# DATA Nugget

## Sexy smells

Featured scientist: Danielle Whittaker from Michigan State University

*Research Background:*

Animals collect information about each other and the rest of the world using multiple senses, including sight, sound, and smell. They use this information to decide what to eat, where to live, and who to pick as a mate. Choosing a mate is an important decision that requires a lot of information, such as how healthy a potential partner is, and information about their genes. Mate quality can affect how many offspring an animal has and if their genes will get passed on to the next generation.

Danielle holding a male dark-eyed junco. Notice the white feathers in his tail.

Many male birds have brightly colored feathers that are attractive to females. For example, the peacock has bright and elaborate tail feathers, called ornaments, which are thought to communicate a male's quality. Besides using their sense of sight to see ornaments, female birds may use their other senses to gather information about potential mates as well. Danielle, a biologist, wanted to figure out if birds use vision and their other senses, such as smell, to determine the quality of potential mates.

Danielle decided to research how dark-eyed juncos communicate through their sense of sight and smell. Dark-eyed juncos, a type of sparrow, are not colorful birds like peacocks, but they have bright white feathers in their tails. Male dark-eyed juncos have more tail-white than females. Females may use the amount of white in a male's tail to determine whether he is a high quality mate. Danielle was also interested in several chemical compounds found in junco preen oil, which birds spread on their feathers. This preen oil contains compounds that give birds their odor. Danielle found that males and females have different odors! Just as males have more white in their tail feathers, they also produce more of a chemical called 2-pentadecanone. Danielle wanted to test whether this chemical might be a signal of mate quality.

To test her two alternative hypotheses, Danielle captured male juncos at Mountain Lake Biological Station in Virginia. She measured their amount of tail-white by estimating the proportion of each tail feather that was white, and adding up the values from each feather. She also took preen oil samples and measured the percent of each sample that was made up of 2-pentadecanone. She followed these birds for one breeding season to

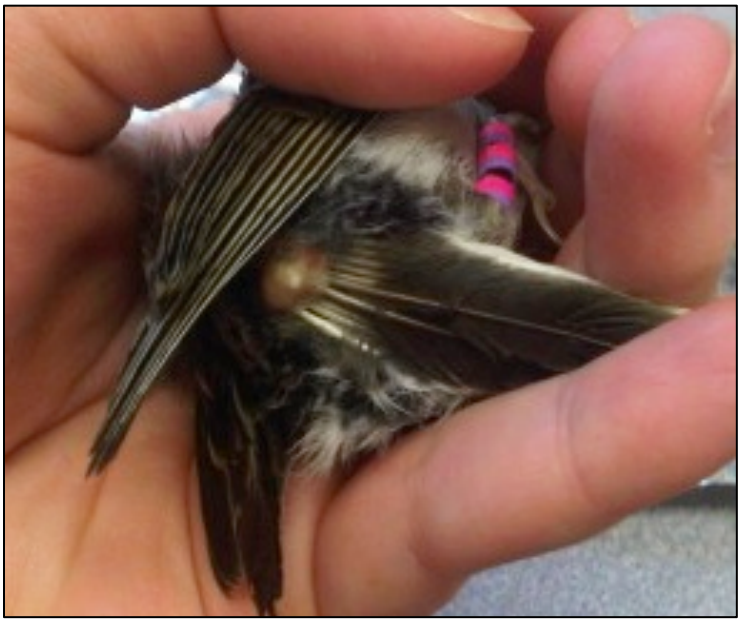
find out how many offspring they had. If females pick mates based on visual ornaments, then she predicted males with more tail-white would have more offspring. If females pick mates based on smell, then she predicted males with more 2-pentadecanone would have more offspring.

**Check for Understanding:** After reading the Research Background, students should be able to

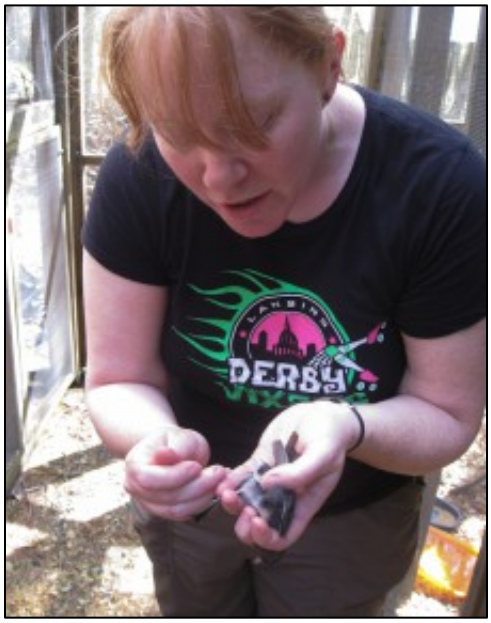
- describe why certain mates would be preferred over others, and why this is important.
- describe different ways that male birds can signal their quality to potential mates.
- understand why ornaments are a reliable way for females to assess quality in potential mates. Because they are costly to produce and make a bird vulnerable to predation, a male that has a large ornament and survives is likely a high quality mate.
- in their own words, state the two alternative hypotheses that Danielle is testing.
- discuss other ways in which animals communicate and why it is important that they can send signals to each other.
- describe why Danielle uses the number of offspring a male has as a proxy for female mate choice. In this experiment, Danielle did not watch to see which males the females mated with. Danielle did paternity analyses using DNA to determine which males fathered each offspring at her field sites. She is making the assumption that males with more offspring were chosen more often by females for mating.

*Scientific Question*: How do female juncos determine the quality of potential mates?

*What is the hypothesis?* Find the two hypotheses in the Research Background and underline them. A hypothesis is a proposed explanation for an observation, which can then be tested with experimentation or other types of studies. Having two alternative hypotheses means that more than one mechanism may explain a given observation. Experimentation can determine if one, both, or neither hypotheses are supported.



A preen gland where dark-eyed juncos produce preen oil.




Danielle removing preen oil from a junco.

*Scientific Data:*

**Use the data below to answer the scientific question:**

| Bird Number | Number of Offspring | Amount of Tail-White | Percent 2-pentadecanone |
|---|---|---|---|
| 160143611 | 0 | 2.4 | 3.8% |
| 160143709 | 0 | 2.3 | 1.4% |
| 188171045 | 0 | 2.5 | 2.8% |
| 192131040 | 0 | 2.7 | 1.9% |
| 222157229 | 0 | 2.6 | 2.3% |
| 232170101 | 0 | 2.3 | 1.5% |
| 232170210 | 0 | 1.7 | 2.1% |
| 160143081 | 1 | 2.6 | 2.1% |
| 222157314 | 1 | 2.4 | 3.1% |
| 222157618 | 2 | 2.4 | 3.8% |
| 232170003 | 2 | 2.0 | 4.6% |
| 232170007 | 2 | 1.8 | 4.5% |
| 232170008 | 2 | 2.1 | 3.2% |
| 232170017 | 2 | 2.4 | 4.0% |
| 222157149 | 3 | 2.3 | 2.6% |
| 222157216 | 3 | 2.6 | 4.8% |
| 160143435 | 4 | 1.8 | 1.6% |
| 192131111 | 4 | 2.6 | 4.1% |
| 222157404 | 4 | 1.9 | 6.6% |
| 232170004 | 5 | 2.7 | 3.8% |
| 192131513 | 6 | 2.4 | 4.2% |
| 232170110 | 7 | 3.0 | 4.7% |

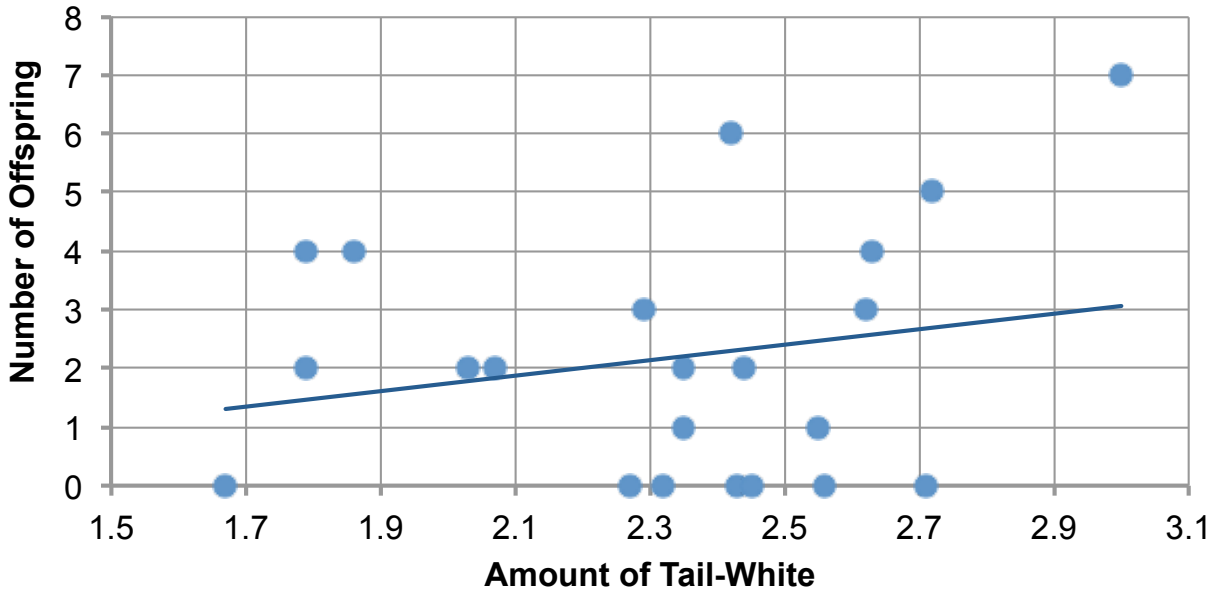
What data will you graph to answer the question?

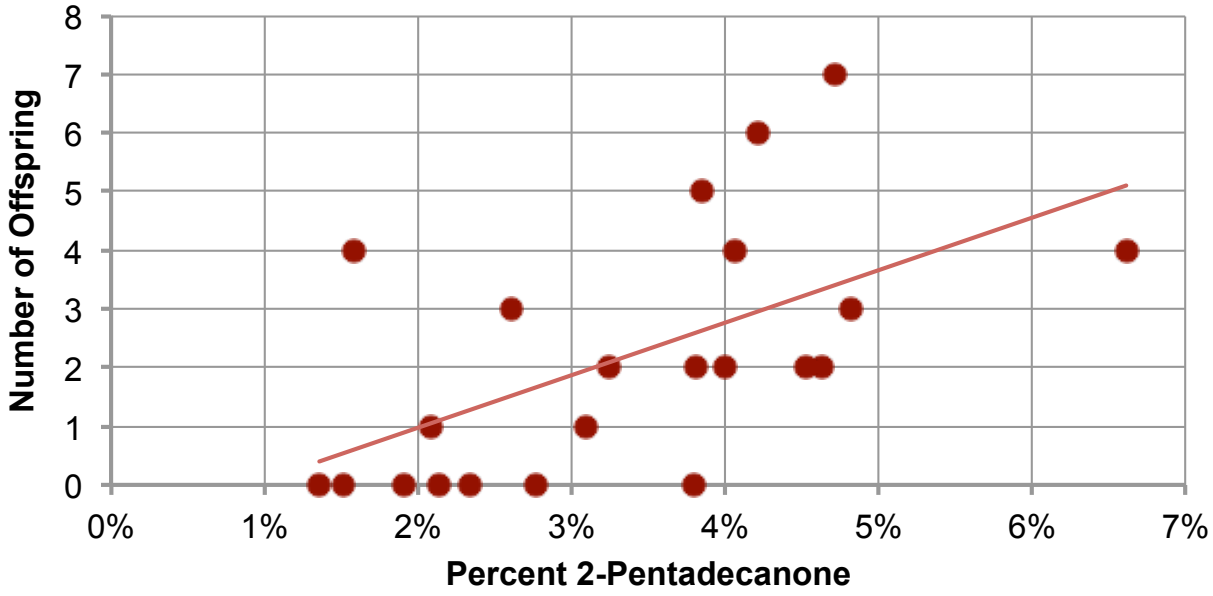
Independent variables: Amount of tail-white and % 2-pentadecanone

Dependent variable: Number of offspring

*Draw your graph below*: Identify any changes, trends, or differences you see in your graph. Draw arrows pointing out what you see, and write one sentence describing what you see next to each arrow.

- There is a slightly positive trend for male tail-white score and the number of offspring they have. The trend for percent of 2-pentadecanone has a steeper positive slope.
- Both plots have a lot of scatter, or variation, that occurs around the trend line.



**Teacher Note:** The line of best fit is included in the teacher guide, but not on the student copies. Once students have graphed the data, you can have them add a line of best fit to their graphs to assist in the visualization of the trend. This can be done simply by eye using a ruler to draw a line through the center of the cloud of points.

It should be apparent to students, once they have drawn their lines, that both graphs show a positive trend. Visually, there appears to be a positive correlation between the two independent variables (X) and the number of offspring (Y). You may choose to pause and have a class discussion about how to interpret these data. When Danielle did statistics on her data she found the trend was significant for the relationship between number of offspring and percent of 2-pentadecanone, but not for number of offspring and tail-white. This supported her hypothesis that female juncos are determining the quality of mates using smell. However, there is also a weaker relationship for tail-white, so there is some evidence that females are using this visual trait to determine mate quality as well. Without access to statistics, students can still interpret these graphs to show that females do tend to choose males with more 2-pentadecanone and tail-white, but the trend is stronger for 2-pentadecanone (steeper slope of the line of best fit). With or without statistics, students can still correctly conclude that the data support the hypothesis.

If you and your students are familiar with regression analysis and associated statistics, they could use Microsoft Excel to calculate the slope and statistics for them. Whenever you make a scatterplot graph, you can produce a statistic called the Pearson correlation coefficient (r). This statistic (r) is a measure of the correlation between two variables X and Y. The statistic gives a value between +1 and –1. It is widely used in the sciences as a measure of the strength of linear dependence between two variables. For example, the correlation can indicate how much the Y variable depends on what the X variable is doing. The closer r is to +1 or –1, the stronger the correlation is between the two variables. However, correlation does not imply causation. See the next Teacher Note in this activity for a discussion on future research steps that could determine causality.

For more information, refer to regression teaching materials posted on our Resources page. These materials guide students through calculating the slope, a correlation coefficient (r), and performing statistics to see if the slope is significantly greater than zero.

- http://datanuggets.org/wp-content/uploads/2014/03/Student-Guide-for-Regression-Analysis.pdf
- http://www.hhmi.org/biointeractive/teacher-guide-math-and-statistics

*Interpret the data:*

Make a claim that answers the scientific question.

Males with higher 2-pentadecanone and more tail-white have the most offspring. It appears that female dark-eyed juncos primarily use male scent to determine the quality of their mates. Females also use tail-white to select mates but to a lesser extent.

What evidence was used to write your claim? Reference specific parts of the table or graphs.

Graph 1: There appears to be a very slight positive relationship between the amount of tail-white in a male and the number of offspring he has. However, this relationship is weak (a lot of scatter around the regression line, very shallow slope) and shows that tail-white does not strongly predict a male's reproductive success.

Graph 2: There is a positive trend of odor in junco males with the number of offspring they produce. This means that the scent of a male predicts his reproductive success, with the smelliest males producing more offspring than the least smelly.

The scatter around the regression lines (all points do not fall exactly on the line) means that other things contribute to mating success for males that we did not measure in this experiment.

Explain your reasoning and why the evidence supports your claim. Connect the data back to the different ways that females collect information on potential mates, and why it is important to identify high quality mates.

Females are likely not using tail-white as a strong signal to select which males to mate with. The scent of a male predicts his reproductive success, with the smelliest males producing more offspring than the least smelly. These data suggest that females might get better information about the quality of a male from their sense of smell rather than their sense of sight.

Did the data support one, both, or neither of Danielle's two alternative hypotheses? Use evidence to explain why or why not. If you feel the data were inconclusive, explain why.

The data from this study support the hypothesis that dark-eyed junco females can use smell to assess the quality of males before mating. However, we do not know for sure that the birds are using their sense of smell to identify male quality or if the 2-pentadecanone is correlated with another trait that is causing the positive relationship with number of offspring.

See the following Teacher Note, discussing correlation versus causation.

**Teacher Note:** This activity can be used to stimulate a classroom discussion on the issue of correlation versus causation. With her experimental design, Danielle found that male birds with more 2-pentadecanone and more tail-white had more offspring. This is supported by the positive correlation between the independent variables (tail-white and 2-pentadecanone) and the dependent variable (number of offspring). However, correlations do not imply causation. Just because Danielle found a correlation between number of offspring and the two measured traits, it does not mean that these male traits directly caused the differences in offspring number. Perhaps there is some other unmeasured bird trait that is correlated with 2-pentadecanone and is actually responsible for the trend in the data. The design of this study was a great first step but does not allow Danielle to test for causation.

What do we need to test for causation? We would need to eliminate the possibility that there is some other correlated variable actually responsible for the pattern. To do this, we need to design an experiment that isolates and manipulates only one variable at a time, holding all others constant. For this study, this could be achieved by selecting 10 male birds that are similar in other important traits such as tail-white and body size and also produce low levels of 2-pentadecanone. Then, Danielle could manipulate the amount of 2-pentadecanone on each individual. For example, Danielle could leave 5 males with low levels of 2-pentadecanone as a control and cover the 5 other males with high levels of 2-pentadecanone. She could then measure which males the female birds mated with. If females chose to mate with males that had more 2-pentadecanone, Danielle could say that 2-pentadecanone causes females to be attracted to males. The same sort of manipulative study could be done for tail-white. Holding levels of 2-pentadecanone constant, Danielle could paint the male junco's tails to manipulate the level of tail-white on different males.

*Your next steps as a scientist:* Science is an ongoing process. What new question do you think should be investigated? What future data should be collected to answer your question?

See the following Teacher Note.

**Teacher Note:** Student responses may vary, and they will probably generate a wide diversity of questions about this system. You can have a class discussion where you jot down all the questions on the board. Be prepared to ask your students to clarify or justify another student's response. Do students see any ways to improve each other's questions? Are some questions untestable? Remember, if your class wants to send their questions about the study system to Danielle, the scientist studying dark-eyed juncos, they can email them to datanuggetsk16@gmail.com.

Danielle's next steps were to

1. create artificial bird odors, manipulating the amounts of each compound in them and testing female preferences for the different odors. Do females really prefer the scent of males with more 2-pentadecanone? This allows her to control for all the other things that might vary between birds other than 2-pentadecanone levels and visual clues (i.e., helps her control for all that other scatter around the regression line).
2. find out what makes these odors in birds and why males with more 2-pentadecanone have more offspring. She is currently investigating whether odor-producing symbiotic bacteria on the birds might be producing the scent.

**Additional teacher resources related to this Data Nugget**

Two blog posts written by Danielle about her work with juncos and odor:

- http://beacon-center.org/blog/2011/12/26/beacon-researchers-at-work-deciphering-avian-aromas/
- http://beacon-center.org/blog/2013/09/10/the-sweet-smell-of-reproductive-success/

A scientific paper published on this research:

Whittaker, D. J., Gerlach, N. M., Soini, H. A., Novotny, M. V., & Ketterson, E.D. (2013). Bird odour predicts reproductive success. *Animal Behaviour, 86*(4): 697-703. Retrieved from http://www.indiana.edu/~kettlab/pubs/Whiitaker%20et%20al.%202013.pdf

To learn more about Danielle, check out this episode from the PBS/NOVA web series "The Secret Life of Scientists and Engineers" where she was featured:

http://www.pbs.org/wgbh/nova/blogs/secretlife/sports/danielle-whittaker/