Some cows' infertility linked to Y chromosome

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At the U.S. Meat Animal Research Center in Clay Center, Nebraska, geneticists Tara McDaneld and Larry Kuehn (left) look for and record variations in data while molecular biologist John Keele and technician Tammy Sorensen take blood samples for DNA pooling. Credit: Janice Watts

In the beef industry, if a cow does not get pregnant after breeding, she becomes an economic liability in the herd. Lack of calf production can significantly reduce annual revenue for producers.

At the Agricultural Research Service's Roman L. Hruska U.S. Meat Animal Research Center (USMARC) in Clay Center, Nebraska, scientists are developing genetic markers for economically important traits, such as reproductive ability, which can be used by producers to select efficient animals. They have also found extraordinary answers as to why some cows are not reproducing.

The USMARC research team led by geneticist Tara McDaneld has discovered one reason for reproductive failure is that some females have introduced segments of the male (Y) chromosome in their genome.

McDaneld, molecular biologist John Keele, and geneticist Larry Kuehn collaborated with producers in gathering reproduction data on several female beef cattle populations. They examined records, which indicated whether cows became pregnant in their first spring breeding, on about 6,400 animals from herds in Florida, Nebraska, Colorado, and at USMARC.

The team then used a cost-saving genetic screening method called "DNA pooling" to genotype animals. The technique combines DNA from many individual animals into a single pool for further evaluation.

"We decided to pool the DNA because individually genotyping the 6,400 animals would be very expensive," McDaneld says. "We had two extreme phenotypes—animals that are pregnant and animals that are not pregnant." Multiple DNA pools were constructed for each phenotype—pregnant and nonpregnant. Each pool contained contributions from about 100 animals, and all animals within a pool had the same phenotype.

Segments of the Y chromosome were found only in the pool of DNA from nonpregnant animals. Normally, females inherit an X chromosome from each parent (XX) and males inherit an X and a Y (XY).

"Considering all the animals were females, they should all have been XX," McDaneld says. "There shouldn't be any Y chromosome at all in the DNA."

Geneticist Tara McDaneld (left) and technician Tammy Sorensen prepare a gel for evaluation of genotypes associated with reproduction. Credit: Janice Watts

The first thought was that females with the Y chromosome could be "freemartins." This condition, resulting from twinning in cattle, causes infertility in the female calf born at the same time as her male twin. Although the male twin is rarely affected by reduced fertility, the female

twin is completely infertile in a high percentage of the cases. The reproductive tracts of freemartins do not develop normally. In addition, because of the blood exchange between male and female fetuses, the Y chromosome can often be detected in the female's blood, Keele says.

To validate their findings, the scientists used a PCR test that amplifies chromosome Y in individual animals. They found that up to 25 percent of the animals with low reproductive efficiency in the Florida population and 20 percent of the low USMARC group were positive for the Y chromosome. None of the animals with prior pregnancies were positive for the Y chromosome.

"We concluded that some females were not getting pregnant because they carried segments of the Y chromosome," Keele says. "And interestingly, there was evidence that some of the Y-containing females were not twins. Hence, they could not be freemartins, yet they inherited Y chromosome material from somewhere, most likely from their fathers."

The USMARC team developed a PCR test that indicates whether a female is carrying Y-chromosome fragments. They also developed single nucleotide polymorphism (SNP) assays that contain genetic markers to identify chromosome Y-associated material in low-reproductive heifers. SNPs are genetic variations that provide information about an animal's genetic value and are often used in breeding programs.

"A lot of money goes into breeding an animal and keeping her long enough for her to get pregnant," McDaneld says. "Beef producers can use these PCR screening tools for chromosome Y before breeding, to test heifers and identify those that are less likely to consistently get pregnant."

"If a female calf is tested at birth and found to carry Y chromosome

segments or markers, she can be used for meat production instead of for breeding," Keele says.

The test could also be used to identify heifers that are unable to reproduce. In rare cases, calves are born with female physical characteristics but are in fact genetically male (XY). These calves have defects in the male development pathway, Keele explains, and they are infertile. This condition can now be tested for, and the affected animals can be culled from breeding herds.

A further benefit of this test is to identify potential breeding bulls that have Y chromosome segments in their X chromosome. These bulls will produce normal male calves, but all of their daughters will have a copy of the contaminated X chromosome. Consequently, the reproductive capacity of the bull's daughters will be potentially much poorer.

A genetic test for female reproduction in a bull does not improve his reproductive performance, but rather, it improves the pregnancy rate of his daughters, Keele explains. "Bulls are able to have more offspring than cows; consequently, male selection is more effective than female selection for improving any trait. Testing a sire before using him to produce replacement females will improve reproductive performance in the herd if bulls with the X chromosome genetic defect are identified and culled."

Scientists are examining data from heifer populations for other variations in the genome and are finding other regions that may generate reproductive markers in the future, says Kuehn. For example, they have identified a deletion on chromosome 5 that is associated with females' inability to get pregnant, which they plan to pursue in further research.

Producing calves to sell at the market every year is the main driver for beef cow producers, Kuehn says. Heifers that conceive in their first

calving season and then produce a calf every year thereafter are most profitable.

"Although we generally get somewhere from 85 to 95 percent fertility in cow herds, it's the most economically important trait in cow production," Kuehn says, "because if a cow doesn't produce a calf, the producer gets nothing but expenses—feed, labor, and other costs—out of that cow for that year."

More information: "Male Chromosome Hinders Female Cattle Reproduction" was published in the April 2014 issue of *Agricultural Research* magazine.

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