Food and Agriculture Center for Science Education

More from Less: Improving Beef Genetics

Middle School, Life Science

Task Overview

In this task, students will write an argument that justifies the selection of a particular bull to be mated with a group of cattle to meet the criteria set forth by the producer. First, students will identify trait heritability and make connections between trait heritability and making cattle produce beef more efficiently. Then, students review basic probability of outcomes for calf traits based on the expected differences from two different bulls. Students are introduced to a concept called Expected Progeny Difference. Next, students are asked to focus on a production trait of growth and make comparisons of the genetic difference between two calves on several economically and environmentally important traits. Last, students justify a decision to select a particular bull to be used in a selective breeding program to get a desired outcome.

Background Information

Traits passed from parent to offspring influence the efficiency of the offspring. Certain traits, such as feed efficiency are of special importance to a livestock producer as feed is expensive to produce and comes with ecological impacts for production. Cattle that are better able to efficiently convert feed into pounds of protein (beef) for human consumption are more profitable to cattle farmers and have less of an impact on the environment. While some traits that control feed efficiency are highly heritable, others are less easily passed from one generation to the next and attributed to environmental conditions in which the calf was raised. So, understanding the traits that can be influenced, and consequently improved upon, is important to making more beef from fewer cattle that require fewer resources.

Next Generation Science Standards

Three-Dimensional Claim

Write an argument from available evidence that supports, or refutes, the effect of selective breeding on certain characteristics passed from the parent to offspring based on relevant criteria.

This task is intended to elicit student learning of the following **NGSS elements** for each of the three dimensions:

Disciplinary Core Ideas

LS4.B: Natural Selection (MS)

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- In artificial selection, humans have the capacity to influence certain characteristics of organisms by selective breeding. One can choose desired parental traits determined by genes, which are then passed on to offspring.

Science and Engineering Practices

Engaging in Argument from Evidence (MS)

- Make an oral or written argument that supports or refutes the advertised performance of a device, process, or system, based on empirical evidence concerning whether or not the technology meets relevant criteria and constraints.

Crosscutting Concepts

Cause and Effect (MS)

- Phenomena may have more than one cause, and some cause-and-effect relationships in systems can only be described using probability.

Suggestions for Use

This task is intended to be used as a formative assessment to identify student strengths and weaknesses with the ideas of genetics and heredity and evaluation of possible solutions considering sustainable practices. The use of this task will help to identify students' strengths and needs to provide feedback to students. This will support shifts in instructional practice during a mid-unit assessment.

Assumptions

This task assumes students have prior knowledge about sexual reproduction and heritability of traits. While this task does not require them to perform a Punnett square, this background activity will also prove helpful.

Materials Needed

- More from Less: Improving Beef Genetics Student Task

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Assessment Guidance

Introduction

Beef cattle can convert feeds such as grasses and leftover food waste (e.g. produce from the grocery store) that are unusable to humans into protein that humans are able to use. However, some beef cattle can do this much better than others. This process of comparing how well animals convert feed to their own weight gain is called feed efficiency. Feed efficiency is controlled, in part, by genetics that are passed from parent to offspring. Given different scenarios of feed and environmental conditions, you must decide what genetic traits will most likely yield increased feed efficiency for your herd of cattle.

Prompt 1:

Different traits have different heritability. Heritability is a measure of how variety in cattle's genes account for differences in their traits. The remaining portion often comes from environmental conditions. Review the table below that compares estimated heritability on certain important traits then respond to the questions below.

Trait	Estimated Heritability
Weight of baby calf at birth	0.45
Weight gain of calf, birth to weaning	0.25
Feed efficiency	0.45
Height of calf	0.82
Percent pounds of meat yielded per animal	0.45
Size of ribeye (a cut of meat) per hundred pounds of weight of the animal	0.70
Thickness of the fat on the meat	0.45
Tenderness of the meat	0.60
Retail product, percent	0.30

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Trait	Estimated Heritability
Retail product, pounds	0.60

Estimated Heritability	Category of Heritability
≤ 0.30	Low
0.31-0.49	Medium
≥ 0.50	High

Which trait(s) are considered of low heritability? What challenges might manage for a low-heritable trait pose to a producer of livestock trying to make improvements over time to this trait with his group of cattle?

Which trait(s) are considered highly heritable? How might a producer of livestock use this information to help make improvements from one generation to the next with his or her group of beef cattle? Use evidence to support your claim.

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What is the heritability of feed efficiency? What other factors besides parent's genetics could contribute to an offspring being better or worse at converting feed into weight gain? Use evidence to support your claim.

How does knowledge of the heritability of traits help a producer of livestock improve traits in his or her animals through selective breeding? Use evidence to support your claim.

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Prompt 1 Performance Outcome:
Describe the relevant criteria for characteristics passed from parent to offspring in a selective breeding program.

SEP	• describe the relevant criteria
DCI	• for characteristics passed from parent to offspring in a selective breeding program

Prompt 1 Rubric			
	Emerging	Developing	Proficient
Sample Student Response	**1.** Retail product is a low heritable trait. Some challenges a lowly-heritable trait might pose are that you cannot control improvements simply through the genetics of the parents. **2.** From the table above, some highly heritable traits are height of calf and size of ribeye. This information is useful to a producer of livestock because more emphasis can be placed on genetics. **3.** Feed efficiency is considered a medium heritability trait. **4.** Knowledge of heritability of traits may help a producer of livestock make improvements because they would be able to make decisions on which parent livestock to use in selective breeding.	**1.** Retail product, percent and weight gain of calf are considered low heritable traits. Some challenges a lowly-heritable trait might pose are that you cannot control improvements simply through the genetics of the parents. Much of the variability (70% or more) comes from other factors beyond genetic potential which makes them more difficult to control. **2.** Some highly heritable traits are height of calf and size of ribeye. This information is useful to a producer of livestock because more emphasis can be placed on genetics when trying to make improvements in these areas. Choosing the correct parents can have more of an influence in making improvements than other areas and less variability will come from the environment.	**1.** Retail product, percent and weight gain of calf, birth to weaning are considered low heritable traits. Some challenges a lowly-heritable trait might pose are that you cannot control improvements simply through the genetics of the parents. Much of the variability (70% or more) comes from other factors beyond genetic potential which makes them more difficult to control. **2.** From the table above, some highly heritable traits are height of calf, size of ribeye, tenderness of the meat, and pounds of retail product. This information is useful to a producer of livestock because more emphasis can be placed on genetics when trying to make improvements in these areas. Choosing the correct parents can have more of an influence in making

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		3. Feed efficiency is considered a medium heritability trait. Environment might affect the animal's weight gain too. 4. Knowledge of heritability of traits may help a producer of livestock make improvements because they would be able to make decisions on which parent livestock to use in selective breeding. Improvements on traits that are highly heritable can happen more rapidly since the producer has more control over them. The medium to low heritable traits would be more difficult to make improvements on because there is less of a chance of them being expressed in offspring due to environmental variability.	improvements than other areas and less variability will come from the environment. 3. Feed efficiency is considered a medium heritability trait. Other factors that contribute to the overall feed efficiency of the animal are likely environmental conditions such as climate, feed available to the animal, health of the animal, supplements / growth promotors used, etc. 4. Knowledge of heritability of traits may help a producer of livestock make improvements because they would be able to make decisions on which parent livestock to use in selective breeding. Improvements on traits that are highly heritable can happen more rapidly since the producer has more control over them. The medium to low heritable traits would be more difficult to make improvements on because there is less of a chance of them being expressed in offspring due to environmental variability.
Look-Fors	• Limited criteria are provided for traits that the producer deems important in a selective breeding program.	• Some relevant criteria are provided for traits that the producer deems important	• Relevant criteria are provided for traits that the producer deems important

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	• Claims are lacking supporting evidence. • Responses lack detail and/or substance.	in a selective breeding program. • Some claims are supported by supporting evidence, but some is lacking. • Most responses are thorough and detailed.	in a selective breeding program. • Claims are supported by at least one piece of supporting evidence. • Each response is thorough and detailed.

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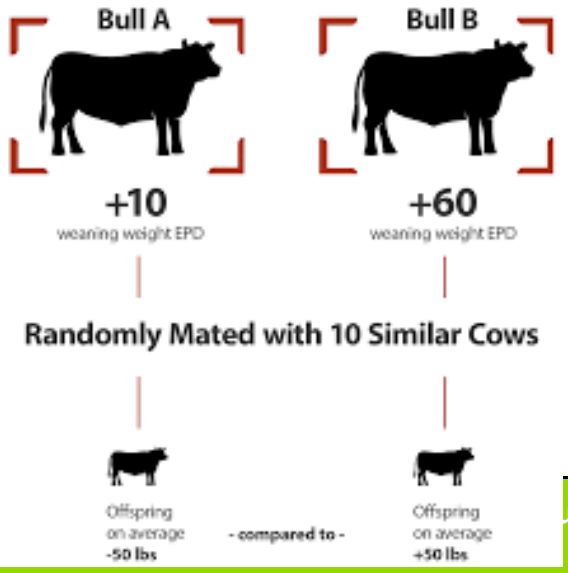
Prompt 2

Many producers of livestock use a set of statistics called Expected Progeny Difference (EPDs) to help make management. EPDs allow for the comparison of animals within a breed for their genetic potential as parents for a given trait. EPDs are tracked on economically important traits, such as weaning weight, because they impact how much money a producer of livestock may earn. Interpret Figure 1 below that compares Bull A to Bull B on the predicted weight of offspring at a moment in time called weaning (or weaning weight).



What difference was there b ld a producer of livestock select for this trait?

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What does the figure credit for the difference in weight between the two sets of offspring? What other factors may have contributed to the differences in weight between the two populations of cattle?

What evidence is there that certain characteristics are passed from the bull to the offspring for the desired outcome of additional weight gain?

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Prompt 2 Performance Outcome: Review evidence that certain characteristics are passed from parent to offspring that causes a desired outcome.	
SEP	• evidence • certain characteristics are passed from parent to offspring that
DCI	• desired outcome
CCC	• causes

Prompt 2 Rubric			
	Emerging	Developing	Proficient
Sample Student Response	**5.** Based on the figure above, the two sets of offspring were an average of 50 lbs different from each other. **6.** The difference in weight between the two sets of calves was due to the genetic difference between the two bulls (Bull A and Bull B). **7.** The EPD predicted that Bull A was +10 and Bull B was +60.	**5.** Based on the figure above, the two sets of offspring were an average of 50 lbs different from each other. This is an important trait to select for. **6.** The difference in weight between the two sets of calves was due to the genetic difference between the two bulls (Bull A and Bull B). This is due to the differences in the bulls and the environment. **7.** The EPD predicted that Bull A was +10 and Bull B was +60. So, you would expect there to be a difference of 50 between them. Here, the unit of measurement is in lbs because of we are talking about the weight of calves at weaning. Assuming the bulls are mated to any 10 similar cows, the evidence is that there is a 50 lb difference between the calves from Bull	**5.** Based on the figure above, the two sets of offspring were an average of 50 lbs different from each other. This is an important trait to select for since this is how most cattle producers make money, from the sale of the weight of their calves. **6.** The difference in weight between the two sets of calves was due to the genetic difference between the two bulls (Bull A and Bull B). While the genetic potential of these bulls will impact the weight differences between these two sets of calves, there are other factors that will impact the final weight of these animals such as the genetic potential of the mother, climate of where they were raised, feed

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		A and Bull B.	used, health of the animals, etc. **7.** The EPD predicted that Bull A was +10 and Bull B was +60. So, you would expect there to be a difference of 50 between them. Here, the unit of measurement is in lbs because of we are talking about the weight of calves at weaning. Assuming the bulls are mated to any 10 similar cows, the evidence is that there is a 50 lb difference between the calves from Bull A and Bull B. So, the difference in weight comes from, at least in part, the genetic potential of bulls.
Look-Fors	• No cause-and-effect relationships are expressly or inherently drawn. • The connection between traits being passed from parent to offspring is weakly drawn. • Responses are minimal and lacking evidence.	• Cause and effect between the desired trait and the associated beneficial outcome is implied. • The connection is expressly drawn between traits being passed from parent to offspring. • Most responses are thorough and supported by evidence.	• Cause and effect between the desired trait and the associated beneficial outcome is expressly indicated. • The connection is expressly drawn between traits being passed from parent to offspring. • All responses are thorough and supported by evidence.

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Prompt 3:

Evaluate the following table comparing two steers (castrated male beef animal). The two steers were fed the same feed for the same number of days in the same conditions. The primary difference between the steers was the genetic potential passed down from parents.

NOTE:
Dry Matter is a type of feed for cattle, typically called hay.

Feed Conversion Ratio is a measure of feed use efficiency and compares the pounds of feed given to the animal compared to the pounds of weight gained.

Ration is the amount of feed given to the animal in one day.

Characteristic	Steer A	Steer B
Starting Weight (lbs)	900	900
Growth Rate (lbs/day)	3.5	3.5
Dry Matter Intake lbs/day	21	28
Feed Conversion Ratio	6:1	8:1
Ration Cost ($/lb DM)	0.085	0.085
Days on Feed	200	200
Cost per Day ($)	$1.79	$2.38
Total Feed Cost ($)	$357	$476

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What similarities and differences do you find between these two steers on the characteristics outlined above?

Which steer is more profitable to the producer?

Think back to the first prompt. How heritable is feed efficiency? What effects were there in feeding steers with two different genetic profiles for feed efficiency?

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Based on this information and the information in Prompt 1, what recommendations would you give to the producer hoping to make improvements to the genetics affecting feed efficiency of his or her steers?

Prompt 3 Performance Outcome: Compare the effect of certain characteristics being passed from parent to offspring.	
SEP	• compare the
DCI	• certain characteristics being passed from parent to offspring.
CCC	• effect

Prompt 3 Rubric			
	Emerging	Developing	Proficient
Sample Student Response	**8.** Both steers have the same starting weight and growth rate and others. They differ on all other traits. **9.** Steer A is more profitable. **10.** Feed efficiency is a medium heritability trait. Feeding a less efficient steer is more expensive. **11.** More feed efficient cattle cost the producer less.	**8.** Both steers have the same starting weight, growth rate, ration cost, and days on feed. They differ on all other traits such as dry matter intake, feed conversion ratio, cost per day, and total feed costs. **9.** Assuming everything else is the same, Steer A is more profitable to the producer as he has less total feed cost, $357 versus $476.	**8.** Both steers have the same starting weight, growth rate, ration cost, and days on feed. They differ on all other traits such as dry matter intake, feed conversion ratio, cost per day, and total feed costs. **9.** Assuming everything else is the same, Steer A is more profitable to the producer as he has less total feed cost, $357 versus $476.

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		10. Feed efficiency is a medium heritability trait. Feeding a less efficient steer is more costly to the producer than a steer that is more feed efficient. **11.** The more feed efficient cattle are, the less it costs the producer to buy feed, and more profitable they can be. Since feed efficiency is a medium-heritable trait, the producer has some control over improving feed efficiency in a selective breeding system through the genetics of parent offspring.	**10.** Feed efficiency is a medium heritability trait. Feeding a less efficient steer is more costly to the producer than a steer that is more feed efficient. **11.** The more feed efficient cattle are, the less it costs the producer to buy feed, and more profitable they can be. Since feed efficiency is a medium-heritable trait, the producer has some control over improving feed efficiency in a selective breeding system through the genetics of parent offspring.
Look-Fors	• Weak comparisons are made between two the genetic potential of offspring based on parents or is missing. • The link between parent influence on the traits of offspring is weak or missing. • Claims are not supported by evidence.	• Comparisons are implied between the genetic potential of offspring based on parents. • The link between parent influence on the traits of offspring is mostly implied. • The influence of genetics on trait mostly implied. • Most claims are supported by evidence.	• Comparisons are expressly made between the genetic potential of offspring based on parents. • The link between parent influence on the traits of offspring is expressly outlined. • The influence of genetics on trait expression is described. • All claims are supported by evidence.

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Prompt 4:

Feed efficiency is an important trait to producers of cattle. Feed is expensive so cattle that convert feed into weight gain less efficiently are not as profitable to the producer. Also, raising these less efficient cattle is less sustainable to the planet. Cattle producers must weigh several considerations when making decisions that impact their future offspring.

Assume you are a cattle producer in central New York trying to decide between two bulls that will potentially be used to create cattle offspring in the next year. Read the table below that uses EPDs to compare the two bulls on important characteristics. Assume this producer is focused on balancing feed efficiency and weight gain in his calves.

Animal	**Yearling Weight** Expected Weight of Offspring at Birth (HINT: Lower number is generally better as it indicates an easier birth)	**Weaning Weight** Expected Weight of Offspring When Weaned (HINT: Higher number is generally better as it indicates heavier calves at the time of weaning)	**Yearling Weight** Expected Weight of Offspring at One Year of Age (HINT: Higher number is generally better as it indicates heavier calves when they reach one year of age)	**Feed : Gain Ratio** Expected Ratio of feed consumed to one pound of weight gained in offspring (HINT: Lower number is generally better as it indicates a more efficient use of feed to adding weight to the animal)
Bull A	1.2	37	73	-0.18
Bull B	8.2	54	91	.75
Breed Average	2.0	46	83	.04

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Decide which bull you would advise the cattle producer to use. Compare the two bulls on the criteria and make an argument using several pieces of evidence from the EPD table above to justify your decision. What effect(s) will this decision likely have on future offspring (calves) for this producer? Use evidence to reinforce your claims.

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Prompt 4 Performance Outcome: Make an argument using available evidence that supports or refutes the effect of certain characteristics being passed from parent to offspring on how they impact relevant criteria.	
SEP	• make an argument using available evidence that supports or refutes • impact relevant criteria.
DCI	• certain characteristics being passed from parent to offspring on how they
CCC	• effect of

Prompt 4 Rubric			
	Emerging	Developing	Proficient
Sample Student Response	Ultimately, the producer should select Bull A. The main reason is that this bull has the best genetics. The effect this decision will likely have is that the producer will make more money with Bull A.	Ultimately, the producer should select Bull A. The main reason is that this bull has the best ratio of feed consumed to weight gained of -0.18 versus the breed average of 0.04. Overall, with the emphasis that is being placed on feed efficiency, Bull A is the better option. Since producers make money off the sale of the weight of animals, this decision may make the producer less profitable in the short run, but more profitable and sustainable over time as feed prices climb.	Ultimately, the producer should select Bull A. The main reason is that this bull has the best ratio of feed consumed to weight gained of -0.18 versus the breed average of 0.04. Bull B passes on to his offspring a stronger expected difference on weaning weight of 54 versus 37, and yearling weight of 91 versus 73. Bull A passes on to his offspring has a better weaning weight of 1.2 versus 8.2. Overall, with the emphasis that is being placed on feed efficiency, Bull A is the better option. The effect this decision will likely have is that the producer will have offspring that are .08 lbs lighter than the breed average at birth, 9 lbs lighter at weaning than the breed average, 10 lbs lighter than the breed average as a yearling, but able to convert feed at 0.22 lbs:gain more

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			efficient than the breed average. Since producers make money off the sale of the weight of animals, this decision may make the producer less profitable in the short run, but more profitable and sustainable over time as feed prices climb.
Look-Fors	• Arguments are not supported by evidence. • No, or weak, connections are made between parent's genetics and the offspring's potential for certain traits. • No cause and effect relationships are made between genetic traits and the expression of those traits (and how they impact livestock producers).	• Arguments are mostly supported by at least one strong piece of evidence. • The connection is implied between parent's genetics and the offspring's potential for certain traits. • Cause and effect relationships are mostly made between genetic traits and the expression of those traits (and how they impact livestock producers).	• Arguments are supported by at least one strong piece of evidence. • The connection is expressly drawn between parent's genetics and the offspring's potential for certain traits. • Cause and effect relationships are made between genetic traits and the expression of those traits (and how they impact livestock producers).

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