AN214

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The Economics of Sexed Semen in Dairy Heifers and Cows[1]

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Introduction

The goal with sexed semen is to produce a calf of a specific sex. Sexed semen is widely available now and many dairy producers are using it to obtain more (and better) heifer calves. Because of its higher cost per dose of semen, combined with a reduced conception risk, sexed semen is primarily recommended for use in virgin heifers. The use of sexed semen varies widely among dairy producers. Some producers do not use it at all while others use it on heifers only, and some use it on both heifers and cows (Anonymous, 2008). With heifers (and cows), sexed semen is usually used for first and perhaps second breedings, but typically not for later breedings. The economic benefits of the use of sexed semen are different for every dairy farm. This fact sheet summarizes the recent literature on sexed semen use in dairy heifers and cows. Further, the economics of the use of sexed semen in heifers and cows are evaluated.

Technology

Sexed semen is semen in which the fractions of X-bearing (female) and Y-bearing (male) sperm have been modified from the natural mix through sorting and selection. Sorting is based on flow cytometrical cell sorting for DNA content of sperm (Weigel, 2004; Seidel, 2007). The method works by staining sperm with a DNA-binding fluorescent dye. The bovine Y-chromosome bearing sperm contain 3.8% less DNA than the X-chromosome bearing sperm. Because of the dye, the male and female sperm can be electrically charged differently. This allows for their separation by a fluorescence-activated cell sorter (Seidel, 2007). The method is fairly accurate with ~90% of the sperm containing the desired sex (Garner and Seidel, 2003; DeJarnette et al., 2008). Sexed semen will contain a lower concentration of sperm per straw (approximately 2 million) than non-sexed semen (approximately 20 million) because the sorting process is relatively slow. Because of lower doses of sperm per straw, and possibly a negative effect of the sorting process, fertility of sexed sperm is typically lower compared with conventional sperm (Garner and Seidel, 2003; DeJarnette et al., 2008). Semen cell sorting technology is continuously being improved and improvements in sorting capacity, fertility and reduction of semen cost are expected (Seidel, 2007).

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Random chance and sexed semen results

Random chance affects the results of breeding cows with sexed semen in at least two ways. First, when the true probability of conception (conception risk) is say 50%, you may get more or fewer animals pregnant than half. This is the same effect as flipping a coin 10 times and getting more or fewer than 5 heads. The binomial distribution is the statistical law that calculates the chances of binary results when the outcomes are independent and each trial has the same probability of success. For example, if every animal has a probability of conception of 50%, the chances that you will get 5 animals pregnant out of 10 bred animals is only 25%. There is a 42% chance you get 4 or 6 animals pregnant, a 24% chance you get 3 or 7 animals pregnant, etc. There is even a 2% chance you get 0 or 10 animals pregnant. If you bred 100 animals with a 50% probability of conception for each animal, the chance that you get exactly 50 animals pregnant is only 8%. The chance you get between 45 and 55 animals pregnant is 73%. If the probability of conception is only 40%, the chances you get between 45 and 55 animals pregnant decreases to 18%. The chances you get between 40 and 50 animals pregnant is 52%. Such chances are usually not intuitive to most people.

In practice, the true probability of conception is unknown, but is measured as number of animals pregnant divided by the number bred. When few animals are bred, the probability of conception if more animals are bred is uncertain. Avoid making conclusions too quickly when you have few animals bred and your conception risk will be lower than expected.

Similar probability statistics apply when judging whether sexed semen gives you the expected 90% heifer calves. If you have 10 calves born from sexed semen, there is only a 39% chance that 9 of them are heifers and 1 is a bull calf, as you would expect. There is a 35% chance all 10 calves are heifer calves and a 19% chance you will get 8 heifer calves. There is even a 16% chance you will get at most 4 heifer calves and 6 or more bull calves. Out of each 100 calves born, we expect to get exactly 90 heifer calves only 13% of the time when each calf truly has a 90% probability of being a heifer calf. You have a 94% chance that you ll get between 85 and 95 heifer calves out of 100 calves born. Sexed semen technology gives on average close to 90% female calves (DeJarnette et al., 2008). But don't be surprised if you see more or fewer than 90% heifer calves, especially when you are using sexed semen on a limited number of animals.

Economic considerations

Calf prices

The value of sexed semen comes primarily from a greater chance of getting a heifer calf than a bull calf. Where bull calves may be worth only $50, heifer calves may be worth $450. When heifer calves are not sold, the value of the heifer calf is primarily the difference between the cost to raise a heifer calf to freshening and the purchase price for a similar freshening heifer. In a case where you can purchase a heifer for $2,000 but raise your own heifer calf for $1,600, the value of the heifer calf is $400. This assumes there is no difference in the quality of the freshening heifer (genetics, biosecurity, age at first calving, value of the calf in the freshening heifer, etc.) and ignores the time value of money as will be shown below. Estimates for heifer calf prices vary a lot, but run typically from $400 to $540 (DairyProfitWeekly, 2008). Bred heifers (7 to 9 months pregnant) are worth anywhere from $1,600 to $2,275.

Notice that the value of a newborn heifer calf depends on whether you raise the heifer yourself or sell her and later purchase a springing heifer of equal quality. The time value of money should be considered. For example, if the market value of a newborn heifer calf is $450, the purchase price of a 23-month old heifer is $2,300 (raised one month until calving) and the cost of raising a heifer until 24 months of age is $80.43 per month ($1,930 total or $2.64 per day), then both strategies result in a total cost of $1,930, not considering the time value of money. However, if one considers the 8% annual interest discounted monthly, then the present value of the newborn heifer calf that you keep to be raised decreases to $264. The advantage for the purchase option is caused by a delay of cash outflow until 23

months from the birth of the calf while there is a cash inflow today from the sale of the heifer calf. The present value of the $2,300 for the purchased heifer 23 months from today is only $1,974. At 8% interest, the present value of the raising strategy is a cost of $1,778 and the present value of the purchasing strategy is $1,593. Table 1 lists some values for a new born heifer calf when she is raised or sold. Not considered in these calculations is the risk that a heifer to be raised is being culled for failure to conceive or otherwise; then the value of a heifer price decreases even more.

Semen prices

Sexed semen is more expensive than conventional semen. The average premium may be approximately $30 per straw compared to conventional semen (Fetrow et al. 2007; Anonymous, 2008). This varies with sire.

Sexed semen fertility in heifers

When the decrease in fertility with sexed semen is discussed, first pay attention to the difference between a percent and a percentage point. These are easy to confuse with each other. An example may clarify the difference. For example, a 25% decrease in fertility from a conventional conception risk of 55% results in a 41.3% conception risk (55% - 0.25 x 55%). A decrease of 25 percentage points from 55% is simply 30% (55% - 25%). This is quite a difference! Writers are sometimes sloppy when reporting effects on fertility.

Recent reports suggests that on average fertility of sexed semen is about 75% (70 to 80%) of the fertility of conventional semen in virgin heifers (a decrease of 20 to 30%) (DeJarnette et al., 2007).

A recently published study compared conception risks of different doses of sexed semen in virgin heifers and cows (DeJarnette et al., 2008). Three bulls were sorted with half of the semen designed for use in virgin heifers and the other half for use in lactating cows. Participating herds were selected to have the potential to achieve conception risks of >= 60% in virgin heifers, >= 30% in lactating cows, or both. Results of breedings with conventional semen were not statistically analyzed because of the inconsistencies in use and application of both types of semen (cherry picking among animals, for example). Sexed and conventional semen were supposed to be used randomly within 2 months of delivery. Results were available for 51 herds (2,125 services) that used sexed semen in heifers and 56 herds (2,369 services) that used sexed semen in lactating cows between days 60 and 150 post calving.

There was a sire x sperm dosage interaction in heifers (dosage had no effect on conception risks in sire C, but was greater with higher dosages in sire A). Average conception risks for the 3 sires were 46%, 41%, and 53% in heifers. Among the 14 herds that used >= 50 doses of sexed semen in heifers, conception risks were 47% ± 3.2% (range 33 to 68%). Ten of these herds reported the use of >= 50 doses of conventional semen in heifers and had conception risks of 43% ± 3.6% (range 29 to 61%). Note that these conception risks were for a combination of first and later services. Conception risk in 2nd and greater services reduces rapidly in heifers. Therefore, these results do not provide evidence that conception risks with sexed semen were reduced compared to conventional semen.

Sperm dose alone does not explain the reduced fertility, however (Garner and Seidel, 2003). Successful use of sexed sperm requires excellent management of cattle, careful handling of sperm and use of a skilled inseminator (Seidel, 2007). The level of reproductive efficiency plays an important role in the expected conception risk with sexed semen, with larger differences when reproductive management is poor. Weigel (2004) reported on a field trial conducted in 2001 in Wisconsin involving 816 Holstein heifers. Average conception risk with unsexed semen was 58% across herds, while conception risks with sexed semen were 21%, 37% and 34% in herds with below average, average, and above average reproductive performance.

When reproductive management is excellent, risks of conception for breeding heifers are only slightly lower than normal using low doses of sexed semen (Seidel, 2007). Seidel (2003) earlier reported that with excellent management of cattle, fertility with low doses of sexed sperm were 70 to 80% of normal doses of conventional sperm. Some studies

reported 90% fertility. With marginal management, fertility of sexed semen could decrease to 50 to 60% of conventional sperm.

It is very difficult to get unbiased field comparisons of sexed sperm with conventional sperm due to likely bias in semen use (Garner and Seidel, 2008; DeJarnette et al., 2008). Without well-controlled studies, dairy producers are more likely to cherry-pick the most fertile animals as candidates for sexed semen.

Recent communications with dairy producers revealed that they typically observe a 10% to 15% percentage point in conception risk (say from 55% to 45%, a reduction of 18%, or from 55% to 40%, a reduction of 28%). Taken together, field research indicates that you can, on average, expect ~ 45% first service conception risk for virgin heifers with well managed heifer reproduction programs.

Sexed semen fertility in cows

Based on the reduced fertility of sexed semen in heifers, sexed semen is not recommended for use in cows (Linderoth, 2008). Data on conception risk in cows when using sexed semen are scarce. However, in a Finnish study, 306 lactating dairy cows were bred by AI, of which 157 were inseminated with 2 x 106 frozen/thawed sexed sperm and 149 with 15 x 106 frozen/thawed unsexed (conventional) sperm. The average conception risks were 21% for the sexed-sperm AIs and 46% for the conventional control-sperm AIs, a drop of 54% or 25 percentage points (Andersson et al., 2006). This decrease was significantly different, so chance alone most likely cannot explain this decrease.

In a recent small study in the U.S., 172 cycling lactating Holstein cows were inseminated with units of 10 x 106 conventional sperm or 2 x 106 sexed sperm (Crichton et al., 2006). Conception risks at first insemination were 55.6% for the conventional sperm and 40.4% for the sexed sperm. Due to the low cow numbers, the difference was not significant, however. The authors concluded that "successful use of sexed sperm in dairy cows, which approached a voluntary waiting period of 80 days in milk, was achieved with cows that were selected for reproductive status prior to insemination." They did not, however, report economic results.

In another recent study, 2,197 Holstein cows were either bred with 20 x 106 sperm/dose of conventional semen or 2 x 106 sperm/dose of sexed semen (Schenk et al., 2007). First or second service conception risk were about 25% for sexed sperm and 37.7% for conventional semen, a significant difference of about 12 percentage points. Conception risks for sexed sperm after 84 to 94 days in milk were 7.9 percentage points greater than earlier in lactation (< 84 days in milk) and > 6 percentage points lower in 3rd and 4th lactation cows compared to 2nd lactation cows. There was a real sire effect, with the highest sire having a 6.7 percentage points conception risks greater than the lowest sire. Practically, the authors concluded that sexed semen reduces conception risks by about 12 percentage points and the best conception risks are attained when sexed semen is limited to 1st or 2nd lactation cows after a voluntary waiting period of more than 100 days.

The recent study by DeJarnette et al. (2008) also evaluated the conception risks of sexed semen in cows. Conception risks for different dosages, sires, and parity were not statistically different. Among the 13 herds that used >= 50 doses of sexed semen in lactating cows, conception risks averaged 30 ± 2.4% (range 15 to 41%). Among the 26 herds that reported use of >= 50 doses of conventional semen in lactating cows, conception risks averaged 30 ± 1.0% (range 21 to 39%). Thus, there was no evidence that conception risks with sexed semen were lower than with conventional semen.

Risks of conception with sexed semen in lactating dairy cows can be similar to that of conventional semen if cows have completely normal reproductive characteristics using ultrasound examination, good records, etc. (Seidel, 2007). Such a prescreening of cows is usually impractical.

Effect of service number on heifer conception risks

In a large study by USDA following 537,938 AI services, the average conception risk for Holstein heifers was 56.3% (Kuhn et al., 2006). Approximately 88% of U.S. heifer herds had a 40 to

70% heifer conception risk. They also reported that Jersey heifers actually had lower fertility (52.2%) than Holstein heifers. Conception risk by service number decreases from 53% for first services to 33% for seventh services (Table 2). Chebel et al. (2006) also recently documented this decreasing trend in 6,389 Holstein heifers in an Idaho feedlot. The data in these studies were statistically adjusted. Over 60,000 heifer breedings between November 2006 and November 2007 showed that average unadjusted (raw) conception risks from first to seventh service decreased from 56% to 24% (Michael, 2008). Kuhn et al. (2006) reported that the difference in heifer fertility between the 6 major AI organizations providing semen to the US was relatively small at 2.8%, with the average heifer conception risk ranging between 50.3 and 53.1% across the AI organizations.

The effect of service number on the conception risk of sexed semen is unclear. A 25% reduction in conception risk would mean that the absolute difference (in terms of percentage points) gets smaller with every service number. A 10% point difference would mean that the relative difference increases by service number.

Age of first calving

The reduction in conception risks with sexed semen will result in a longer breeding period and consequently in a greater age of first calving. The cost to raise breeding age heifers is approximately $2 per day with a range from $1.31 to $2.93 (Kohlman et al., 2008). Thus, the use of sexed semen generally increases the cost of raising the heifer and a delayed entry into the lactating herd.

Another consideration is the effect of age of first calving on the performance as a lactating cow. Heifers that calve too young may produce less milk and have reduced fertility in the first lactation and older heifers might experience more dystocia (Ettema and Santos, 2004). However, the effect of age of first calving depends to a great extend on growth rates. Therefore, it is not likely that extended age of first calving necessarily reduces profitability of lactating cows.

Genetic progress

The effect the use of sexed semen has on the rate of genetic progress varies widely and was summarized by Weigel (2004). Without sexed semen, genetic progress is primarily made by the selection of a very small fraction of AI sires. Little selection is possible on the cow side when all heifer calves from cows need to be raised as replacement heifers. Van Vleck (1981) estimated that the rate of genetic progress could increase by 15% if sexed semen was widely available. Later, Baker et al. (1990) suggested that the use of sexed semen in elite cows and sires would have a very minor impact on the rate of genetic progress. The expected annual increase in breeding value from using the Net Merit selection index, not considering sexed semen, is for example 7.6 lbs fat, 172 lbs milk, 0.6 months productive life, and 0.14% daughter pregnancy rate (VanRaden et al., 2006). Sexed semen is usually not available from the best sires.

Most dairy producers do not or cannot rank their heifers for genetic merit. They either breed all heifers, or a random group of heifers, to sexed semen. The generation interval is reduced, however, if heifers become a major supplier of the next generation of animals. The value of increased genetic gain from the female side can often be ignored in practice.

Dystocia

Heifers and cows that calve with female calves have lower risks of dystocia and lower expected dystocia related costs. Fetrow et al. (2007) estimated that the reduced losses from dystocia when sexed semen is used in heifers are about $5.38 per calving. In cows, reduction of dystocia from the use of sexed semen was estimated at $1.48. Cady (1980) found that calving heifers with bull calves had a 10 percentage point greater risk of dystocia. At $147 per case, this results in $14.70 per bull calf (reported by Fetrow et al., 2007). They concluded that the reduction in dystocia should probably not be the principal driver for sexed semen use.

Calculations for heifers

Recommendations for commercial application of sexed semen have been primarily limited to heifers,

because of the expected lower fertility and higher cost of sexed semen (Garner and Seidel, 2008). It is useful to explore the combinations of assumptions that make sexed semen profitable. A spreadsheet was developed to calculate the value of sexed semen in heifers given sets of assumptions. This spreadsheet is similar to the model by Fetrow et al. (2007), except that it does not include the value of female genetic progress, which in practice can often be ignored.

Key assumptions, based as much as possible on the literature, are listed in Table 3. Sexed semen is assumed to have a conception risk of 75% of conventional semen. For example, 75% of a 60% conception risk results in a 45% conception risk with sexed semen, a reduction of 15 percentage points. Heifers that are not pregnant after the maximum number of breedings are culled and generate revenue based on their body weight. Growth and body weight of heifers was taken from Ettema and Santos (2004) with a maximum of 1400 lbs. Culled heifers are replaced by purchased heifers so the number of heifers that enrolls in the breeding program equals the number of heifers that calve.

Given the default assumptions, Table 4 lists the profit per heifer enrolled for 0 to 6 services with sexed semen. Additional services were with conventional semen. Other statistics are shown as well. Sexed semen increases profit at most by $10.35 after 2 sexed semen services. The first 4 services with sexed semen are profitable. The profit is the sum of the cull revenue, value of the calf, and value of the heifer to the dairy and the costs for raising, breeding, and dystocia. With more services by sexed semen, age of first calving typically increases, as well as cost to raise a heifer. When too many services are with sexed semen, the average raising cost per heifer enrolled decrease because the cull rate of open heifers increases more. More sexed semen breedings clearly increase the number of heifer calves born.

The value of sexed semen breedings in the default situation with $10.35 per heifer is relatively small. The value of sexed semen depends greatly on the heifer price, and to a lesser extent on the sexed semen price, and relative decrease in conception risk (Table 5). When heifer calves are worth $300, few scenarios make sexed semen a profitable choice. When heifer calves are worth $500, almost all scenarios make sexed semen a profitable choice. When sexed semen is profitable in the first service, it typically remains profitable in later services as well, even though the conception risk decreases.

Fetrow et al. (2007) used a similar spreadsheet and found similar results as presented here. The sets of inputs they evaluated were slightly different. In their default situation, losses after 6 services with sexed semen were $35. When only one service of sexed semen was used, the loss was $9. The authors concluded that sexed semen in heifers could only be profitable if there are very small differentials in the price of sexed semen (< $25), small impacts on conception risk (< 10%), and no consideration for genetic progress.

Olynk and Wolf (2007) studied break-even heifer calf prices and break-even insemination costs for sexed semen strategies in dairy heifers compared to a strategy with only conventional semen. When conception risk for first service conventional semen was 58% and decreasing after first service, the profit per heifer enrolled was $208. When conception rates for sexed semen were 75% of those of conventional semen and the first service was with sexed semen, the additional profit was $5. Second and later services with sexed semen were not profitable. Under these conditions, break-even heifer calf values were nearly $500. Break-even sexed semen insemination costs were close to $50. Their calculations were quite similar to the ones presented here and on the spreadsheet by Fetrow et al. (2006) but default assumptions differed in details.

In an earlier analysis, Seidel (2003) hypothesized that with near normal fertility of sexed semen and a premium for sexing in the range of $10 per dose, sexed semen likely would become economically and environmentally beneficial for most cattle. In an analysis with 90% fertility of sexed semen compared to conventional semen and heifer calve prices of $380, he found break-even premiums for sexed semen to be $44 (60% conventional semen conception risks) and $26 (40% conventional sexed semen conception risks). To have sexed semen widely adopted by dairy producers, Seidel thought these premiums should be considerable less than break-even.

Calculations for cows

Sexed semen is usually not recommended in cows because the conception risk is considered too low. Intuitively, sexed semen cost per pregnancy and cost from additional days open (because of reduced fertility) are greater than the value of the calf. A simple analysis confirms this conclusion for some reasonable inputs (Table 6). For the most part, the math is straight forward. The conception risk, expected sex and value of the calf, and the percentage abortions and dead calves determine the expected calf revenue per breeding. Nonpregnant cow costs were calculated as the percentage that failed to get pregnant times the value of a new pregnancy based on conventional semen. The value of a new pregnancy is the sum of the effects of greater days open, increased culling etc. because a cow failed to get pregnant. Figure 1 shows some values of a new pregnancy by lactation number and stage of lactation. Early in lactation, values for a new pregnancy are typically lower for first lactation cows than for later lactation cows. It turns out that the value of a new pregnancy is not a major factor in the value of sexed semen in cows. The value of genetic improvement is again ignored in these analyses.

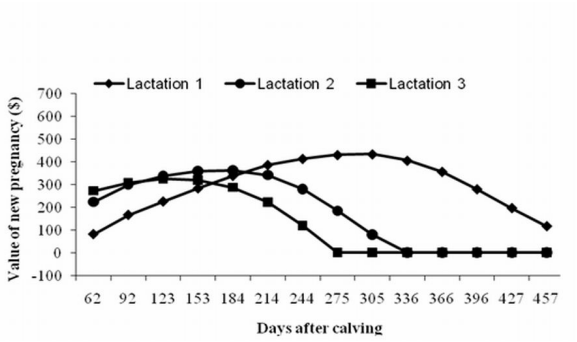

Figure 1. Value of a new pregnancy through conventional semen by days after calving and lactation number.

The sexed semen conception risk must be 31% to make the sexed semen breeding break-even in cost with the conventional semen breeding example in Table 6. Table 7 shows the conception risks with sexed semen in cows needed to at least break-even with the conventional semen breeding costs for a variation of assumptions. Table 7 shows that the break-even sexed semen conception risk is insensitive to reasonable variations in the price of sexed semen, the value of a heifer calf, and the value of a new pregnancy. In the best case for sexed semen, the decrease could be 17% (6 percentage points) when conventional conception risk is 35%, sexed semen costs $40, the value a heifer calf is $500, and the value of a new pregnancy with conventional semen is $100. Therefore, the decrease in conception risk with sexed semen must be quite small under most circumstances to make sexed semen a profitable choice.

Fetrow et al. (2007) also studied the economics of sexed semen in cows. If the value of sexed semen was based only on getting more heifers, and ignoring genetic progress, then their default loss after one service with sexed semen was $21. This is within the range of a loss of $34 as presented here, given some differences in assumptions. None of their sensitivity analysis showed a positive value of sexed semen without genetic progress.

Other considerations

Fetrow et al. (2007) also evaluated the value of increased genetic gain from the female side in their economic calculations. If heifers can be ranked for genetic merit, then the value of genetic gain was approximately $32 per heifer entering the breeding pool if the top 30% of heifers were bred at least initially with sexed semen and the bottom 70% were bred with conventional semen. Without the value of the genetic gain, the use of sexed semen in 30% of the heifers resulted in a loss of $11 per heifer entering the breeding pool (given a large number of reasonable assumptions about prices, fertility etc.). Therefore, considering genetic gain resulted in a $22 (-$11 + $32) value of using sexed semen per average heifer. The optimum mix was using sexed semen in 40% of the heifers for approximately a $33 value of genetic gain per average heifer entering the breeding pool. Their results show the potential benefit from accurately ranking heifers for genetic merit, using for example parent averages.

Fetrow et al. (2007) also reported that under reasonable assumptions the genetic gain from breeding only top cows with sexed semen still barely overcomes its cost. Therefore, they recommended not using sexed semen in cows.

Earlier, Seidel (2003) reported work by B. Cassell who found that the increased lifetime genetic value imparted to heifers due to selecting from 56% of the cow herd as future mothers (instead of 100% as is typical without sexed semen) was worth about $106. This is approximately $35 annually. If it would take 4 doses of sexed semen to produce a heifer calf that survives and enters the herd, then the genetic premium for the herd per dose is about $9.

Fetrow et al. (2007) and De Vries et al. (2008) discussed a series of other effects from sexed semen that add value that have not been included in most analysis. For example, if the supply of heifers increases greatly, it is expected that the purchase price of heifers reduces the cost of raising plus a reasonable profit for the seller. This purchase price should be lower than recent high heifer prices because supply is now limited. A greater availability of heifers, or lower purchase prices, also allows dairy producers to cull more low-end cows. Also keep in mind that after a successful sexed semen breeding today, it takes at least 9 + 24 = 33 months before the resulting heifer calf may freshen and start to generate revenues. The heifer market may have shifted from today's prices. Home raised heifers may also have advantages in biosecurity (better immunity, lower incidence of infectious diseases), but these advantages are difficult to quantify. Another factor is the effect of age of first calving on the animal's performance when she has calved. Ettema and Santos (2004) found that heifers that calved too young or too old had lower incomes in their first lactation. In addition, many farms do not have the facilities, feed, labor, capital needed, or permits to raise many more heifers than they are raising now without using sexed semen. The use of sexed semen in in vitro embryo production and embryo transfer was reviewed by Weigel (2004) and is probably quite valuable.

Summary

Conception risks with sexed semen are on average about 25% lower than conception risks with conventional semen, but field trial results have varied widely. A 25% reduction is approximately 10 to 15 percentage points in heifers. When not considering genetic progress, sexed semen is profitable when the value of the heifer calf is generally at least $400 more than the value of the bull calf. The value of sexed semen does not vary much per service number in heifers. Therefore, if a second service with sexed semen is not considered profitable, then the first service is at best marginally profitable. Sexed semen is usually not profitable in dairy cows, unless the fertility is almost equal to conventional semen. If the genetic merit of animals is known, sexed semen could be profitable on the genetically better animals while it is not profitable on the genetically poorer animals. Therefore, the value of genetic information likely increases when sexed semen is considered.

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Table 1. Value of a new born heifer calf when she is either raised (Raised) or sold and a pregnant heifer is purchased back (Sold)

Raising cost ($)	Purchase cost ($)	Value of new born heifer calf ($)	
		Sold	Raised
2000	2300	450	203
1800	2300	450	380
1600	2300	450	557
2000	2000	450	-55
1800	2000	450	122
1600	2000	450	299

Assumptions: 8% annual interest, discounted monthly. Market price newborn heifer calf is $450. Raising cost is equal in each month. Heifer purchased at 23 months of age and raised on farm one more month. Heifers calve at 24 months of age. Culling of raised heifers not considered.

Table 2. Conception risk (%) and number of breedings by service number in heifers bred with conventional semen in 3 datasets

Service number	Michael (2008)[1]	Kuhn et al. (2006)	Chebel et al. (2006)
1	56 (35,558)	53.3 (341,139)	67.8 (6389)
2	48 (13,841)	52.9 (109,743)	56.3
3	43 (6,032)	49.7 (36,469)	47.7
4	39 (2,263)	47.9 (13,433)	37.2
5	29 (1033)	43.8 (5,119)	
6	25 (601)	39.1 (2,064)	
7	24 (375)	32.7 (907)	

[1] Mostly conventional semen, some sexed semen.

Table 3. Key default assumptions for heifer calculations

Age at first breeding	400 days
21-day service rate	65%
Conception risks conventional semen	60% first service, a reduction of 5.75 percentage points per later service
Conception risk sexed semen	75% of the conception risk of conventional semen
Cost to raise heifers	$2 per day
Maximum number of breedings	8
Number of sexed semen breedings	first 0 to 8 breedings, remainder with conventional semen
Annual discount rate	8%
Market value raised but culled open heifers	$980 or less
Market value calving heifer (without value of her calf)	$1800
Semen cost	$40 sexed, $10 conventional
Value heifer calf	$450
Value bull calf	$50
Death loss per calving	10%
Heifer calves from sexed semen	90%
Heifer calves from conventional semen	48%
Extra dystocia cost	$14.70 per bull calf
Genetic progress	not considered

Table 4. Effect of number of sexed semen breedings on heifer statistics (default assumptions)

Statistic	Number of sexed semen breedings						
	0	1	2	3	4	5	6
Profit/heifer enrolled	266	276	276	273	269	266	262
Cull revenue/heifer enrolled	11	16	20	25	30	34	38
Value of calf/heifer enrolled	214	280	312	329	337	342	344
Value of heifer to farm/heifer enrolled	1766	1753	1741	1730	1720	1710	1702
Raising cost/heifer enrolled	1699	1715	1722	1724	1724	1723	1721
Breeding cost/heifer enrolled	19	54	73	85	92	96	100
Dystocia losses/heifer enrolled	7	5	3	2	2	2	2
Profit/pregnancy	269	281	283	282	279	277	275
Profit/breeding	147	131	121	115	111	108	106
Profit/breeding $	14.71	5.40	3.99	3.41	3.10	2.91	2.78
Avg. age at first calving (days)	703	712	716	718	719	719	718
Breedings/heifer enrolled	1.81	2.11	2.27	2.37	2.42	2.45	2.46
Service per conception	1.83	2.15	2.33	2.44	2.51	2.56	2.58
Breeding cost/pregnancy	10.58	25.72	32.28	35.75	37.88	39.34	40.46
%Calving/heifer enrolled	99%	98%	98%	97%	96%	96%	95%
%Heifer calves/heifer enrolled	47%	66%	75%	80%	82%	84%	84%
%Heifer calves/pregnancy	48%	67%	77%	82%	85%	87%	89%
Average conception risk	55%	47%	43%	41%	40%	39%	39%

Table 5. Sensitivity analysis of value of sexed semen in dairy heifers

Conv-entional CR (%)[1]	Sexed CR (%)	Sexed semen price ($)	Heifer calf value ($)	Profit per heifer enrolled,	Additional profit per heifer enrolled ($)			
				conventional	Number of sexed semen services			
				semen only ($)	1	2	3	4
60	50	35	300	202	5	2	(2)	(6)
60	50	45	300	202	(6)	(14)	(21)	(27)
60	45	35	300	202	(10)	(21)	(33)	(43)
60	45	45	300	202	(20)	(38)	(53)	(65)
50	45	35	300	145	5	4	(1)	(5)
50	45	45	300	145	(5)	(13)	(21)	(28)
50	40	35	300	145	(13)	(28)	(42)	(56)
50	40	45	300	145	(24)	(45)	(63)	(80)
60	50	35	500	287	42	56	59	59
60	50	45	500	287	32	40	41	38
60	45	35	500	287	24	28	24	17
60	45	45	500	287	13	11	4	(5)
50	45	35	500	226	39	53	57	56
50	45	45	500	226	28	36	37	34
50	40	35	500	226	16	16	9	(1)
50	40	45	500	226	6	(1)	(12)	(25)

[1]Conventional semen conception risk and sexed semen conception risk at first service. Both have a 5.75 percentage point decrease in conception risk for every later service. Genetic progress is not considered. ( ) means negative additional profit.

Table 6. Simple analysis of the value of sexed semen in dairy cows.

Assumptions	Conventional semen	Sexed semen
Conception risk	35%	25%
Semen cost	$10	$40
% Heifer calves @ $450 per calf	49%	90%
% Bull calves @ $50 per calf	51%	10%
% Abortions and dead calves	10%	10%
Value of new pregnancy	$200	$200
Results		
Expected calf value per pregnancy	$218	$369
Cows not pregnant after service	65%	75%
Calf revenue	$76	$92
Semen cost	$10	$40
Non-pregnant cow cost	$130	$150
Net return	($64)	($98)
Gain (loss) of sexed semen breeding	-	($34)

Table 7. Conception risks with sexed semen needed to break-even cost with conventional breeding. Conception risks greater than break-even result in an advantage for sexed semen

Sexed semen cost	Value heifer calf	Value of new pregnancy	Conventional conception risk		
			35%	30%	25%
$40	$400	$300	32%	28%	25%
$40	$400	$100	31%	28%	24%
$40	$500	$300	31%	27%	23%
$40	$500	$100	29%	26%	23%
$50	$400	$300	34%	30%	26%
$50	$400	$100	35%	30%	27%
$50	$500	$300	32%	28%	25%
$50	$500	$100	31%	28%	25%

Default inputs: conventional semen: $10; bull calves: $50; abortions and dead calves: 10%. Calculations as in Table 6.