Beyond Breeding Soundness

The role of semen quality and quantity in subfertility.

BY ERIC GRANT

Infertility and subfertility in bulls and females can wreak havoc on a breeding program. While many measures of infertility exist, little is known about subfertility.

Subfertility is diminished reproductive performance. It's less noticeable than infertility, but can still cost producers thousands of dollars a year. But there is hope. Producers can now identify telltale signs of subfertility in males.

Typically, producers have measured breeding success or failure through pregnancy rates, often culling cows rather than bulls when rates drop too low.

Richard Saacke of Virginia Tech suggests there are two components that determine pregnancy rate from a male standpoint:

- Semen's ability to fertilize an egg (i.e., fertilization rate); and
- Whether or not the embryo developed normally and hatched in time to signal pregnancy to the dam.

While most producers are accustomed to using a breeding soundness exam (BSE) as a test for fertility, a BSE may be able to tell us even more about the integrity of the sperm and its probability to fertilize an egg. Specifically, semen motility and morphology may help producers better manage their artificial insemination (AI) programs.

Classifying sperm

By using semen motility and morphology, Saacke created a new sperm classification system. His system separates subfertile sperm into two categories: those unable to reach the egg (compensable) and those that are motile but incapable of sustaining fertilization or pregnancy (uncompensable).

Compensable traits include immotile sperm, sperm with tail defects, immature sperm and sperm with distinctly misshapen heads. Factors affecting sperm-egg recognition, binding and egg penetration are also compensable traits. So far, however, no standard tests are available to identify these qualities in sperm.

Increasing sperm numbers can compensate for this defect in sperm quality. Producers finding compensable sperm in a bull's semen must increase the number of sperm inseminated. This increases the number of motile sperm, thereby increasing the chances of more sperm reaching the egg.

The minimum number of motile sperm needed to achieve maximum fertility varies among bulls. High-fertility bulls have a lower threshold than those with low fertility.

"Semen traits that are detrimental to fertility, but can be overcome by increasing numbers of sperm inseminated, represent the compensable components of semen," says Saacke. "Semen traits that adversely affect fertility at any sperm dosage would be the uncompensable traits."

Identifying sperm with compensable and uncompensable traits may help producers reduce failed pregnancy rates.

Saacke's findings indicate that normal and slightly misshapen sperm, particularly misshapen heads, are the most likely candidates for uncompensable traits. These sperm look normal and are capable of reaching the egg and initiating fertilization, but for some reason cannot sustain the pregnancy. Saacke says semen with subtly misshapen heads or nuclear vacuoles on otherwise normally shaped heads yield higher frequencies of low-quality embryos and lower fertilization rates.

While compensable traits in sperm can be overcome by higher doses, Saacke says uncompensable sperm (sperm with morphological abnormalities) can be indicative of a larger problem. So, if uncompensable sperm are detected in a sample, that entire lot of sperm is probably defective.

Morphology is best measure

While research directed at the health and content of the spermhead DNA appears promising, it's not ready for commercial use. Presently, the best measure of uncompensable traits lies in the morphology of sperm.

The level of abnormal sperm in a sample, especially sperm with abnormal heads, is the best indicator of uncompensable traits. Saacke recommends heavy discrimination against semen determined to have uncompensable sperm.

To investigate the fertility of sperm, Saacke evaluates accessory sperm six days following insemination. Accessory sperm are those that become entrapped in the *zona pellucida* (outer covering) of the cow's egg after breeding. Saacke says the reason the sperm become entrapped in the *zona pellucida* is because a fertilized egg activates a block that inhibits the sperm from progressing.

The sperm stuck in the *zona pellucida* represent the number and quality and the sperm available for fertilization when the egg was receptive. Thus, they serve as good specimens for study. The number and morphological status of the sperm helps gauge the bull's impact on pregnancy rate.

At six days' post-insemination, the embryo is flushed nonsurgically, and the quality of the embryo is graded as excellent, good, fair, poor, degenerate or unfertilized. Excellent and good embryos result in twice as many pregnancies than fair to poor embryos.

Once the embryo has been evaluated, the *zona pellucida* is digested, which allows scientists to count and evaluate the accessory sperm. The higher the number of accessory sperm, the higher the quality of the embryo.

After collecting nearly 1,000, 6-day-old embryos, Saacke has found that excellent and good embryos tend to have more accessory sperm than fair, poor,

degenerative and unfertilized eggs. Scientists consider the embryo quality, sperm quality and quantity to determine the bull's impact on pregnancy rate. "Essentially, our research approach utilizes the 6-day-old egg or embryo as a biomonitor of the male or semen quality," says Saacke.

Bulls with uncompensable sperm have fewer competitors vying to fertilize the egg. Uncompensable sperm may fertilize an egg, but because of the poor quality, there may be very early embryonic death. Therefore, using uncompensable semen will result in a lower pregnancy rate.

Research indicates that selection of the male, semen dosage and site of insemination all positively affect the number of accessory sperm. Bulls vary in the number of accessory sperm per egg, as well as the minimum number of sperm for maximum fertilization.

Depth and time of insemination

As these traits cannot be predicted from current semen evaluation procedures, they must be gathered from AI nonreturn data. The data must have sufficient services on a given bull at or below threshold numbers of sperm per dose.

Deep insemination can enhance sperm delivery. However, site of insemination was found to make only small increases in sperm per egg. Saacke recommends that very deep insemination be used only when the sperm dose is below threshold, or if sexed semen is being used.

Saacke also found that embryonic quality and accessory sperm numbers can be affected by time of insemination. Using varying quality and quantities of semen, he found the number of accessory sperm was highest when insemination occurred 24 hours after onset of estrus.

The quality of embryo, however, was poorest at that time. The quality was the best when insemination occurred at heat onset, but fertilization rates are lower at this time. The optimum insemination time to maximize pregnancy rates is approximately 12 hours after onset of heat. Therefore, AI timing should be performed at 12 hours after estrus detection for maximized pregnancy rates.

"Comparing AI at heat onset vs. 12 and 24 hours later indicates optimum pregnancy rate would be expected at approximately 12 hours post-onset," says Saacke. "Loss of pregnancy rate to early inseminations is due to fertilization failure (but embryo quality is high). Whereas, loss to late insemination is due to embryonic failure (but fertilization rate is high). Thus optimum insemination time appears to be a compromise."

Producers should note this experiment was conducted using an electronic heat-detection system that recorded the time of a cow's first mount. Saacke says a good rule to use if you aren't using an electronic heat-detection system is "if you see her in heat, breed her."

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