Introduction to Plant Phenology Lab

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Learning Objectives:

By the end of this module students will be able to:

1. Define and identify the reproductive parts of a plant

2. Explain the concept of flowering phenology

3. Apply the knowledge of reproductive morphology to scoring phenology in herbarium specimens

4. Analyze trends in phenology and interpret the resulting graphs

5. Understand the importance of data quality and defining variables

Vocabulary:

Phenophase - observable stage in the life cycle of an organism (i.e. flowering stage)

Phenology - The study of the seasonal timing of life history events

Nth day of the year - Day of the year from the beginning of the year (i.e. January 1 is the 1st day of the year)

Introduction:

Phenology, the seasonal timing of life history events, is important to the survival of plants and their ecological associates for whom plants provide homes and food and on whom the plants depend on for various ecosystem services. Because plant phenology is often cued by climatic variables, such as temperature and precipitation, studying plant phenology is significant for those interested in understanding the effects of climate change on ecosystems.

For plants, most research has examined either vegetative or flowering phenology. Flowering phenology is characterized by an onset date, peak date and termination date. Typically, researchers focus on several phenological stages or phenophases, such as timing of early bud (when most flowers are in bud), peak flowering date (many flowers are fully open), and fruit set date. By observing these stages with climatic variables, researchers have found several general trends. For example, researchers have found that spring flowering plants have started to bloom earlier as temperature warms (see multiple examples in Banaszak et al., 2020). However, phenological trends are highly species dependent and for many species, there is often little detail about their phenology and associated geographical or environmental cues, especially for arid ecosystem plants.

One large data source of phenological data is herbaria. Herbaria are collections of preserved plant specimens that represent a wealth of data in both the specimen itself and its metadata (i.e. locality and date data). In recent years, specimens have been used for myriad applications in genetics, conservation, ecological niche mapping and phenology. With advances in digitization, herbaria have been able to publicize both data and high resolution images of their specimens for a global audience. Flowers, insect damage, leaves and fruit all can be observed in these herbarium specimen images. Each specimen may have reproductive morphology that indicates where the specimen was in its life cycle at a particular place and time. We can leverage this information from many historical specimens, which sometimes come from hundreds of years ago, allowing us to observe changes in phenology over time.

A note of caution: Because the original intent for herbarium specimens was to be used for floristic and taxonomic studies, most specimens have been collected with flowers and ideally with fruit, because of their important diagnostic characteristics. As a result, phenological studies using only herbarium specimens may be biased. Keep in mind these and other potential collecting biases as you work through this lab. Many of these biases can be remedied by the use of more herbarium specimens (= more data) and supplemental field studies.

Activities

Today, you will be characterizing the phenology of the local Desert Prickly Pear Cactus (*Opuntia phaeacantha*) using herbarium specimens from the UTEP Biodiversity Collections, as well as specimens from other herbaria around the country. This cactus species spans the southwest US, lower Great Plains and Mexico. These specimens and their images have been made available through the Global Biodiversity Information Facility <https://www.gbif.org/>. You’ll also be examining a few common variables that might affect the phenology of this plant. Read the instructions below and complete each exercise. Write your answers on the worksheet provided in the lab.

## Pre-lab Activity

Think- Pair- Share (5 minutes) Discuss this with your TA:

*What are some factors that might affect the timing of a plant’s life cycle?*

For any study, it is important to define your variables and define how you will score a variable. The following exercise is designed to help you define the phenophases for the data collection phase of this lab (Keep it in front of you!). For the chosen species (in this case prickly pear), draw the different parts of the plant that we will be looking at today. Where applicable, label each with terms you learned in class (listed below) and describe in text the identifying characteristics of each part.:

**list of terms:** spine, glochid, areole, stem (cladode), bud, androecium, gynoecium, stigma, style, anther, filament.

Flower (*inferior or superior ovary?*):

Fruit:

Unopened flower (bud)

## Activity 1: Data collection

1. Each student will be preassigned a set of 5 images to score on a shared google doc that is linked in your blackboard folder. Navigate to the link related to your section and your assigned specimens. Your TA will give you instructions on what specimens you will collect data for.
2. You will be working in the first tab named “Data Entry Sheet”. All data will be entered in the columns that are highlighted in yellow. Replace your “Assignee” number with your first and last name so that you can receive credit.
3. The data have been downloaded in GBIF for you and represent preserved specimens of *Opuntia* phaeacantha throughout the southwest. Under the “multimedia” column, click the link in the appropriate cell to open the link to a high resolution image of the specimen. You can zoom in on the specimen by clicking the image with the magnifying glass.
4. Based on your image, score the phenophases in each column as “yes” or “no” (all in lower case) for unopened flowers (buds), opened flowers, fruit, and roots. **The automated graphs in the next tab function with what are called “pivot” tables and aggregate unique values. Be sure to spell the “yes” and “no” values correctly or your data will become messy and the graphs will not automate properly! Drop down options should appear as you start to type, or you can select from the drop down menu. A red flag will appear if you enter the data improperly. You are entering attribute data that may be shared with researchers all over the world, so be sure to score the photos to the best of your ability! The best way to do this is to copy your yes and no values down the column as appropriate!**
5. Next, we will collect interpolated precipitation data from when the plant was collected (**Maximum temperature from the spring of the given year is already provided**). You will need to use the following columns highlighted in green from your data: Latitude, Longitude, and Year of collection. Navigate to the Oregon State Prism Climate Explorer <https://prism.oregonstate.edu/explorer/> . The link is provided in your blackboard shell.
   1. Copy and paste the latitude and longitude coordinates for your specimen into the climate data explorer.
   2. Click **Zoom to Location (You have to press this!)**
   3. Make sure that “precipitation” is checked in the data settings.
   4. Select “Annual Values” and enter in the **PREVIOUS** year your specimen was collected for in the start and end date
   5. Click “Retrieve Time Series”
   6. Once the graph has been generated at the bottom of the page, mouse over the blue bar graph to get the value in units of ppt.
6. Repeat steps 2-4 for the rest of your specimens

## Activity 2: Results

The google sheet has already been set up to automatically generate graphs of interest for you in the Results Dashboard. Navigate to each tab. The graphs are summarized as the following:

1. histogram of flower budding, flowering and fruiting
2. Nth day of flowering and fruiting vs. precipitation
3. Nth day of flowering and fruiting vs. temperature

**To help you better understand the range of times in the phenophase, the “Nth Day to Day of Month Reference Sheet” tab lists a conversion of Nth day to Month and Day. Remember that a smaller Nth day of the year means an earlier day of the year. Use the above graphs to answer the following.**

1. Based on all the data and graphs that you’ve generated, characterize the timing of the different phases (budding, flowering, fruiting) using the histograms you generated. **Be sure to describe when each phase starts, when it peaks, and when it ends in terms of the month (i.e. it begins to flower in early December, peaks in January and ends in late March)**.
2. budding
3. flowering
4. fruiting
5. Which of the above phases overlap if they do?
6. How did temperature and precipitation affect the flowering/fruiting times of the *Opuntia*? For each of the letters below, **circle** the appropriate words to describe the trends of the (Nth day vs. temperature/precipitation) graphs. In the observation section, describe generally how strong the correlation was, any patterns you noticed, and if there were any outliers,
   1. **for flowering:**
      1. As precipitation **(increased/decreased)** flowering time **(increased/decreased/didn’t change much)**

Observations:

* + 1. As max temperature of the spring **(increased/decreased)** flowering time **(increased/decreased/didn’t change much)**

Observations:

* 1. **for fruiting:**
     1. As precipitation of last year **(increased/decreased)** fruiting time **(increased/decreased/didn’t change much)**

Observations:

* + 1. As max temperature of spring **(increased/decreased)** fruiting time **(increased/decreased/didn’t change much)**

Observations:

## Activity 3: Discussion questions

1. Based on the data you have generated today, what phenophases would you expect to see on the prickly pear outside right now? (go look outside after this lab!)
2. Write some possible explanations for why temperature and precipitation may have affected the following. If you did not see a very strong trend, explain why you may not have seen a correlation.
3. flowering time
4. fruiting time
5. Today, you may have found that the timing of a phenophase may have shifted with either precipitation, temperature or both. Given that many pollinators depend on plants, what is one way that you think insects that are dependent on this plant may also be affected if the flowering time shifts earlier or later?

Your feedback about this module/lab is very important! When you finish, use your phone to scan the QR code below to take a survey (it will take 5 minutes; all answers are completely anonymous). If you cannot access the QR code, you can also access the survey at <https://utep.questionpro.com/t/AWHwCZvCq5>

## Assessments

Your lab assignment/homework is to answer all of the *questions in italics* above*.* Write your answers in the worksheet in lab

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## References and Resources:

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Phenophase data collection sheet

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Name | Catalog Number | Opened flowers | fruit | unopened flowers | roots | decimalLatitude | decimal Longitude | Preciptiation | Temperature |
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