Interactions: Genetics and Reproduction

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In general, genetic improvement programs have not been directed toward increasing reproductive efficiency in dairy cattle. Reproductive traits have small heritability estimates; therefore, genetic selection requires several generations to achieve measurable improvements.

Some reproductive traits which have been studied are:

- days open
- services per conception
- conception rate
- semen production
- semen fertility
- calving ease

Tremendous genetic improvements have occurred in the dairy cattle population. The progress has been due to the identification and the subsequent availability of superior sires through artificial insemination (Al). Since 1973 a new technology, embryo transfer (ET), has provided an additional avenue for genetic progress. The genetic and economic returns from this technology remain subject to the selection pressure placed on the dams and sires used.

In this fact sheet, the heritabilities of reproductive performance traits, the influence of reproductive efficiency on genetic progress, and the effect of embryo transfer on genetic progress are discussed.

Reproductive Performance

Estimates of heritability for reproductive traits are low (Table 1). For example, estimates for dystocia (difficult calving) range from .03-.15. This means 3 to 15% of the variation in dystocia scores is due to additive gene action. Animal performance is a combination of the genetic ability of an animal and the effects of the environment to which the animal is subjected. Thus 85 to 97% of the variation in dystocia is modified by environmental influences or non-additive gene action.

Table 1: Range of Heritability Estimates of Reproductive Traits in Dairy Cattle.

Trait	Heritability
Days open	.01-.10
Dry period	.15-.35
Breeding problems	.00-.20
Calving interval	.00-.10
Services/conception	.00-.10
Age at first calving	.15-.70
Dystocia	.03-.15

Adapted from Mao, I.L. 1984. Variations in Dairy Cattle Population: Causes and Consequences. Proc. National Invitational Workshop on Genetic Improvement of Dairy Cattle Wisconsin p. 34.

Although reproductive traits have low heritability, progress can be made. In Sweden, the incidence of cystic ovarian disease (Fact Sheet IRM-25) was 10.8% in 1954. By selecting against sire lines with a high incidence of cystic ovaries the occurrence of cysts was reduced to 5.1% in 1961.

Because the heritability estimates for reproductive traits are low, environmental influences dominate the genetic influence. Management plays a key role in determining the animal's performance for a given reproductive trait. Cows may not be bred quickly in an attempt to increase production records. The number of days open to first insemination varies considerably from herd to herd depending upon whether the producer starts breeding cows at 45, 60 or 90 days postpartum. In addition to conscious effects of management, failure to detect estrus (Fact Sheet IRM-6) increases days open as a result of the missed opportunities for cows to conceive. Many studies have shown this to be the single most costly management error in dairy herds.

Recently, the genetic relationship between reproductive performance and milk yield has been examined. Some researchers have reported a decline in days open as milk yield increased. It appears that reproductive efficiency can be maintained at an acceptable level as long as management is excellent. Therefore, economics dictate continuing intensive selection for production testing.

The genetic relationship between first lactation yield and virgin heifer fertility are complementary. Those heifers that will milk the most tend to breed easier than those heifers that will milk less during the first lactation. Thus if there is an antagonistic relationship between reproduction in lactating animals and milk yield, it may be caused by the stress of production.

Approximately one-fourth of the cows are culled because of reproductive problems. Since conception rates are a combination of the fertility of the bull and cow, it is critical to evaluate the male component of reproduction. To maintain acceptable levels of semen fertility and sperm concentration, AI studs have extensive quality control programs.

The AI studs are investigating the relationship between semen volume, concentration and total sperm and the yield of milk and milkfat. The lack of relationship indicates semen production in bulls and milk production in daughters are regulated by independent gene complexes. Therefore, selection for increased milk production should not alter semen production.

Selection for semen production will yield little response. The heritability of semen volume, concentration and total sperm are .12, .00 and .02, respectively. Determining management practices to maximize semen output from bulls with high predicted merit will provide more rapid returns than selecting for semen production.

Currently, the AI studs are rating the fertility of bulls within their respective studs. One system ranks Non-Return Rate from 1-5. The scores are interpreted as 1 = High; 2 = Above Average; 3 = Average; 4 = Below Average; and 5 = Low. Another stud does a similar ranking; however, 1 is low and 5 is high. Therefore, it is critical that producers familiarize themselves with the fertility rating system(s) used by the AI stud(s) from which they purchase semen.

In addition, the National Association of Animal Breeders (NAAB) ranks Holstein AI sires for the ease with which their calves are born. The calving ease summary is published each July. There are two measures included.

The first is the ***probability of being easier than breed average.*** This estimate takes into account his estimated transmitting ability for calving ease and how accurately his transmitting ability has been estimated. The sire with the greater probability is likely to be the better choice.

The second is the ***expected percentage of difficult births.*** A direct estimate of the expected problem births is provided when a bull is used to breed average heifers. An average bull would have approximately 11% difficult births, but it will vary from 1-2% for the best bulls for calving ease up to 30-40% for the poorest bulls. Thus, particular care should be taken when sires are selected for use on virgin heifers.

When selecting sires the following guidelines can be used:

1. Base primary selection on production or the combination of production and type best suited to the herd's needs.
2. For open heifers, choose from the sires normally used. However, select only those bulls whose calves will be born with the least expected difficulty.
3. Avoid using difficult calving sires to breed cows having a history of calving problems.
4. Place little emphasis on calving ease for second and later calving.
5. Use sires with high fertility ratings on problem breeders.

Genetic Progress

The four factors determining genetic progress are: accuracy of selection, selection intensity, generation interval, and genetic variation. Management skills can influence the generation interval and selection intensity. Genetic progress and profit potential are reduced by management decisions that result in increases in the number of animals culled for involuntary reasons or lengthens the generations interval. Reproductive performance is a major management concern since extending the calving interval and forced or involuntary culling increase the generation interval, while involuntary culling also decreases the selection intensity.

By meeting the reproductive goals of a 12 month calving period, 1.7 services per conception, 60% or more first service pregnancies and/or 24-27 months of age at first calving, producers have an opportunity to maintain optimum generation intervals and maximum selection intensity. Producers without the management skills to use AI to attain the aforementioned goals make economic and genetic sacrifices.

If heifers are not bred to superior AI sires, progress is reduced. Using genetically superior sires increases the genetic progress 3 to 4 times the rate of herds using natural service. To reap the genetic and economic rewards of AI, accurate estrous detection and high conception rates are necessary.

As the calving interval increases, the number of calves born and the number of bred heifers available for herd replacement per year is reduced (Table 2). The end result is less voluntary culling of cows which reduces selection intensity. Less profitable cows must be kept.

By extending the calving interval from 12 to 14 months and by delaying the entry of first calf heifers into the milking herd from 24 to 27 months, approximately 5 months is added to the generation interval. If a beef bull is used on first calf heifers, the calves can't be used for replacement heifers and the generation interval is lengthened by approximately 4 months. The result is a major loss to genetic progress.

Embryo Transfer

Since 1973, the number of ET calves has increased tremendously (Table 3). ET's currently account for less than 2% of registered births. However, future growth may reach 500,000 by 1990.

Table 3: Number of ET Female Births Recorded by U.S. Breed Organizations by Year of Birth

Year of birth	Total ET's Registered
1973	10
1974	8
1975	16
1976	100
1977	172
1978	310
1979	797
1980	1719
1981	1337
Total	4467

Adapted from Aitchison, T. E., 1984. Embryo Transfer—Genetic and Economic Opportunities, Proc. National Invitational Workshop on Genetic Improvement of Dairy Cattle, Wisconsin. p. 95.

Some of the many possible uses of ET are: production of replacement females, progeny testing females, production of bulls for AI progeny testing, testing for carriers of genetic recessive, exportation of embryos for profit, conversion of a herd from grade to registered animals, genetic and laboratory research, progeny testing bulls with fewer numbers of offspring, and commercial exploitation. To this point, ET's have not been a great source of genetic progress, at least for production. However, more ET's are being used in AI sampling programs and in milking strings as replacement heifers.

Table 2: Effect of Calving Interval on Number of Replacements in 100-Cow Herd

Calving Interval	Ave. No. Calves Born per Year	Bred Heifers Available for Herd Replacement per Year*
12	100	40
13	92	37
14	84	34
15	76	31

* Assumes 80% of the female calves born survive to freshen as first calf heifers.

Not all of the possible uses are economically feasible. To produce replacement females from the top end of the herd the cost of an embryo transfer must be in the range of $50-$100/embryo. Low estimates are in the $300/embryo range today, but transfer costs are closer to $1200 in general. Costs can be minimized when enough home-grown heifers are available as recipients.

By combining the desire to obtain replacement females from a superior individual in the herd and selling male calves to the Al industry, embryo transfer can be economically justifiable. The market value for bull calves average $2,000-$3,000 currently. At this price, or the higher price obtained in some auctions, embryo transfer may become extremely profitable.

Currently, using ET's to progeny test females does not appear to be a wise use of resources. When information on multiple offspring is available, it will be used to increase the future accuracy of evaluation. The use of ET's to identify the males and females which are carriers of undesirable genetic recessives is a viable alternative. Animals with superior genetics which have been recessive tested are more likely to be used as parents for young sires.

Summary

Although most reproductive traits have low heritability, progress can be made slowly. Management (environmental influences) plays a much larger role in reproductive efficiency than genetics. However, reproductive inefficiency can slow genetic progress by increasing the generation interval and by reducing the selection pressure.

Manipulation of the reproductive processes has resulted in the new technology of ET. Although there has been rapid adoption of ET, many realistic opportunities to accelerate genetic progress remain.