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DATA Nugget

Beetle Battles

Featured scientist: Erin McCullough from the University of Western Australia

Research Background:

Erin has always loved beetles! Here she is with a dung beetle in Tanzania, during a graduate school class trip.

Male animals spend a lot of time and energy trying to attract females. In some species, males directly fight with other males to become socially dominant. They also fight to take over and control important territories. This process is known as **male-male competition**. The large antlers of male elk are an example of a trait that has been favored by male-male competition. In other species, males try to court females directly. This process is known as **female choice**. The flashy tails of male peacocks are a good example of a trait that has been favored by female choice. Lastly, in some species, both male-male competition AND female choice determine which males get to mate. In order to be successful, males have to be good at both fighting other males and making themselves attractive to females. Erin is a biologist interested in these different types of mating systems. She wondered if she could discover a single trait that was favored by both male-male competition and female choice.

In horned dung beetles, male-male competition and female choice are both important in determining which males get to mate. Females dig tunnels underneath fresh piles of dung where they mate and lay their eggs. Beetles only mate inside these underground tunnels, so males fight with other males to become the owner of a tunnel. Males that control the tunnels have a better chance to mate with the female that dug it. However, there is often more than one male inside a breeding tunnel. Small males will sneak inside a main tunnel by digging a connecting side tunnel. Additionally, the constant fights between large males means that the ownership of tunnels is constantly changing. As a result, females meet many different males inside their tunnels. It is up to them to choose the male they find the most attractive, and with whom they'll mate. In this species of dung beetle, males try to persuade females to mate by quickly tapping on the females' back with their forelegs and antennae. Previous research has found that females are more likely to mate with males that perform this courtship tapping at a fast rate. Because both fighting and courtship tapping take a lot of strength, Erin wondered if the trait of strength was what she was looking for. Would stronger male dung beetles be favored by both male-male competition and female choice?

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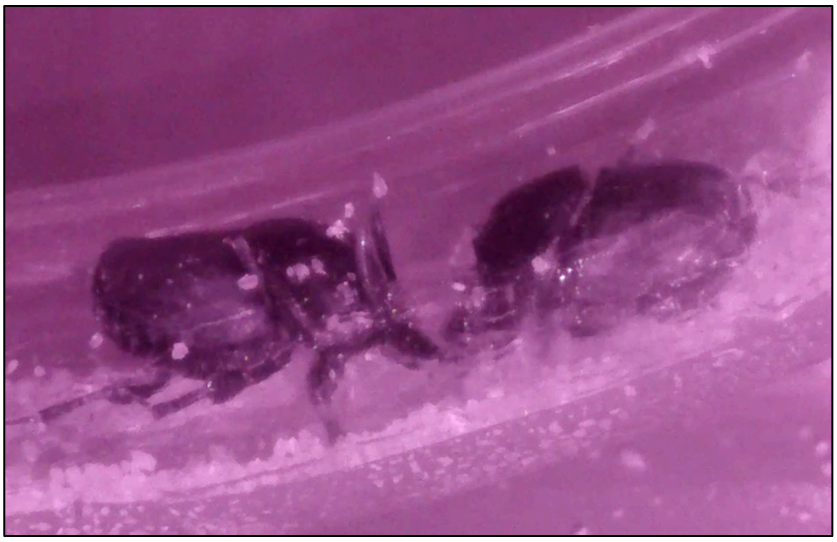
To test her hypothesis, Erin conducted a series of experiments to measure the mating success, fighting success, and strength of male dung beetles. First, Erin measured the mating success of male beetles by placing one male and one female in an artificial tunnel (a piece of clear plastic tubing). She watched the pair for one hour, and measured how quickly the males courted, and whether or not the pair mated. Second, Erin measured the fighting success of males by staging fights between two males over ownership of an artificial tunnel. Beetle battles consist of a head-to-head pushing match that results in one male getting pushed out of the tunnel, and the other male remaining inside. To analyze the outcome of these fights, Erin randomly selected one male in each pair as the focal male, and scored the interaction as a "win" if the focal male remained inside the tunnel, and as a "loss" if the focal male got pushed out of the tunnel. In some cases, there was not a clear winner and loser because either both males left the tunnel, or both males remained inside. These interactions were scored as a "tie". Finally, Erin determined each beetles' strength. She measured strength as the amount of force it took to pull a male out of an artificial tunnel. To do this, she super-glued a piece of string to the back of the beetle, had it crawl into an artificial tunnel, attached the string to a spring scale, and then pulled on the scale until the beetle was pulled out of the tunnel.



Two dung beetle males fighting for ownership of the artificial tunnel. Why is the photo pink? Because beetles mate and fight in dark, underground tunnels, Erin carried out all of her experiments in a dark room under dim red-filtered light. Beetles can't see the color red, so working under red-filtered light didn't affect the beetles' behavior, and allowed Erin to see what the beetles were doing.

To keep beetles alive in the lab, Erin set up a bucket with sand, and placed one pile of dung in the center (left). Female beetles dug tunnels below the dung (right).

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Scientific Question: How does strength affect a male horned dung beetles' chances of winning fights or being chosen as a mate?

What is the hypothesis? Find the hypothesis in the Research Background and underline it. A hypothesis is a proposed explanation for an observation, which can then be tested with experimentation or other types of studies.

Scientific Data:

Use the data from the two tables below to answer the scientific question:

Table 1. Strength measurements in millinewtons (mN) for males that did and did not mate with a female.

	Mated	Not mated
Strength (mN) (mean ± standard error)	94.9 ± 7.3	113.1 ± 8.7

Table 2. Difference in strength (measured in millinewtons [mN]) between a focal male and his opponent for trials where the focal male won, tied, and lost male-male fights. *(A positive value means that the focal male was stronger than his opponent, while a negative value means that the focal male was weaker than his opponent.)*

	Win	Tie	Loss
Difference in strength (mN) (mean ± standard error)	27.9 ± 11.6	-8.0 ± 17.4	-28.7 ± 12.4

** Standard error (SE) tells us how confident we are in our estimate of the mean, and depends on the number of replicates in an experiment and how much variation is in the data. A large SE means we are not very confident, while a small SE means we are more confident.*

What data will you graph from **Table 1** to answer the question?

Independent variable: _____

Dependent variable: _____

What data will you graph from **Table 2** to answer the question?

Independent variable: _____

Dependent variable: _____

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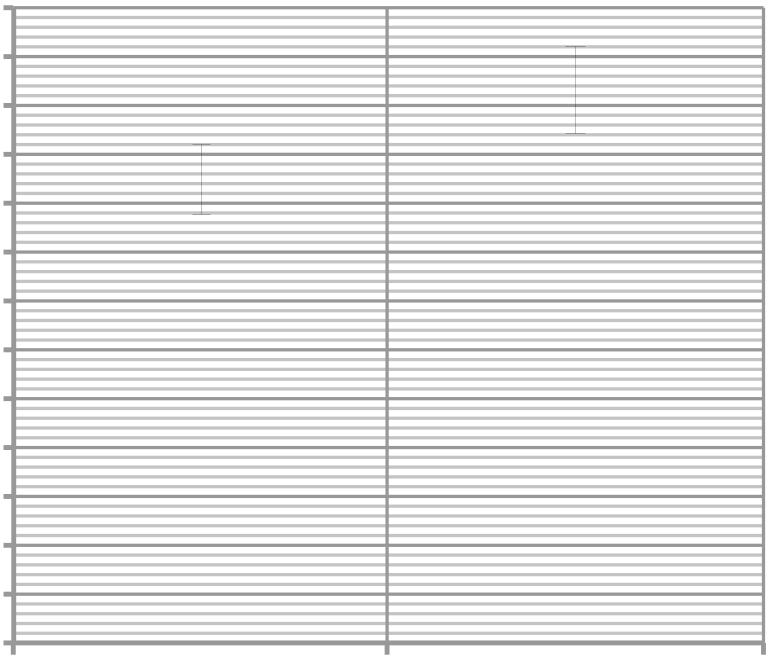
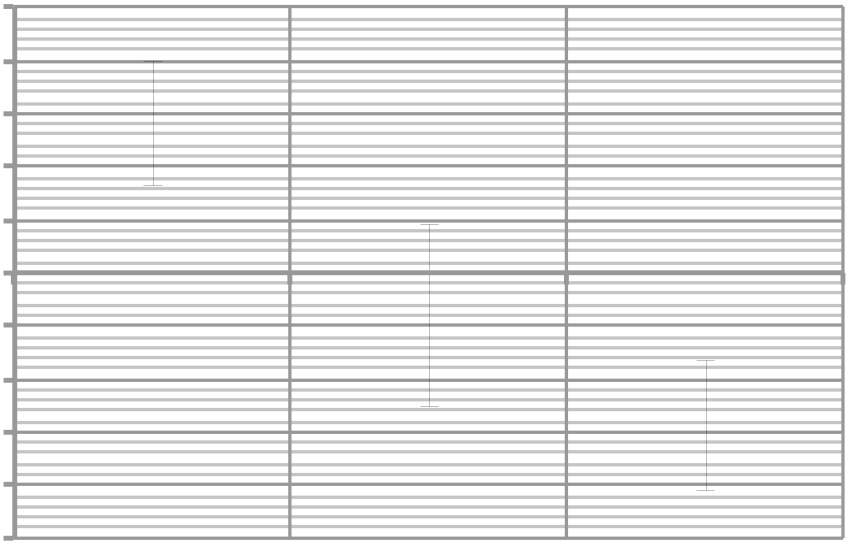
Draw your graphs below:

Graph 1:



Graph 2:



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Interpret the data:

Make a claim that answers the scientific question.

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

Explain your reasoning and why the evidence supports your claim. Connect the data back to what you learned about the different strategies used by male dung beetles to attract females and fight off males.

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What does the data from this study tell us about the scientist's hypothesis?

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 this question?