Not All Bulls Are Born Equal

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BY MAGGY ZANGER

An urban laboratory with the requisite computers, microscopes and shelves of glass bottles and tubes may seem a remote location for exploring the intricacies of bull fertility.

Bonnie Phelps, a postdoctoral researcher in animal sciences at The University of Arizona, and Mary Bellin, a senior research specialist, are working with Roy Ax, the department head and a reproductive physiologist, to find a quick, easy, inexpensive fertility test. The question of fertility is extremely important to cattle breeders who need to know how sires rate.

Their research brings the latest in laboratory technology to solve an age-old question. What exactly happens between insemination and fertilization? And, how can this information be used out in the dairy barn or on a cattle ranch?

Based on Ax's past research, they think a specific protein or combination of proteins on the sperm surface are critical to prepare the sperm for fertilization.

At that point, the practical implications of their research become clearer. Examining sperm for the crucial protein should predict whether a particular bull will be highly fertile. And, if a bull of desired genetic quality has a low fertility rate, the critical protein might be added to end the problem. The implications go beyond the bovine to the human. The enzymes and proteins found in bull semen are also found in humans. The information Ax's team learns might be applied to human infertility research, particularly since experimentation is far easier on cattle than on people,

team members from left to right Mary Bellin, Roy Ax, & Bonnie Phelps.

"So this has a wider utility than just in relation to bulls," Ax says. "We have every intention of continuing this with our colleagues in the medical school."

Not all bulls are born equal; that's where the problem begins for cattle breeders. Only one in seven bulls has the genetic quality breeders look for. Unfortunately, about ten percent of the genetically superior bulls may not be highly fertile. Currently, the ways breeders evaluate bull fertility are imprecise or take a long time. Either way, the breeders lose money.

Two common tests involve measuring the scrotal circumference of adult bulls and checking sperm motility; both are done routinely at cattle sales. The circumference is related to semen output and motility measures the number of live sperm. But high numbers of live sperm don't accurately predict successful fertilization. A bull may have plenty of live sperm but still have a low level of fertility, which is calculated by the number of cows needing to be re-inseminated, called the return rate.

Currently, field tests are the most accurate way to gauge bull fertility. Testing for fertility is a long and costly process requiring many actual inseminations to calculate the relative bull fertility. Meanwhile, the bull is fed, housed, insured and given medical care without any real indication that its sperm is of the quality required to bring a return on the investment to the breeder.

"It would be much easier and simpler to put only the superior bulls in service," Ax says. "But there is no good basis for doing that now."

An accurate test of fertility would have another benefit. If a breeding service knew fertility levels, they could dilute the semen of high-fertility bulls, making more efficient use of semen supplies without lowering conception rates. The average artificial insemination (AI) dose is 30 million sperm, Ax says. Every bull has an optimal number of sperm needed to assure successful fertilization. Boosting that number two or three times won't improve a low-fertility bull's performance rate, but the AI dose for high-fertility bulls can be reduced by 15 million sperm, or even 25 million.

The same procedures Phelps uses in the laboratory can be used to test bull sperm to see if the crucial proteins are present and in the right form. If they are not, breeders can safely predict, even without field tests, that the bull will not be a highly successful sire. As an added benefit, the crucial proteins theoretically could be added to make sperm from a low-fertility bull more successful, assuming the genetic characteristics were desirable.

"The screening method could be quite valuable," Phelps says. "And, if you have a bull with all the genetic characteristics you want but with a low fertility rate, you potentially could improve the quality of the sperm by adding back specific proteins."

She estimates that she and Bellin will have solid results in a year or so. With the groundwork completed, the livestock industry could use the research results to carry the technology from the lab to the field. A field test, based on UA research, could give veterinarians and breeders an accurate method for predicting bull fertility at an early age.

Soon their success literally could move from the laboratory to the dairy barn or ranch.

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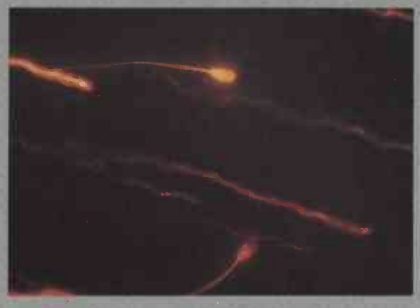
Sperm Detectives Use High-Tech

BY MAGGY ZANGER

The UA team of animal scientists base their fertility test on the reactions taking place in the bull sperm during the complex process of capacitation. This six- to nine-hour process takes place in the female reproductive tract, and it's more subtle than simply introducing a healthy sperm to a healthy egg. Freshly ejaculated sperm cannot fertilize an egg. They undergo capacitation, which activates enzymes in the sperm head that are necessary for egg penetration.

During ejaculation, the sperm head is coated with protein that later binds with a carbohydrate from the cow's reproductive tract. Phelps and Bellin believe a particular carbohydrate-binding protein on the sperm is central to successful fertilization. Phelps says they're looking at five classes of the carbohydrate-binding proteins to find out which are crucial; one may be the pivotal factor or a combination, or the amounts of proteins may be the key.



Contrast the bull sperm (top center) where enzymes are still contained within the spermhead or acrosome, with sperm at bottom in which the acrosome has eroded.

Once the sperm is coated with the carbohydrate, via the carbohydrate-binding protein, and the capacitation is completed, the action moves to enzymes contained within the sperm head in a structure called the acrosome. Before actual fertilization takes place, enzymes must be released from the acrosome to help sperm penetrate the egg. The acrosome ultimately erodes, exposing the enzymes, and finally the egg can be fertilized.

"We can see under a microscope very quickly whether the sperm are intact or whether it has acrosome-reacted," Ax says. Acrosome reaction (AR) is correlated with fertility. Sperm from high-fertility bulls had significantly higher percent increases in AR than sperm from low-fertility bulls when their sperm were incubated with carbohydrate from the cow reproductive tracts.

The first tests Ax developed to monitor AR took nine hours to get results because the bull sperm were incubated in a chemical environment that mimicked a cow's reproductive tract. Another test he worked out took only an hour to get a fertility reading. It involved placing a radioactive tag on the carbohydrate and incubating with sperm in solution. Alternatively, a fluorescent label can be placed on the carbohydrate, changing the color of the sperm to green once the carbohydrate is bound to the sperm. These tests are more reliable than the nine-hour procedure, but unfortunately, only institutions approved for radioisotope diagnostics or fluorescence microscopy can perform the procedure.

At this point the three scientists are using chemical reactions of the proteins coating the sperm to identify a "fertility print." The next step in the research is identifying genes related to fertility so that scientists can predict the potential fertility of a day-old bull.