**Case Study Key: Pollination of the Early Spider Orchid (*Ophrys sphegodes*)**

**by the Solitary Bee (*Andrena nigroaenea*)**

This case study builds from research conducted on the relationship between spider orchids and solitary bees. The research uses natural history collection data to explore a potential phenological shift between an orchid that employs sexual deception and a solitary bee.

Students completing this exercise will be able to:

1. Appy knowledge of plant form and function to identify plant sexual structures.
2. Measure shifts in the timing of plant flowering due to climate change.
3. Predict the effects of phenology shifts on plant/pollinator interactions.
4. Investigate publicly available biodiversity datasets when addressing a relevant scientific question or problem

**Plant Morphology:**

*Ophrys sphegodes*, the early spider orchid, has flowers with yellow-green sepals and petals and one highly modified, velvety brown central petal (a **labellum**) at the base of the flower. Each flower contains both an androecium and a gynoecium that is fused into a structure called a column or **gynostemium**. There is single male anther is found at the tip of the column and instead of producing individual pollen grains, the pollen is concentrated in two masses (called **pollinia**) at the end of the anther (you can see the green column curved over the top of the brown labellum in the picture below). The stigma is on the underside of the column just below the anther.

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| --- | --- |
| Macintosh HD:private:var:folders:TL:TLeomGpAH24WJTp1NCqapk+++TM:-Tmp-:TemporaryItems:Early-spider-orchid-flower-Dorset.jpg | 1. Is the flower complete or incomplete?   *Complete*   1. Is the flower perfect or imperfect?   *Perfect*   1. Is the flower radially or bilaterally symmetrical?   *Bilateral* |

The *Ophrys sphegodes* ovary typically develops into a dry fruit that breaks open at maturity along three or six longitudinal slits, releasing the seeds. Example cross-sections of orchid fruits are shown below.

|  |  |
| --- | --- |
| Macintosh HD:Users:linto1dl:Desktop:orchid fruit.png  image source: public domain | 1. Is orchid fruit dehiscent or indehiscent?   *Dehiscent*   1. Within that category, what specific type of fruit do orchids have?   *Capsule* |

**Pollination/Coevolution:**

|  |  |
| --- | --- |
| *Ophrys sphegodes* is pollinated by the solitary bee *Andrena nigroaenea*. These orchids attact pollinators by sexual deception. They produce the sex pheromones of female bees and also provide visual and tactile cues, attracting the males for “mating”. During pseudocopulation, the pollinia are transferred to the male bee’s head and pollen can be transferred to the next flower visited. The flowers don’t provide nectar to the bees as a reward, so there is a net energy loss to the bees who are fooled by the deception. | Source: <https://www.flickr.com/photos/>  gails\_pictures/ [Gail Hampshire] |

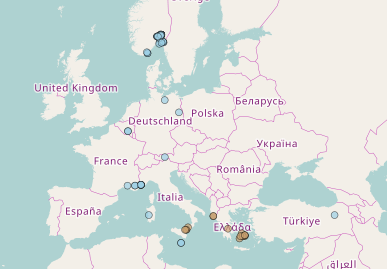
1. If a random mutation occurred in the bee species that led to a new phenotype in their sex pheromones that allows males to more accurately identify females, how might the presence of *Ophrys sphegodes* act as a selection pressure that influences the fitness of individuals with this new version of the trait in competition with individuals with the original sex pheromone cues?

*If there were two phenotypes in the sex hormones and one of the phenotypes allowed males to find females more accurately, that phenotype would be favored by natural selection. Individuals with that phenotype would produce more offspring (have higher fitness) and that form of the trait would increase in frequency.*

1. Go to [www.iDigBio.org](http://www.iDigBio.org)/portal. Search for *Ophrys sphegodes*.
   1. How many specimen records were located? *24 [Fall 2016 – subject to change over time]*
   2. What countries were the specimens collected in? *Greece, Italy, UK, France*
2. Now add *Andrena nigroaenea* to your search.
   1. How many *Andrena nigroaenea* specimen records were located? *67[Fall 2016 – subject to change over time]*
   2. How does their distribution compare to *Ophrys sphegodes*?

*overlaps or near/within part of the range*

* 1. Take a screen shot or export your map and paste the result below.



1. If the distribution of *Ophrys sphegodes* and the range of *Andrena nigroaenea did not overlap*, what would this tell you about the pollination of *Ophrys sphegodes?*

*If their ranges did not overlap, then Andrena migroaenea could not be the pollinator of Ophyrs sphegodes*

**Phenology:**

Phenology is the study of the timing of life cycle events in different species. Many of these events are triggered by seasonal temperature changes. As the global temperature increases to rise due to climate change the timing of life cycle events might by disrupted.

In, 2011 researchers examined 102 herbarium specimens of *Ophrys sphegodes* from the Natural History Museum in London. For each specimen, the percent of open flowers was determined. This data was used to determine the peak flowering dates for each year for which there was adequate data.

To see how the timing of the bee reproduction aligns with peak flowering dates, the researchers examined field records of the flight date (first flight of spring) for *Andrena nigroaenea* from the Bees, Wasps, and Ants Recording Society (BWARS). BWARS is a citizen science project in Britain and Ireland. Volunteers are trained to make and record accurate observations of these organisms into a shared database. The researchers also examined over 350 *Andrena nigroaenea* specimens at the Natural History Museum and Oxford University Museum. Based on these two sources, the researchers determined the average time to first flight for each year.

Climatic data for all years were obtained from the UK Meteorological Office and mean March to May (Spring) temperature was calculated for each year. Peak flowering time and time to first flight were plotted against mean March to May temperature and regression lines were fitted to both data sets. Simplified data points are shown in the table below to allow you to recreate these lines. Dates are reported as “Days after March 1” as in the original paper (as points of reference, May 1 is 61 days after March 1; June 1 is 92 days after March 1).

To see the complete data and figures, refer to the original articles (Robbirt et al., 2011; Robbirt et al., 2014).

Table 1. Comparison of flowering time and bee emergence at different spring temperatures. [Data extracted from Robbirt et al., 2014]

|  |  |  |
| --- | --- | --- |
| March – May Temperature  (°C) | Peak Flowering Time  (days after March 1) | First Bee Flight  (days after March 1) |
| 7.0 | 85.1 | 92.9 |
| 7.5 | 81.8 | 85.0 |
| 8.0 | 78.5 | 77.3 |
| 8.5 | 75.4 | 69.7 |
| 9.0 | 72.2 | 61.8 |
| 9.5 | 69.0 | 54.1 |
| 10.0 | 65.7 | 46.2 |

1. Plot peak flowering time and first bee flight (x-axis) vs March – May temperature (y-axis) in Excel. Plot both lines on the same graph and paste your graph below. Include axis labels and a figure legend.
2. Describe what the graph shows. How do these two species respond to differences in temperature? Which of the two species is responding more strongly?

As the Temperature increases the first flight is earlier and the flower peak is earlier (fewer days after March 1). The slopes for flowers shows and earlier flower peak at higher temperatures but the slope for the bee emergence time is steeper or "stronger."

1. *Ophyrs sphegodes* flowers can remain fertile for 4-6 weeks. In bees, males appear only at a specific point in the life cycle, mate with females, and quickly die off. Therefore, the orchids have a limited window of time to trick the male bees into transferring their pollen.
   1. At 7°C, how does the timing of the arrival of the bees compare to the peak flowering time?

Flowers are open and likely receptive when Bees emerge

* 1. At 10°C, how does the timing of the arrival of the bees compare to the peak flowering time?

Flowers do not peak for 19 days after the bees emerge

* 1. Predict how continued increases in global temperature might affect the reproductive success and abundance/existence of *Ophyrs sphegodes*. Use evidence from the graph to support your prediction.

If temperature further increases the asynchrony between the bee and orchid will result in a large gap in time, the bees may be past mating when the orchids are at peak receptivity and will not be actively looking for a mate. This could result in a low pollination success.

**References and Resources:**

Jacquemyn H, Hutchings MJ. 2015. Biological flora of the British Isles: *Ophrys sphegodes*. *Journal of Ecology* 103, 1680-1696.

Robbirt KM, Roberts DL, Hutchings MJ, Davy AJ. 2014. Potential disruption of pollination in a sexually deceptive orchid by climatic change. *Current Biology* 24, 2485-2489.

Robbirt KM, Davy AJ, Hutchings MJ, Roberts DL. 2011. Validation of biological collections as a source of phenological data for use in climate change studies: a case study with the orchid *Ophrys sphegodes*. *Journal of Ecology* 99, 235-241.