mean	Minimum	Maximum

Part 3: What do bees need?

- Discuss the variation in the data on the board and revisit the hypotheses from Part 1. Steer the discussion toward nesting materials and food for provisioning of nests with a question like, "What do these pollinators need to make their nests?"
- Students' goal in Part 3 is to determine if their species is more limited by provisioning (food) resources or plug resources when making their nests. Each group will figure out what their species uses for each of these purposes by visiting: science-live.org/bees/about/pollinatordiversity.html.
- Once they know what their species need, students will determine which of the predictor variables available to them (in the "Predictor Variables" tab in the Google Spreadsheet) best fits their species. Some classes may need help with this – we suggest pulling up the Predictor Variables on the main computer screen and going through each variable, so students are clear on what each represents. A key to these variables is provided below.

  KEY TO PREDICTOR VARIABLES:

  - *Total Bee/Wasp Nests* – This is a sum of all the Osmia, Megachile, Isodontia, and Hylaeus nests present at each time period, compiled from the Bees' Needs Project. It is used for predicting Anthrax, which lays its eggs into bee/wasp nests.
  - *% Leaf Buds Open* – This is the percent of lilac leaf buds in Boulder County that have begun to unfurl leaves at each time point. Lilacs are a tell-tale sign of spring's arrival, and open leaf buds are followed by full leaves on the bushes, so this is a good indication of leaf availability for leaf cutting bees like Megachile and Anthrax, which parasitizes leaf nesting species. This data is from the National Phenology Network.
  - *Mud* - This data is a "mud index" generated by ScienceLIVE staff based on daily temperature and precipitation data from CoCoRaHS.org and WUnderground.com. This is useful for Osmia, which plugs its nests with mud, and Anthrax, which parasitizes mud nesting species. See note in Google Spreadsheet re: Sept 2013!
  - *Pollen* – These values represent a pollen index generated from Pollen.com for the months of interest to this study. Pollen count data was multiplied by 10 for ease of comparison on student graphs. This data will be useful for the two bee species that provision nests with pollen: Megachile and Osmia.
  - *Cricket+Katydid* – This is the total number of tree crickets and katydid nymphs present in each time period in historical insect surveys conducted by the University of Colorado. This is a useful metric for Isodontia, a wasp that provisions its nests with tree crickets and katydid nymphs.
  - *% Grass Cover* – This is data on the percent of a Boulder-area prairie covered in green native grass in each time step. The percentage declines as grass dries out in the hot summer months. This useful for Isodontia, which plugs its nests with grass. This data is from datadryad.org: Prevéy JS, Seastedt TR (2014) Seasonality of precipitation interacts with exotic species to alter composition and phenology of a semi-arid grassland. Journal of Ecology 102(6): 1549-1561.

- Students will graph the provision and plug data in Google Spreadsheets and determine which of their resources (provisions or plugs) has a peak closest to their species' peak nesting period. While this is a gross oversimplification of these systems, it introduces the concept of limiting factors and how dependent living creatures are on one another and their environment.
- After students have determined whether their species is plug- or provision-limited, have them add this information to the table on the board, facilitating a class discussion about the differences and similarities among species.
- There are extension questions regarding natural selection and climate change for the students to answer on their worksheet. See ANSWER KEY for suggested responses.

Appendix: Standards Addressed

Next Generation Science Standards Addressed*:

Middle School:

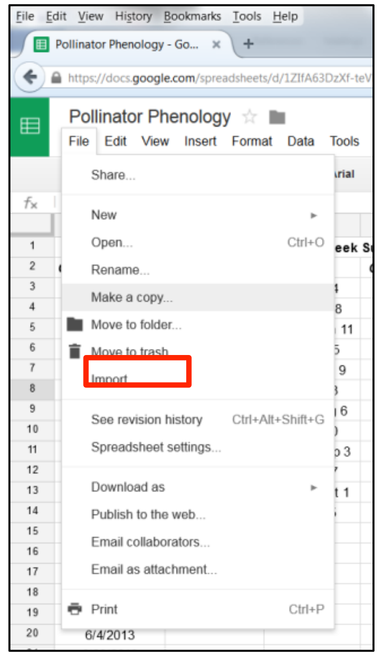
- MS-LS4-6. Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.
    - LS4.C: Adaptation
        - Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes. (MS-LS4-6)
- Crosscutting Concepts
    - Graphs, charts, and images can be used to identify patterns in data

High School:

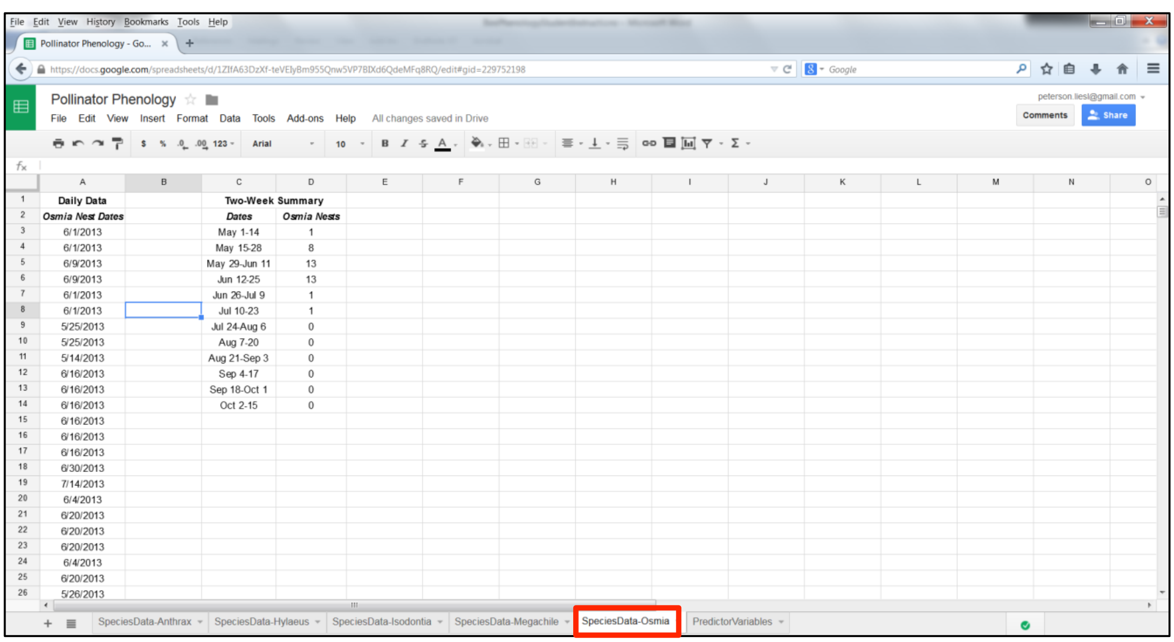
- HS-LS2-2. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.
- HS-LS3-3. Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.
- HS-LS4-2. Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.
- HS-LS4-3. Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.
- HS-LS4-4. Construct an explanation based on evidence for how natural selection leads to adaptation of populations.
    - LS4.C: Adaptation
        - Evolution is a consequence of the interaction of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment. (HS-LS4-2)
        - Natural selection leads to adaptation, that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not. (HS-LS4-3),(HS-LS4-4)
        - Adaptation also means that the distribution of traits in a population can change when conditions change. (HS-LS4-3)
        - Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline–and sometimes the extinction–of some species. (HS-LS4-5),(HS-LS4-6)
- HS-LS4-5. Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.
    - [Clarification Statement: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.

Graphing and Summary Statistics Instructions

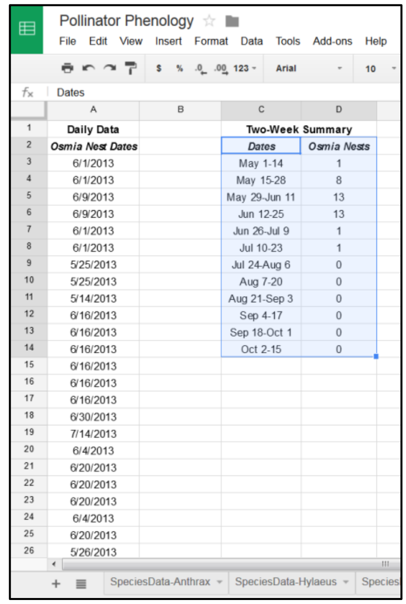
Part 2: Graphing and Summarizing Nest Dates



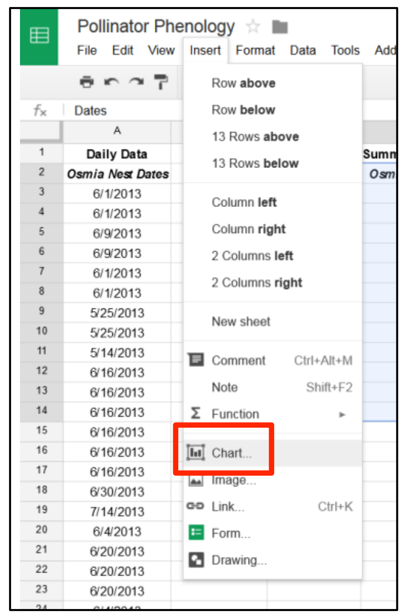
1. To graph when pollinators make their nests:
   - Open the Google Spreadsheet titled "Pollinator Phenology." https://docs.google.com/spreadsheets/d/1ZIfA63DzXf-teVElyBm955Qnw5VP7BIXd6QdeMFq8RQ/edit?usp=sharing
   - IMPORTANT: Click on "File" → "Make a Copy" and save the file with your group's name.
   - This spreadsheet has several worksheets:
     - *Species Data (e.g. SpeciesData-Anthrax)* – these worksheets each contain a summary of the nests created by one of five pollinator species in Bees Needs nesting blocks. The data are in two forms:
       - *Daily Data* lists all the nesting dates from Bees Needs nest blocks produced by the species.
       - *Two-Week Summary* summarizes the daily data into the number of nests created by the species in each of the twelve 2-week blocks between May 1 and October 15, 2013.
       - We will need the data in both of these forms to answer today's question.
     - *Predictor Variables* – this worksheet contains potential explanatory variables for pollinator nesting phenology (timing). We will use it in Part 3.
2. Your teacher will assign you a pollinator species to analyze. Begin with the *SpeciesData* worksheet for the species you were assigned.



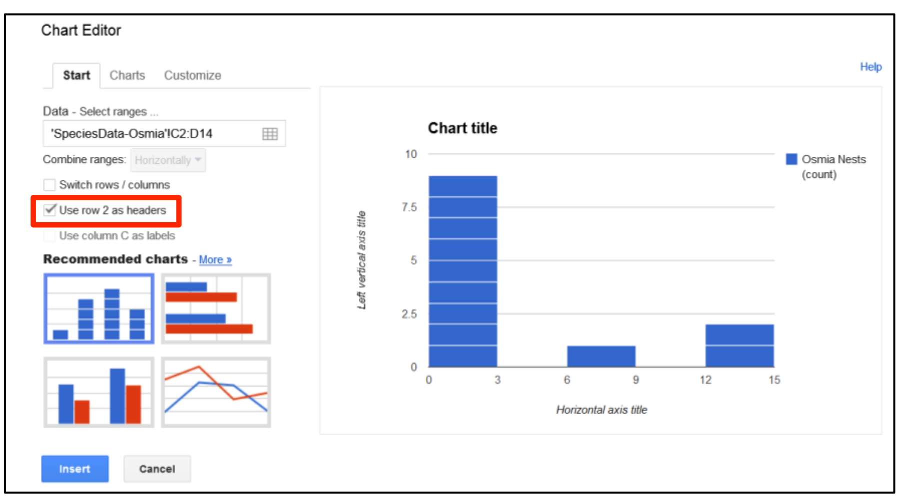
3. Make a graph of nest frequencies for your species:
   - Highlight the two columns you are interested in graphing: your independent variable (the "Dates" column) and your dependent variable (e.g. the "Anthrax Nests" column). Both of these columns are under the "Two-Week Summary" header.



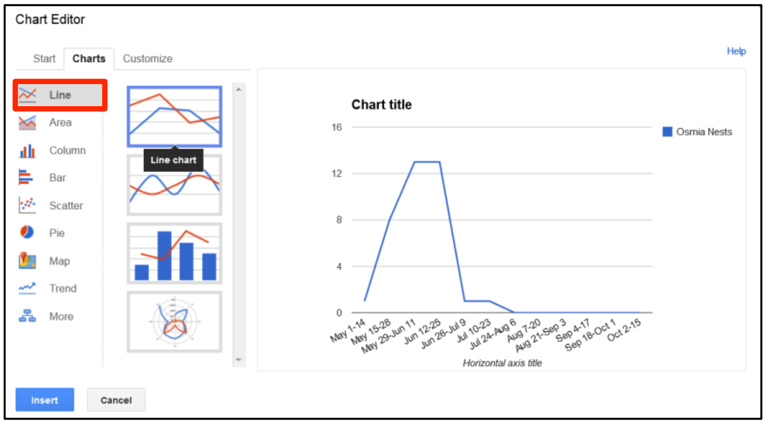
   - With the two columns highlighted, click on "Insert" → "Chart"



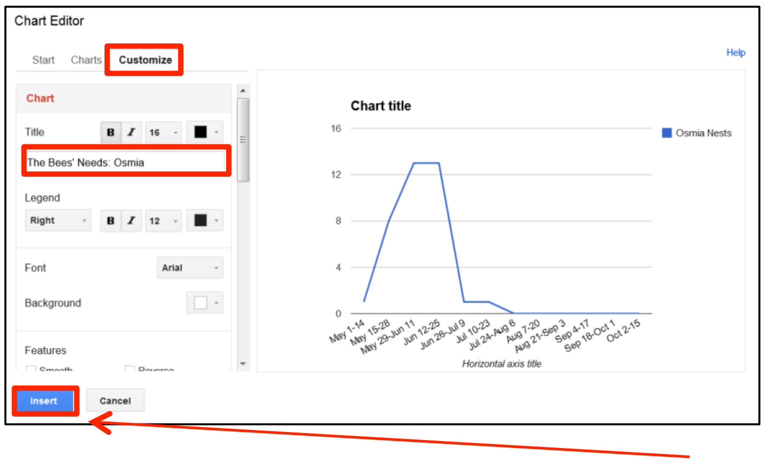
   - When the Chart Editor opens, in the "Start" tab, make sure the box next to "Use row 2 as headers" is checked.



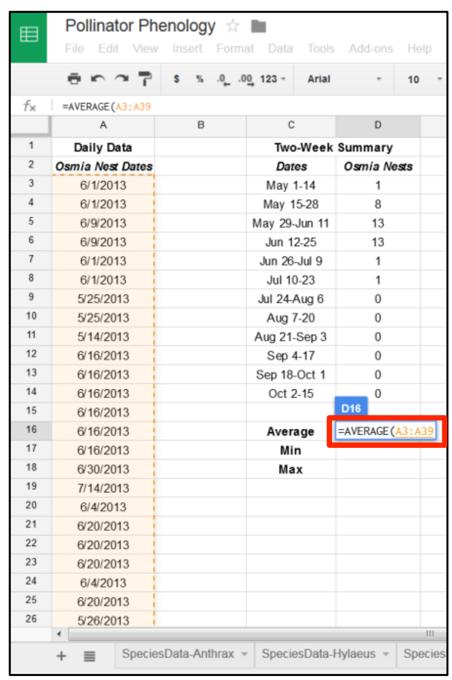
- Click on the “Charts” tab and select “Line.” Click on the first option that is listed next to “Line” (angled lines, rather than curved lines).



- Click on the “Customize” tab to provide a chart title, axis labels, and to change other formatting components of your graph, as you so desire.



- When you are done formatting and providing labels, click the blue “Insert” button.
- **Have your teacher check your graph at this point.**

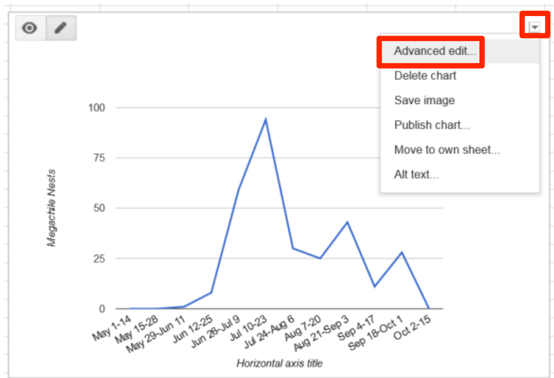


4. ***Analyzing your data.*** What do you see? Now that you have a graph, it is important to figure out what it is showing you. ***Summary statistics*** can also help you better understand your data. You will now calculate the ***average***, ***minimum***, and ***maximum*** nesting dates to help you understand when your pollinator nests.
   - Google Spreadsheets can calculate the ***average*** value of nesting date for you. In the blank cell to the right of the box labeled “**Average**,” type **=AVERAGE()**, click inside the parentheses () and highlight the dates in the “Daily Data” column. Enter your average in TABLE 1 on your worksheet.

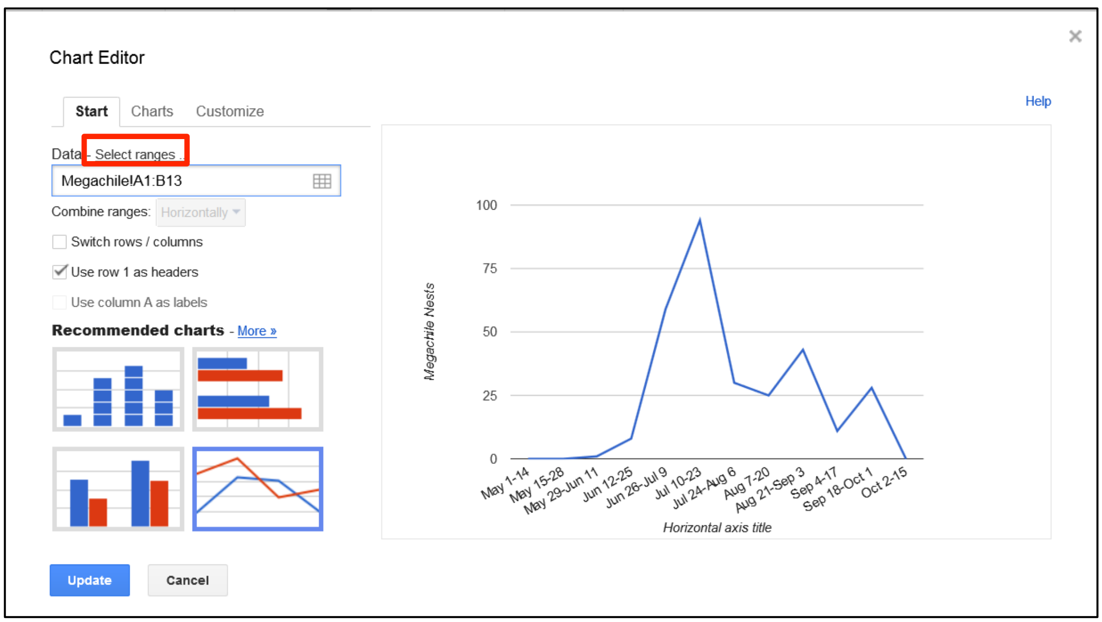
- ○ Next, calculate the ***minimum*** and ***maximum*** of Daily Data using the **=MIN()** and **=MAX()** functions, and enter them in TABLE 1.

Part 3: What do bees need?

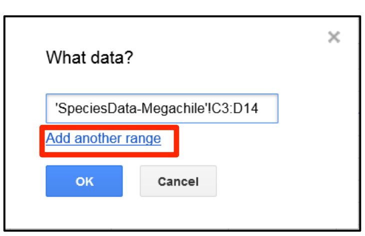
1. We now want to add more data to the graph you made earlier.
    - To do this, click on your graph in Google Spreadsheets.
    - Once you have clicked on your graph, a small triangle will appear in the top right corner of your graph.
    - Click this and select "Advanced Edit"

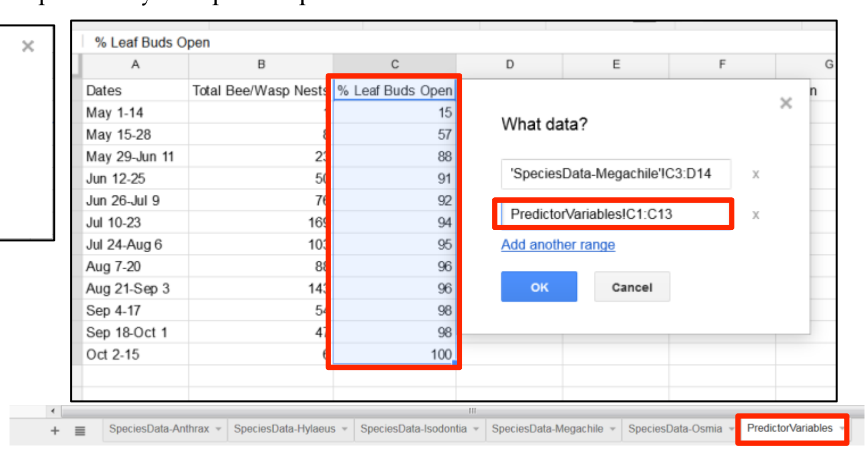


2. Once in Chart Editor, click on the "Start" tab and click "Select ranges."



3. In the "What data?" Window, select "Add another range," click in the new, blank box that appears, and navigate to the column of data you want in the "PredictorVariables" tab of the spreadsheet. Start with the variable that represents your species' provision resource.





4. Once the correct cells have been highlighted, click “Add another range” again and highlight your plug resource data column in “PredictorValues.”
5. When both data columns have been added to “What data?,” click “OK,” followed by “Update” in the main Chart Editor page.
6. You should now have a graph with multiple colored lines on it. If you don’t, ask your teacher to help you.

Date:______________________ **Name:** _________________________

Today's Question: Why do some pollinators nest earlier than others?

Part 1: Initial Hypotheses

A ***hypothesis*** is an educated answer to a scientific question. Come up with some hypotheses now for why pollinators might nest at different times.

1. Pollinator nest timing is determined by…____________________________________
2. ____
3. ____

Part 2: Graphing and Summarizing Nest Dates

To answer today's question, first we need to know when native pollinators build their nests. To do this, follow the instructions on your *Graphing and Summary Statistics Instructions* sheet.

TABLE 1: Analyzing your data.

Average	Minimum	Maximum

Part 3: What do bees* need? ***and other wood-nesting pollinators!**

Now that you have looked at when pollinators nest, we need to figure out ***why*** each of these pollinators nest when they do. Since all these species are wood nesters, we're going to focus on what each species uses in the nesting process. All these species need 1) something to feed (provision) their offspring and 2) something to plug their nests to protect their eggs and larvae from the elements. So we are going to test two alternative hypotheses:

H1) Pollinators' nest timing is determined by the availability of the food they provide their offspring.

H2) Pollinators' nest timing is determined by the availability of the material they use to plug their nests.

We will test these two hypotheses by graphing nest food and plug data on top of your graph of nest timing. How will we know which hypothesis is supported? Discuss this with your group.

To test these two hypotheses, first you need to figure out what your species uses to provision and plug its nests. To find out, go to science-live.org/bees/about/pollinatordiversity.html. Click on your species and enter what you find here:

Provisions with: ____

Plugs with: ____

Now return to your Google Spreadsheet and select the tab labeled "Predictor Variables." Which of these data sets best fit your species' provision and plug needs?

Provision Data Variable Name: __________________________________

Plug Data Variable Name: _____________________________________

Using the instructions under **Part 3: What do bees need?** on your *Graphing and Summary Statistics Instructions* sheet, add your two predictor variables to your pollinator nesting graph. Once you have graphed them, find the **date** for the peak value (highest value) for your species' nests, provision resource, and plug resource and complete the table below.

TABLE 2: Peak nesting and resources. ***Date Range***

Peak nesting: When does your species make the most nests?	
Peak provisions: When is your provision resource most abundant?	
Peak plugs: When is your plug resource most abundant?	

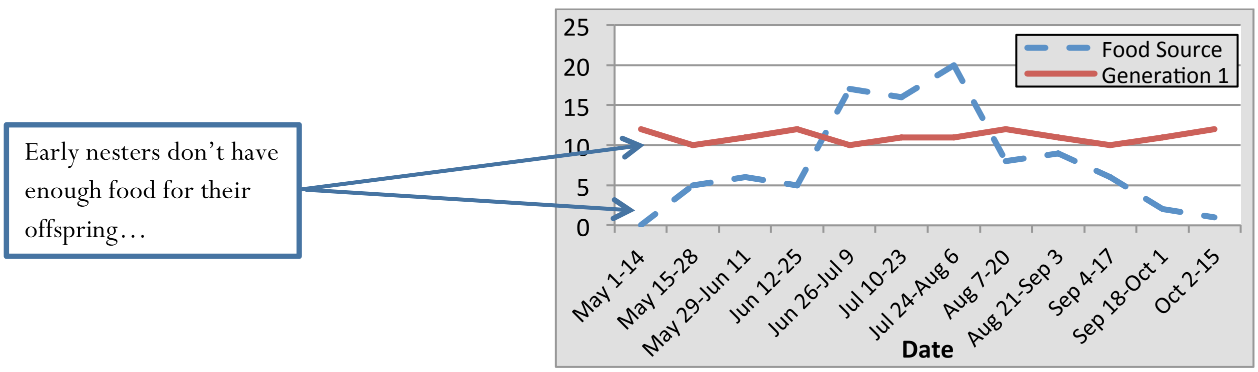
Based on your answers in TABLE 2, which hypothesis, H1 or H2, does your species support? __________

Why?

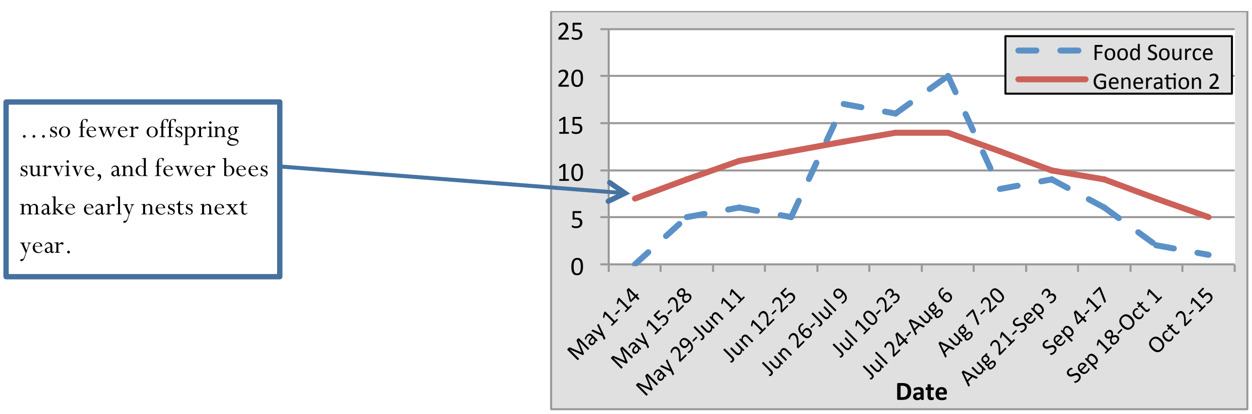
Part 4: Extensions

When factors like food or nest plug materials are limited, they can limit the nest success of individuals that try to nest in times of fewer resources: if there isn't enough food to provision the nest or aren't enough materials to properly seal the nest, eggs are less likely to hatch and become adults next year. On the other hand, nests made when resources are most abundant will probably produce the most offspring, leading to more members of the population next year that will reproduce at the same time as their parents (see graphs below). If the timing of food/nesting resources remains fairly consistent from year to year, then, over many generations, more and more of the population will nest in the same, optimal nesting time, causing peaks like those you graphed today. **Limited resources** like seasonal food or nesting materials that control the survival and reproduction of individuals in a population are called **selection pressures**.

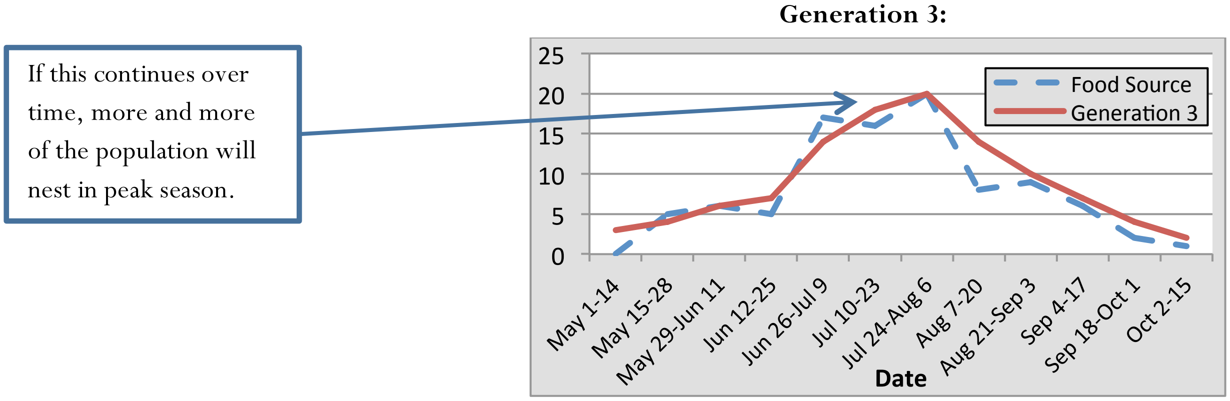
Generation 1:



Generation 2:



Generation 3:



1. There is a fifth pollinator species in the Google Spreadsheet that none of the class groups analyzed: Hylaeus. You will see a graph of Hylaeus nesting patterns on the "SpeciesData-Hylaeus" tab. Calculate average, minimum, and maximum values for Hylaeus and compare them to the other species we looked at today. Also, look at the peak nesting date for Hylaeus.
    a. How does this species' nesting behavior graph look different from yours? From the other species on the board?
    b. Look up Hylaeus on the ScienceLIVE website to find out what it uses for provisioning and plugging its nests. Why might this species show different nesting behavior than the other species we looked at today?

2. The data you looked at today show that there is an ideal time to build nests for each pollinator species, indicated by the peak nesting dates that we focused on. Now let's look at the non-peak nesters: those individuals that built nests earliest on your graph.
    a. Do you think the nests these early individuals made are as high quality as those made in the peak nesting period? (Hint: Do they have everything they need to build a successful nest?)

    b. Given your answer to (a), during which dates will the most successful nests be made? Consequently, which pollinator parents will produce the most offspring?

    c. Let's assume nesting time is inherited – parent pollinators pass nesting date on to their offspring. If all the offspring produced in 2013 nest in the same time period as their parents did, when will peak nesting be in the next year (2014)?

3. As climate changes, many species of plants are changing their phenology: they are producing leaves, pollen, and flowers up to one month earlier than they did 100 years ago.
    a. If nesting resources peak two weeks earlier in 2023 than in 2013, will your answer to (1-b) be the same? If not, which individuals of your species will have the most success in 2023?
    b. Will the population be as big in 2023 as in 2013? Why/why not?
    c. If all members of your species nested ONLY during the two-week peak period you recorded for 2013 (in other words, if there were no early or late nesters in 2013, only peak season nesters), how would your species be affected by climate change?

Science LIVE

ANSWER KEY

What the Bees Need: Pollinator Nesting Phenology

Date:______________________ **Name:** _________________________

Today's Question: Why do some pollinators nest earlier than others?

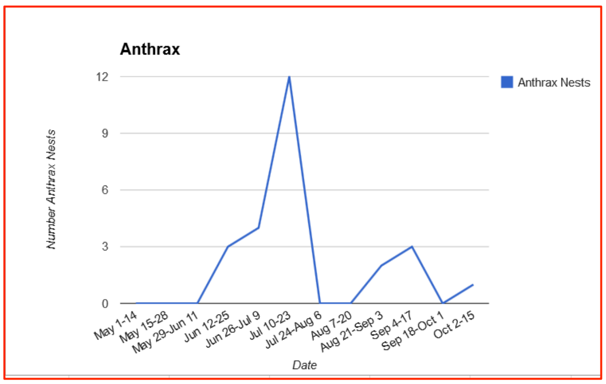
Part 1: Initial Hypotheses

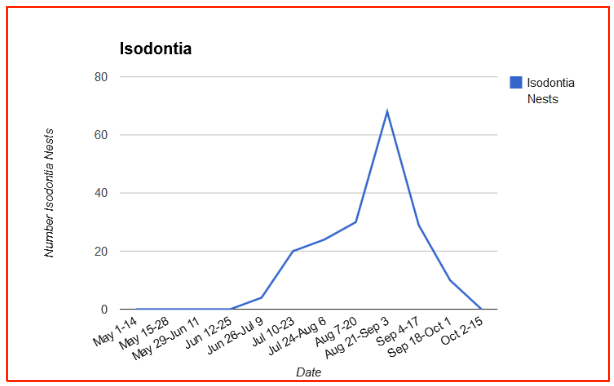
A ***hypothesis*** is an educated answer to a scientific question. Come up with some hypotheses now for why pollinators might nest at different times.

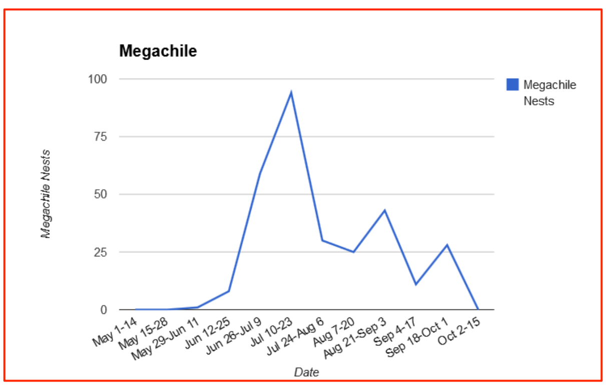
1. _Pollinator nest timing is determined by…_any potential ideas are welcome at this stage_______

Part 2: Graphing and Summarizing Nest Dates

To answer today's question, first we need to know when native pollinators build their nests. To do this, follow the instructions on your *Graphing and Summary Statistics Instructions* sheet.







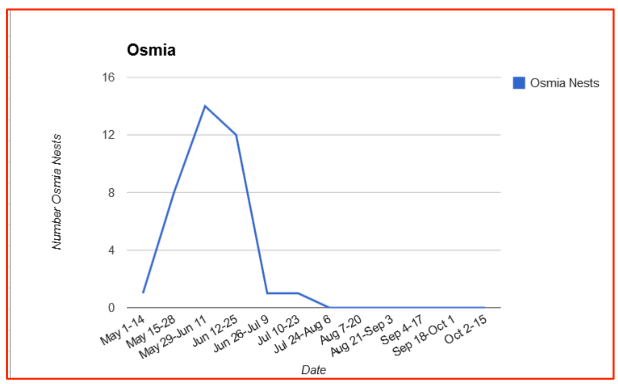


TABLE 1: Analyzing your data.

Species	Average	Minimum	Maximum
Anthrax	7/21/13	6/14/13	10/1/13
Isodontia	8/18/13	7/6/13	10/1/13
Megachile	7/30/13	6/1/13	10/1/13
Osmia	6/7/13	5/14/13	7/14/13

Part 3: What do bees* need? ***and other wood-nesting pollinators!**

We will test these two hypotheses by graphing nest food (provision) and plug data on top of your graph of nest timing. How will we know which hypothesis is supported? Discuss this with your group.

The predictor (plug or provision) that peaks closest to the nesting peak must be the key determinant of nest timing. The pollinator must wait for both factors to be present in the environment before it can successfully nest, so the resource that peaks later will be the main limiting factor for nesting.

To test these two hypotheses, first you need to figure out what your species uses to provision and plug its nests. To find out, go to science-live.org/bees/about/pollinatordiversity.html. Click on your species and enter what you find here:

Species	Provisions	Plugs
Anthrax	other pollinator larvae	Mud and leaves (uses the plugs built by other pollinators)
Isodontia	tree crickets and katydid nymphs	grass
Megachile	pollen	leaves
Osmia	pollen	mud

Now return to your Google Spreadsheet and select the tab labeled "Predictor Variables." Which of these data sets best fit your species' provision and plug needs?

Species	Provision Variable	Plug Variable
Anthrax	Total Bee/Wasp Nests	Mud Index
Isodontia	Cricket+Katydid	% Grass Cover
Megachile	Pollen	% Leaf Buds Open
Osmia	Pollen	Mud Index

TABLE 2: Peak nesting and resources.

Species	Peak Nesting Date Range	Peak Provision Date Range	Peak Plug Date Range
Anthrax	Jul 10-23	Jul 10-23	May 1-14
Isodontia	Aug 21 – Sep 3	Jul 24 – Aug 6	Jun 12-25
Megachile	Jul 10-23	May 1-14	Jul 10-23*
Osmia	May 29 – Jun 11	May 15-28	May 1-14

*Some students may be confused because leaves don't actually "peak" they plateau (reach 100% and stay there for the rest of the season). They should pick the date at which leaves first reach 100%, Jul 10-23.

Based on your answers in TABLE 2, which hypothesis, H1 or H2, does your species support? ___________

Species	Hypothesis Supported
Anthrax	H1-Provisions
Isodontia	H1-Provisions
Megachile	H2-Plugs
Osmia	H1-Provisions

Why?

Though some groups will support H1 and others H2, all should have the same reasoning: the variable that is controlling nesting peaks closer to the nesting peak than the other variable (e.g. Anthrax's food source peaks later than its plug material).

Part 4: Extensions

1. There is a fifth pollinator species in the Google Spreadsheet that none of the class groups analyzed: Hylaeus. You will see a graph of Hylaeus nesting patterns on the "SpeciesData-Hylaeus" tab. Calculate average, minimum, and maximum values for Hylaeus and compare them to the other species we looked at today. Also, look at the peak nesting date for Hylaeus.
    a. How does this species' nesting behavior graph look different from your species? From the other species on the board?

       Hylaeus has a similar average, minimum, and maximum to Megachile, but it doesn't have one peak – it peaks 3 times and has high nesting rates for most of the season.

    b. Look up Hylaeus on the ScienceLIVE website to find out what it uses for provisioning and plugging its nests. Why might this species show different nesting behavior than the other species we looked at today? Are the selection pressures for Hylaeus different than those for the other species we looked at today?
       Hylaeus plugs its nests with silk it makes itself, and provisions its nests with pollen, which is common throughout the season. Neither of these factors are limiting, so there aren't strong selection pressures on nesting phenology. Because of this, it isn't as dependent on its environment as other species and doesn't have a peak nesting date – it nests throughout the season.

2. The data you looked at today show that there is an ideal time to build nests for each pollinator species, indicated by the peak nesting dates that we focused on. Now let's look at the non-peak nesters: those individuals that built nests earliest on your graph.
    a. Do you think the nests these early individuals made are as high quality as those made in the peak nesting period? (Hint: Do they have everything they need to build a successful nest?)

       The early and late nesting individuals probably don't make as high quality nests, because their nesting materials and food aren't at their peaks during these times.

    b. Given your answer to (a), during which dates will the most successful nests be made? Consequently, which pollinator parents will produce the most offspring?

       The most successful nests will come from the individuals that nest at peak season, when their food and plug resources are available. As a consequence, the peak season nesters will produce the most offspring.

    c. Let's assume nesting time is inherited – parent pollinators pass nesting date on to their offspring. If all the offspring produced in 2013 nest in the same time period as their parents did, when will peak nesting be in the next year (2014)?

       Peak nesting will be in the same time period in 2014 as in 2013.

3. As climate changes, many species of plants are changing their phenology: they are producing leaves, pollen, and flowers up to one month earlier than they did 100 years ago.
    a. If nesting resources peak two weeks earlier in 2023 than in 2013, will your answer to (1-b) be the same? If not, which individuals of your species will have the most success in 2023?
       If nesting resources peak two weeks earlier, the individuals nesting in 2013's peak season won't have as much success – instead, individuals nesting two weeks earlier, when there are more nesting resources, will produce more offspring.

    b. Will the population be as big in 2023 as in 2013? Why/why not?
       The population will probably be smaller in 2023, because there are fewer parents making nests that early. As they have more nest success, the population will probably grow again.

    c. If all members of your species nested ONLY during the two-week peak period you recorded for 2013 (in other words, if there were no early or late nesters in 2013, only peak season nesters), how would your species be affected by climate change?
       If all members of a species only nested in peak season, the species couldn't respond to climate change. The species would decline and probably go extinct.