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PROFITABLE USES OF SEX-SORTED SEMEN

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Introduction

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. Because of this limitation, 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). Although sexing procedures damage sperm from the standpoint of fertility, there is no evidence that sexing procedures result in abnormal offspring (Tubman et al., 2004).

The main problem with this technology is that partly due to fewer sperm per insemination dose, pregnancy rates are about 10 percentage points lower than with unsexed semen, and that is from AI 12 to 24 hours after observed estrus; fertility will be even lower using appointment breeding without heat detection. Nevertheless, sexed semen is commercially available from many bulls. Most applications concern artificial insemination of heifers; use of sexed semen with dairy heifers has become widespread.

Recommended Procedures for AI with Sexed Semen

Because fertility with sexed sperm is lower than with unsexed semen, especially with appointment breeding, profitable use requires careful consideration. This is especially true due to the increased cost of sexed semen, usually $15 to $25 extra per dose. Sexed semen is packaged in 0.25-ml straws, which requires a different insemination gun from the standard 0.5-ml straws. There is a slight theoretical advantage in semen quality with use of the smaller straws, but they require more careful handling due to the larger surface to volume ratio compared with the larger straws. Thus, 3 seconds is the absolute maximum time for moving these straws from one liquid nitrogen tank to another without damaging the sperm, and similarly for moving straws from the tank to the thaw bath.

Nearly all research with AI of sexed semen has been done along with some form of estrus synchronization, and breeding 12 to 24 hours after onset of a detected estrus; the optimum timing appears to be about 18 hours post onset of estrus. Although appointment breeding without heat detection is not recommended with sexed semen, if this is done, the recommended appointment time is 6 hours later than that for unsexed semen. With synchronization procedures in which cattle are bred after an observed estrus up to, for example, 72 hours post prostaglandin, and those not seen in estrus are then bred by appointment, a sensible approach is to use sexed semen for those bred after heat, and the less expensive unsexed semen for the appointment breedings, because these usually will have much lower fertility, especially so with sexed semen.

Note that the usual recommendation for sexed semen is to use it for first services only. Due to lower fertility, the breeding season can easily be lengthened using sexed semen, especially if used for second and third services.

Next, I will summarize potential applications of sexed semen in beef 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 $15-25 extra) from a broad selection of bulls. One bull stud offers 75% X-sperm or Y-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 be ideal to produce bred heifers for sale, especially for example, crossbred heifers.

2. Increasing selection intensity by choosing genetically superior dams of replacements.
At equilibrium, nearly half of the 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 beef producers think of is that only 25% of females (10% bulls with semen sexed for females) would need to be bred for replacements instead of the normal 50%, 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 a considerable amount for some matings, if selling breeding stock, if fertility of sexed semen was similar to controls. Of course, the 75% of dams not needed for replacement matings could be bred to terminal cross sires, increasing the value of resulting calves for feeder cattle.

3. Breeding heifers to have heifer calves to decrease the incidence of calving difficulty.
A major problem is dystocia when heifers have their first calf. 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, so resulting calves should be excellent replacements. 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, at least in dairy cattle (DeJarnette et al., 2009). However, this only involves a few animals.

4. 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%. With IVF or superovulation, one might want bull or heifer calves, depending which sex is most valuable. A large number of full brother bulls from some dams would be easy to market in some situations. Fortunately, several companies provide IVF services using sexed sperm. This is more successful for semen from some bulls than others. Unfortunately, the IVF approach also incurs the costs of embryo transfer.

Although it is possible to sex embryos resulting from IVF or standard superovulation and nonsurgical embryo recovery programs with reasonable accuracy without using sexed semen, this sexing process is relatively expensive, and embryos of the less valuable sex sometimes 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

1. Increase the percentage of bull calves for meat production.
For beef production, weaned steers are more valuable than heifers because males are larger and grow more efficiently. This advantage is usually between $50 and $100 for commercial cattle. Dystocia and resulting death with bull calves is only slightly higher than with heifer calves from multiparous cows (Morris et al., 1986). The main problem with this application is that the additional value of males may not be sufficient to compensate for the lower fertility with sexed semen (Seidel. 2003).

Programs, for producing calves for beef from dairy cows using sires and breeds 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.

2. Increase the percentage of bull calves for seedstock purposes.
This application might be the most profitable application of sexed semen for beef cattle, but of course is limited to seedstock producers. It does not necessarily require selling more bulls, but producing the bulls from the dams that are the best mothers for particular markets. This application can be very interesting since for each mating, a decision would need to be made as to whether the cow or heifer is best used for producing 1) a bull, or 2) a heifer for breeding purposes, or 3) a crossbred bull for meat production. Whether the dam is a heifer or cow becomes an additional consideration.

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. Increased efficiency translates into still fewer beef and dairy cows. Despite these side effects, sexed semen likely will be beneficial to the long-term health of the beef 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.

References

Chebel, R. C., F. S. Guagnini, J. E. P. Santos, J. P. Fetrow, and J. R. Lima. 2010. Sex-sorted semen for dairy heifers: Effects on reproductive and lactational performances. J. Dairy Sci. 93:2495-2507.

Cran, D. G., L. A. Johnson, N. G. A. Miller, D. Cochrane, and C. Polge. 1993. Production of calves following separation of X- and Y-chromosome-bearing sperm and in vitro fertilization. Vet. Rec. 132:40-41.

DeJarnette, J. M., R. L. Nebel, and C. E. Marshall. 2009. Evaluating the success of sex-sorted semen in US dairy herds from on farm records. Theriogenology 71:49-58.

Morris, C. A., G. L. Bennett, R. L. Baker, and A. H. Carter. 1986. Birth weight, dystocia and calf mortality in some New Zealand beef breeding herds. J. Anim. Sci. 62:327-343.

Seidel, G. E., Jr. 2003. Economics of selecting for sex: The most important genetic trait. Theriogenology 59:585-598.

Seidel, G. E., Jr. 2010. Artificial insemination of the superovulated cow. Proc. 23rd Natl. Assoc. Anim. Breeders Tech. Conf., pp. 107-111.

Tubman, L. M., Z. Brink, T. K. Suh, and G. E. Seidel, Jr. 2004. Characteristics of calves produced with sperm sexed by flow cytometry/cell sorting. J. Anim. Sci. 82:1029-1036.