

Sex-sorted semen: How does an increase in sperm numbers affect fertility?

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Introduction

Throughout the world, there is abundant interest in sex-sorted semen. Unfortunately, the separation of X- and Y-chromosome-bearing sperm by flow cytometry (cell sorting) is an inefficient process as approximately 75 percent of sperm in an ejaculate are discarded (or lost) during the procedure. Furthermore, to achieve 90 percent purity of a specific sex, typical sorting rates for bull sperm are between 3,000 to 6,000 sperm per second. Consequently, the process is considered very slow as it would take approximately 1 to 2 hours to sort the number of sperm in a typical A.I. dose (20 million). As it is not economically feasible to produce only 1 straw of sex-sorted semen (with 20 million sperm) per hour, research has focused on maximizing fertility of low numbers of frozen-thawed, sex-sorted semen. Currently, each

straw of sex-sorted semen produced in the United States contains approximately 2.1 million sperm.

Why not use a higher number of sex-sorted sperm per dose?

If we ignore for a moment the current sex-sorting efficiency limitations, and assume that there will be new developments that allow for increased speed of sorting – what might be the effect of use of a higher number of sex-sorted sperm per dose? To fully understand the results of recent research focused on the effect of sex-sorted sperm dosage on conception rates, it's important to understand the underlying principles of semen dilution and fertility. Salisbury and VanDemark first suggested the relationship between sperm quantity and quality, when they proposed that fertility increases with increasing numbers of

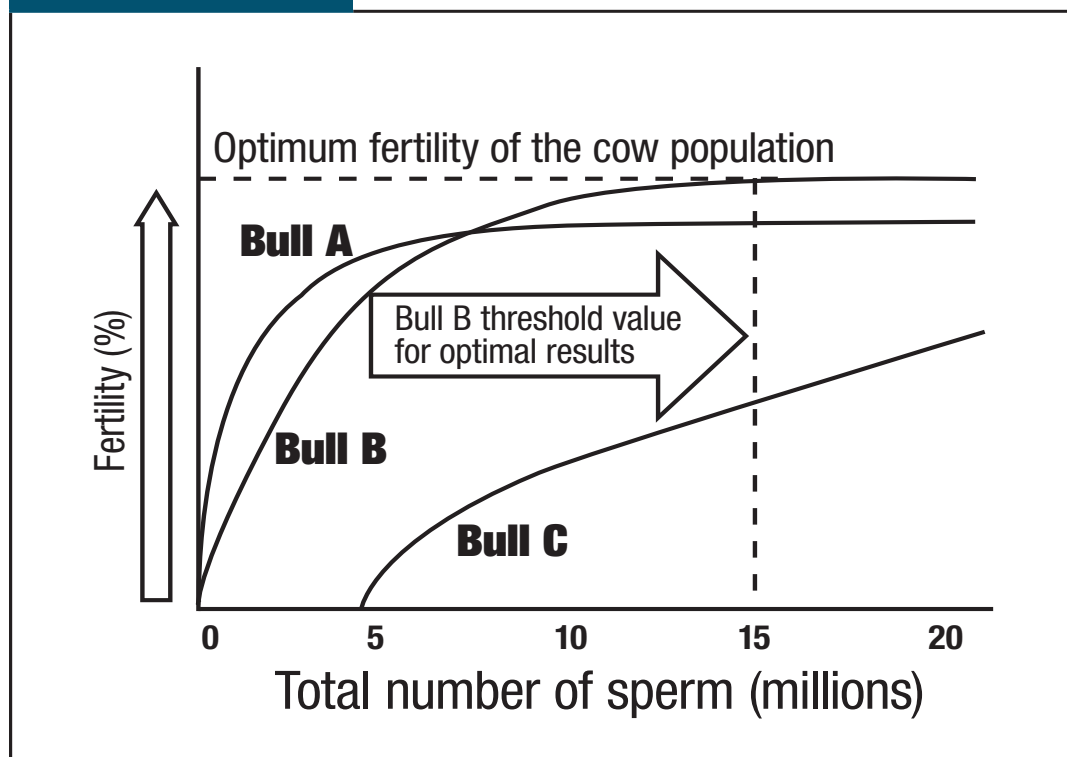
viable sperm inseminated up to a threshold level. After this threshold level has been attained, the female population becomes the limiting factor and increases in sperm numbers do not result in further increases in fertility. This can be seen in **Figure 1**, where bull B reaches a threshold value for optimal results at 15 million sperm per dose. Further increases in sperm numbers for bull B will not result in further increases in fertility, because the limiting factor is now the fertility level of the female population. In contrast, bulls A and C do not reach a threshold value for optimal results even when 20 million sperm per dose are used (See **Figure 1** on page 30)

Figure 1 provides graphic evidence that there are seminal traits which are “compensable” and others which are “uncompensable,” as originally described by

Saacke and coworkers. Seminal deficiencies, seen as reduced fertility when sperm numbers are below threshold, which can be overcome or minimized by increasing the sperm dosage would be considered “compensable.” Compensable traits of semen quality are believed to be related to sperm viability, specifically to the ability of inseminated sperm to not only reach the egg, but also bind to and penetrate the outer covering of the egg (zona pellucida). Therefore, if a semen sample contains a low percentage of viable sperm, this may be compensated for by increasing the number of sperm per dose. In contrast, seminal deficiencies resulting in suppressed fertility regardless of sperm dosage would be considered “uncompensable.” As illustrated in Figure 1, the maximal fertility of bulls A and C is a function of uncompensable traits and the optimum fertility of the cow population. Uncompensable traits of semen quality are associated with abnormal sperm shape (morphology) and DNA integrity, and are manifested by the incompetence of fertilizing sperm to complete fertilization and sustain early embryonic development.

DeJarnette and coworkers recently studied the effect of sex-sorted sperm dosage on conception rates in dairy heifers and lactating cows. Three bulls were used in the study, with sex-sorted dosages of 2.1, 3.5, and 5.0 million sperm. Following 2,125 services in heifers, a significant response in conception rate to increasing sperm dosage was seen in only one sire (**Figure 2**; bull A). From the nearly linear response to increasing sperm dosage, it is apparent that bull A possessed compensable seminal traits (**Figure 2**). In contrast, sperm dosage had no effect on conception rates within bulls B and C. Although the

Figure 1



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Sex-sorted semen, cont'd from front

numerical increase in conception rate achieved by bull B when sperm dosage was increased from 2.1 to 3.5 million provides evidence of compensable traits, both bulls B and C appear to possess a similar level of uncompensable traits, as seen by the comparable fertility at 3.5 and 5.0 million sperm dosages. Overall, there was no effect of sperm dosage on conception rate for the 2.1, 3.5, and 5.0 million sperm dosages, respectively. Lastly, among herds that used greater than 50 doses of sex-sorted sperm, conception rates averaged 47 percent (range 33 to 68 percent).

In contrast to the results in heifers, there was no effect of sex-sorted sperm dosage on conception rates achieved following 2,369 services in lactating cows, even though the same ejaculates from the same sires were used in cows and heifers. Does this mean that lactating cows respond differently to increasing sperm dosage as compared to heifers? No, as this data provides evidence that the fertility potential of the female population (as described by Salisbury and VanDemark) places biological limits on the ability of seminal traits to affect an observable fertility response. Furthermore, it is possible that other factors may be more limiting to conception than semen quality and sperm numbers which may decrease the ability to detect conception rate differences associated with the inseminates used in the study. Among herds

that used greater than 50 doses of sex-sorted semen, conception rates averaged 30 percent (range 15 to 41 percent). Lactation number tended to affect conception rates, as first- and second- lactation cows achieved numerically greater conception rates (30.4 percent and 31.1 percent, respectively) than third- and higher lactation cows (25.6 percent).

Considering the current limitations in processing efficiency (specifically related to the number of doses per hour) and published data regarding conception rates following A.I. with different sex-sorted sperm numbers per dose, there is not enough compelling evidence to suggest that increased sperm numbers per dose are warranted. In fact, DeJarnette and coworkers argue that the wide variation in conception rates (15 to 41 percent for cows; 33 to 68 percent for heifers) in their study following A.I. with sex-sorted sperm, despite using the same sires and experimental pool of semen, indicates that many opportunities exist to develop and refine on-farm management techniques to enhance the fertility potential of cows and heifers.

Availability, cost and practical use of sex-sorted semen

Sexing Technologies (www.sexingtechnologies.com) is currently sorting X- and Y-chromosome-bearing sperm for Select Sires, Inc., ABS Global, Alta Genetics, Genex, Heifer

Quest, and Lagoa (a subsidiary of Holland Genetics located in Brazil). The cost of sex-sorted semen is approximately \$30 to \$55 per dose. Accelerated Genetics does not currently have a sex-sorted sperm product on the market. Instead, Accelerated Genetics developed Bovatel, a gender-bias semen product that is advertised as being able to yield 10 additional heifer calves for every 100 pregnancies.

Although four of the five major U.S. A.I. studs are currently marketing sex-sorted semen from a variety of bulls, it is unrealistic to believe that sex-sorted semen from the most elite bulls will be available anytime soon, due, in part, to 1) slow processing speed, 2) disposal (or loss) of approximately 75 percent of each ejaculate that is sorted (specifically, the undesired Y-chromosome-bearing sperm and sperm that the flow cytometer is unable to distinguish as X- or Y-chromosome-bearing), and 3) the reality that sex-sorted sperm from different bulls will most certainly differ in the ability to a) tolerate sexing, freezing and thawing, and b) achieve acceptable conception rates when used at low numbers.

The inherent reduced fertility of multiparous cows makes the use of sex-sorted semen in cows more problematic than in heifers. A reduction in conception of 5 percentage points in cows may be devastating as compared to the same reduction in heifers, especially because any reduction increases the risk that a cow may remain open and be culled. Nevertheless, a scenario in which the top 30 percent of cows were bred with sex-sorted semen at first service only (with a 10 percentage point reduction in conception rate, from 35 percent to 25 percent), revealed a net gain of \$1 per cow in the breeding pool. Reproductive success and profitability with sex-sorted semen in lactating cows is likely to be elusive. Consequently, usage of sex-sorted semen in lactating dairy cows is still not recommended.

Currently, the most obvious practical use of sex-sorted semen is to breed heifers to have heifer calves. Therefore, recommendations for sex-sorted

semen are:

- Use in well-grown, well-managed heifers.
- Administer A.I. approximately 12 hours after observation of heat.
- Thaw straws using warm water (95 to 98 degrees F) for a minimum of 45 seconds.
- Do not use sex-sorted semen in timed-A.I. programs.

Accurate heat detection and well-trained inseminators will be mandatory to maximize fertility with sex-sorted semen. Furthermore, herds struggling with poor management, inaccurate heat detection and improper semen handling and deposition will continue to struggle and may witness plummeting conception rates while using sex-sorted semen.

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References omitted due to space but are available upon request.

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Figure 2

