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Sexed Semen Applications in Dairy Cattle

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Semen of most mammalian species can be sexed with greater than 90% accuracy with an instrument called a flow cytometer/cell sorter. Unfortunately, the process is slow relative to the number of sperm in a typical artificial insemination dose. Furthermore, the process damages sperm, although to a lesser degree than current procedures for cryopreservation. Because of these limitations, commercially available sexed semen for artificial insemination has lower sperm numbers per dose (about 2 million sperm) than are used conventionally (usually >10 million sperm/dose). Thus far, there is no evidence that these sexing procedures result in abnormal offspring (Tubman et al., 2004).

The main problem with this technology is that pregnancy rates are about 10 percentage points lower than with unsexed semen. Nevertheless, sexed semen is commercially available for many bulls. Most applications will be limited to artificial insemination of heifers, which have higher fertility with fewer sperm than cows, and use of sexed semen with dairy heifers has become widespread.

Here, I will summarize potential applications of sexed semen in dairy cattle, assuming that accuracy of sexing semen is greater than 90%, that fertility is about 80% of fertility of unsexed semen, and that sexed, frozen semen is available at a reasonable cost (typically around $15-20 extra) from a broad selection of bulls. Some bull studs offer 75% X-sperm at a lower cost.

Applications Producing Heifer Calves

1. Increase the percentage of heifer calves to expand the herd or sell replacements. Normally, averaged over thousands of animals, 49% of calves born will be heifers, and a few of these will be sterile freemartins. Due to chance alone, it is not that unusual to have only 40% heifers from 100 consecutive calvings. For example, there is about a 20% chance that at least 8 of the next dozen calves born in any herd will be bulls. Semen sexed for females at 90% accuracy would greatly decrease these chance vagaries of sex ratio; about 90% of calves born would, in the long run, be heifers. Such a program would enable rapid herd expansion without the risk of introducing diseases that occur with purchased animals. It would greatly increase the practicality of maintaining “closed” herds if that were an objective.

Note, however, that if most herds use such a program there will be a large surplus of heifers, and the price of heifers could drop substantially, making some heifer-rearing systems less profitable. This problem likely would be offset in the long run because of the profitability of breeding older cows to beef sires for rapidly growing calves for beef.

2. Increasing selection intensity by choosing genetically superior dams of replacements.
At equilibrium, about 80% of dairy females must be bred for herd replacements to maintain herd size because over half the calves born are bulls, and some of the heifers born die, become unthrifty, or do not become pregnant. Instinctively, the first application of sexed semen that most dairymen think of is that only 45% of females (10% bulls with sexed semen) would need to be bred for replacements instead of the normal 80%, thus increasing selecting intensity. This is a good use of sexing technology, but it is not nearly as powerful as the genetic progress resulting from selecting superior males. However, this application could be worth nearly $50/mating if fertility of sexed semen was similar to controls (Van Vleck, 1981).

3. Breeding heifers to have heifer calves to decrease the incidence of calving difficulty.
A major problem on dairy farms is dystocia when heifers calve. This can be minimized by breeding only well grown (but not fat) heifers and by using service sires that produce a low percentage of difficult births. The latter course, while reasonably effective, can result in lighter calves that will develop into smaller cows, which could become a problem after several generations of such a program. In any case, the majority of dystocias are due to bull calves, which average about 5 lb heavier in birth weight than heifer calves.

A large study in New Zealand with primiparous beef heifers (Morris et al., 1986) illustrates sex differences well; death losses from birth to weaning were 10% for heifer calves and 18% for bull calves, mostly due to sequellae of dystocia. To decrease dystocia substantially, one could use bulls that sire a low percentage of calves with difficult birth plus semen sexed to produce 90% heifer calves. There is the added benefit that these first calf heifers should be better genetically, on average, than the older cows in the herd. In my opinion, this will be one of the most important uses of sexed semen, both in dairy and beef cattle production.

There are, however, some problems with this application. The main one is that around 10% of calves resulting from semen sexed to produce females will be bulls. For reasons that are unclear, deaths at birth or shortly thereafter are higher than expected for the bulls of the “wrong” sex (DeJarnette et al., 2009). However, in most cases, those bull calves have little economic value, and there are few of them.

A second concern is that dystocia was not really decreased in one study examining this issue (Chebal et al., 2010). They did, however, find a decreased incidence of twins with sexed semen, and found that use of sexed semen was profitable when used for first services of heifers.

4. Proving young bulls.
To maintain the current rate of genetic progress in most dairy cattle breeding programs, it is necessary to progeny test young bulls. This continues to be problematic, and incentives are used to encourage farmers to produce calves and lactations for these programs. It is particularly frustrating that half of the calves born are bulls, and therefore useless for proving their sires. If semen sexed at 90% accuracy for heifer calves were used, only 55% as many cows would need to be bred to get the same number of heifers for proofs. The fringe benefits of having 90% calves for replacements might make such a program very successful.

A related problem is obtaining young bulls from elite cows to progeny test in the first place; half the time a heifer is produced. This often is dealt with by superovulating the potential bull mother, so by chance at least one bull is produced. Sexed semen without superovulation will be an attractive alternative in some situations.

5. Circumventing the shortage of calves born due to lengthened lactations.
The average dairy cow has 3 calves in her lifetime. For a variety of reasons, calving often is a traumatic time for cows, resulting in various health problems. One management techniques that is losing popularity is to lengthen lactations by propping up the lactation curve with bovine growth hormone (BST). This, however, has the net effect of fewer calves per lifetime, and if the strategy is taken to the extreme, a herd may not produce sufficient heifer calves to maintain herd size. At the very extreme, selecting intensity could be near zero on the dam's side of the pedigree. Skewing the sex ratio to favor females would be a very sensible way to circumvent this problem.

6. Sexing semen for in vitro fertilization, superovulation, and embryo transfer programs.
The first calves produced with accurately sexed semen resulted from in vitro fertilization (IVF), which requires many fewer sperm than artificial insemination (Cran et al., 1993). Accuracy of sexing sperm was 90%. Typically with IVF or superovulation, one would want heifer calves, since large number of full brother bulls from most dams would be difficult to market at a profit because such programs are relatively costly. Another problem is that sex ratios with some IVF programs without sexed semen are in the range of 55% bull calves (Hasler et al., 1995; Pegoraro et al., 1998). Fortunately, several companies provide IVF services using sexed sperm. This is more successful for some bulls than others.

Although it is possible to sex embryos resulting from IVF or standard superovulation and nonsurgical embryo recovery programs with reasonable accuracy, the sexing process is relatively expensive, and embryos of the less valuable sex often are discarded. It is much more elegant and less expensive to sex semen so that embryos of the less valuable sex are not even produced.

There are several studies documenting use of sexed semen for superovulation (reviewed by Seidel, 2010). There appears to be great variation in fertility of sexed sperm for superovulation from bull to bull. On the average, the number of embryos suitable for embryo transfer is decreased 30 to 50% compared to use of unsexed semen. However, this can still be quite profitable because nearly all recipients receive embryos of the desired sex, so animals and costs of procedures are not wasted on the "wrong" sex.

Applications Producing Bull Calves

The value of 3-day-old Holstein bulls has varied between less than $10 and greater than $150. Price volatility has been great, especially for the "colored" breeds. The majority of dairy bull calves end up being used for veal or beef, and this will continue. Those calves destined for veal or beef production systems would be more valuable if sired by beef breeds such as Angus or Charolais. They would be even more valuable if male, on the order of a $50 advantage for beef production, because males are larger and grow more efficiently. Dystocia and resulting death with bull calves is only slightly higher than with heifer calves from multiparous cows (Morris et al., 1986).

Programs for producing male calves for beef from dairy cows using sires that transmit good carcass qualities mesh especially well with programs to have female calves from heifers and from the best cows genetically. Such integrated programs would make the $10 dairy bull calf for meat a thing of the past, but would also compete with more traditional beef production systems. Breeding some dairy cows with unsexed beef semen might be the best approach because of higher pregnancy rates and lower semen costs. The beef crossbred females would also be quite valuable for meat production. Thus, at equilibrium, one might use sexed semen for all first services of heifers, and unsexed beef semen for the genetically lowest one-third of the cow herd.

Other Considerations

In addition to being financially successful if sexing costs are low enough and fertility is near normal (Chebel et al., 2010), sexed semen programs will result in more efficient milk and meat production. Fewer animals will be required per unit of product, making use of this technology ecologically sound. Less feed will be required and less manure will be produced than without sexed semen.

Sexing technology is not totally benign. There could be some dislocations as dairy beef becomes more difficult to distinguish from meat from beef breeds. Systems of raising dairy replacements could change substantially. Increased efficiency translates into still fewer dairy cows. Despite these side effects, sexed semen likely will be beneficial to the long-term health of the dairy industry, primarily because it would enable providing better products for consumers in a shorter time frame and at lower cost than not using sexed semen.

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