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EMBRYO TRANSFER IN BEEF CATTLE

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Embryo transfer allows one or more fertilized eggs (embryos) to be transferred from a donor female to other cows (recipients or surrogate mothers) for subsequent development and birth. Generally, the embryo transfer calf remains with its surrogate mother through weaning.

Persons with adequate training and experience can perform embryo transfer with a reasonably high success rate. However, due to its relatively high cost, the use of embryo transfer to date has been limited mostly to increasing the reproductive rate of valuable cows from seedstock herds and to research applications.

Most beef cows produce only one calf per year and fewer than 10 calves in their lifetimes. By combining embryo transfer with the process of superovulation (increased ovulation rate via hormonal stimulation of ovarian follicles), some cows can yield 50 or more embryos per year.

Procedures for Successful embryo transfer

Figure 1 illustrates the sequence of the major procedures and events which occur in successful embryo transfer and the relationship between donor and recipient cows.

Estrous synchronization

A recipient cow must be in the proper stage of the estrous cycle to receive the embryo and maintain pregnancy. The cycles of the donor and recipient cows need to be synchronized so that their respective heat periods occur within about 24 hours of one another.

Since the estrous cycle lasts about 21 days in the cow, normally only about 5% of cycling recipients would have natural heats coinciding with a given donor. Estrous synchronization makes it unnecessary to maintain large herds of recipients.

The estrous cycles of cows may be synchronized by injection of prostaglandin F2-alpha. Commercial prostaglandin products currently available for estrous synchronization for beef and dairy

cows and heifers include Lutalyse and Estrumate. Bovilene is available for beef and non-lactating dairy females.

Synchro-mate B includes a synthetic progestin given through an ear implant and an injection consisting of a progestin and an estrogen. Synchro-mate B is currently available for use with beef and dairy heifers, and approval for cows is anticipated.

Producers should check with their veterinarian for current use approval status of all such products and availability of new products.

It is important to realize that prostaglandins work only on females which are cycling naturally.

Superovulation

Although a single embryo may be recovered from a normal estrous cycle, it is usually more desirable to stimulate multiple ovulation so that several embryos may be obtained from a single flush.

The response of cows to follicle stimulation varies considerably. Zero to 30 or more eggs may be obtained from a single flush, with none, some, or all eggs fertilized. A typical flush commonly results in 8 to 10 embryos with 6 to 8 of transferable quality.

The frequency with which a cow should be superovulated varies from cow to cow. It is generally recommended that cows not be superovulated on successive estrous cycles.

Superovulation is accomplished by hormonal stimulation of the ovarian follicles. One method is to give twice daily injections of follicle stimulating hormone (FSH) for 5 consecutive days, beginning at the stage of the cycle when the follicles are most active (8 to 15 days after the onset of heat). An injection of a prostaglandin F2-alpha compound may be given on the second or third day of the 5-day series, bringing the cow into heat about 36 to 48 hours later.

The donor cow is generally inseminated at 12, 24, and 36 hours after the onset of estrus. Natural service has also been used suc-

cessfully. Another method to stimulate superovulation is to give a single injection of a hormone known as pregnant mare serum gonadotropin (PMSG) at about day 15 or 16 of the estrous cycle.

Embryo collection and transplant

The great majority of cattle embryos are collected non-surgically. The non-surgical technique is less expensive and lends itself to on-farm transfer, compared to the surgical method which requires surgical skills and more sophisticated facilities. Basically, collection involves passing a rubber catheter through the cervix and flushing the embryos out of each uterine horn with a flushing fluid. The catheter contains three channels: one for fluid inflow, one for outflow of fluid and embryos, and one which provides for inflation of a small balloon which holds the catheter in place. Flushing is done about 6 to 8 days after breeding.

The transfer embryo is inserted into the recipient's uterine horn next to the ovary which has a functional corpus luteum. Non-surgical transfer typically involves insertion of the embryo into the uterine horn with a 1/4 cc French straw placed in a 1/4 cc French A.I. gun. The A.I. gun is passed through the cervix and into the proper horn before expulsion.

Surgical transfer involves making an incision in the flank and a small puncture in the proper uterine horn, through which the embryo is inserted via a small pipette.

Embryo manipulation

The flushed fluid is examined under a microscope to locate embryos. The embryos are examined for evidence of viability and then transferred immediately to the synchronized recipient cow, or they may be prepared for manipulation or storage. Manipulations include obtaining biopsies for sexing and embryo splitting.

The sex of an embryo can be determined by examination of chromosomes from cells obtained by biopsy. Although time consuming, the procedure is not usually harmful to a viable embryo, if done properly. Other potential methods of embryo sexing, including the HY-antigen method, are under investigation.

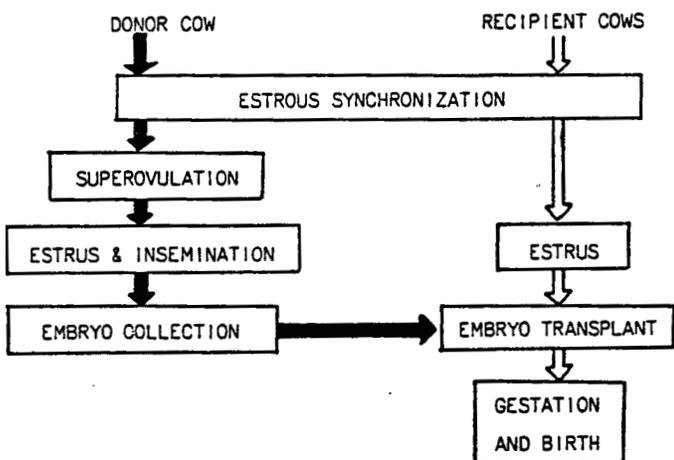


FIGURE 1. PROCEDURES INVOLVED IN EMBRYO TRANSFER

The physical splitting of an embryo may result in identical twin embryos, which are generally transplanted into different recipient cows. The primary benefit of splitting embryos to date has been to increase the number of embryos available for transfer from a given donor cow.

The production of identical twins also has considerable potential as a research tool, since differences observed between the identical twins are non-genetic and must be due to differences in environmental influences.

The capability to freeze embryos allows considerable flexibility, although pregnancy rates obtained from this procedure are generally lower than rates obtained with fresh embryos. Freezing allows embryos to be stored for long periods of time and permits flexible management of recipients. When collection results in more embryos than available recipients, the extras can be stored.

Combining use of frozen embryos and estrous synchronization of recipients may allow a more restricted calving season for large embryo transfer programs. Producers with valuable donor cows but no desire to get involved with the management and expense of recipients can utilize embryo transfer through the use of embryo freezing.

Selection of donors and recipients

Because of its relatively high cost, embryo transfer to date has been limited primarily to seedstock herds.

Only truly genetically superior cows should be considered as candidates for donors. There are many opinions among breeders as to what constitutes a genetically superior cow. Economic importance and heritability of traits should be two major factors.

Some tradeoffs exist regarding the potential advantages and risks of using heifers as donors. A primary potential benefit is shortening the generation interval. However, some breeders prefer to first let the heifer sustain a pregnancy to term, allowing evaluation of such criteria as udder development and first-calf performance. Still others prefer to use only "proven" cows, which have produced several calves.

The selection of recipient cows is very important but is sometimes underemphasized. Even though the surrogate contributes no genetic material to the offspring, she does exert important maternal environmental influences which affect the physical makeup (phenotype) of the calf. For example, her milk production will affect calf weaning weight. There is also a maternal environmental effect on calf birth weight. Cows with reproductive problems or low calf weaning weights should not be used as recipient cows.

On-farm vs. off-farm embryo transfer

The success rate of attaining pregnant recipients in an embryo transfer program is dependent on many factors, including heat detection and strict adherence to schedules. Coordination and timing of heat synchronization, superovulation, embryo collection, and transfer are critical. Proficiency in artificial insemina-

tion is also required, since most donor cows are bred artificially. Considerable training and a high level of management are necessary.

Professional embryo transfer services are available at a transfer center or at the producer's farm, or a portion of the services can be performed at each location.

For example, donor cows can be superovulated, bred, and collected at the transfer center, with the producer providing the recipients. Alternatively, donor cows can be superovulated, bred, and collected on the producer's farm, with the embryos being implanted in recipients at the transfer center. Farm personnel can do all the embryo transfer work, but this requires considerable knowledge, training, labor, and management capabilities.

The extent to which a breeder elects to personally participate should depend on the availability of adequate facilities, recipient cows, time, labor, and level of technical skills, management ability, and desire.

Perhaps the primary reason for considering on-farm embryo transfer is that the initial cash outlay is generally less, especially if the breeder already owns cows which can serve as recipients. Another advantage of on-farm embryo transfer is that it reduces the time, cost, and stress of transporting cows. Also, keeping embryo transfer cows on the farm allows their display for merchandising purposes.

Embryo transfer and performance testing

Embryo transfer presents problems regarding analysis of performance records of transplant calves. Potential bias exists because of the maternal influences of the surrogate dam.

At the present time, several organizations which analyze performance records either do not calculate ratios for performance traits of embryo transfer calves, or the calves are given a ratio of 100 (average).

Estimated breeding values for a calf can be calculated from the performance of the calf's relatives. In that case, calves of the same sex and from the same flush will have identical estimated breeding values for a given performance trait, despite differences in individual performance. The estimated breeding values remain the same until the animals produce (by non-embryo transfer) offspring of their own.

The fact that a calf is an embryo transfer calf does not by itself mean the calf is better than average or below average. Because of the relatively high cost of embryo transfer, breeders generally will use above average cows mated to superior bulls, so a high proportion of above average offspring would be expected. However, considerable variation among the offspring is common.

A common misconception relates to the uniformity (or lack of it) of embryo transfer calves from the same flush. Except when embryos are split, embryo transfer calves from the same flush are generally no more alike genetically than full brothers and sis-

ters resulting from natural reproduction methods. In addition, differences in maternal effects of recipient cows will likely contribute to additional phenotypic calf variation.

Other potential uses of embryo transfer

Ease of transportation

The capability of freezing embryos for long-term storage allow for easy and inexpensive transport of genetic material compared to the transportation cost of live cattle.

Of great potential is the international marketing of germ plasm through frozen embryos, although many health regulations apply and vary from country to country. The possibility of spreading disease through embryos or embryo media should continue to be of concern.

Preservation of germ plasm

By freezing embryos, the germ plasm of a cow or a mating can be preserved for the future. Flexibility in merchandising is also enhanced.

Typical sustained pregnancy success rates for freeze-thaw embryos are currently about 30 to 40%. Embryo "banking" would likely increase if improved technology increases success rates to 50 to 60%.

One application of embryo freezing also involves embryo splitting. One embryo is allowed to develop immediately, while the identical twin embryo is frozen. Whether or not the frozen embryo is allowed to develop depends on the performance of its genetic twin.

One concern regarding preservation of embryos is that the generation interval will be lengthened.

Twinning

It has been estimated that maintenance of the breeding herd itself uses about 55% of the total feed energy utilized in beef production. Some potential exists in decreasing cow maintenance requirements per calf through twinning.

Embryo transfer is an effective method of inducing, although it is not cost effective for commercial production at the present time.

A heifer calf born as a twin with a male calf will usually be sterile; she is known as a freemartin. By combining either the practice of embryo sexing or embryo splitting with embryo transfer, the problem of obtaining a freemartin twin heifer can be avoided.

Obtain offspring from young females

With somewhat limited success, fertilized eggs can be obtained from females not yet physiologically mature enough to sustain pregnancy. This provides an opportunity to speed up genetic change by decreasing the generation interval.

Obtain offspring from cows with reproductive problems

Cows classified as "problem breeders" are usually avoided for use as donors. However, embryo transfer can sometimes be used

to obtain offspring from terminally ill cows and from some cows which themselves cannot maintain pregnancy because of certain non-heritable reproductive problems, such as injuries to reproductive organs.

Caution should be exercised so that heritable reproductive problems are not passed on to the offspring.

Testing for genetic defects

To test bulls as carriers of genes for certain recessive genetic defects, they can be mated to cows that possess the recessive gene. If the bull is a carrier, mating him to cows that are homozygous for the recessive trait increases the probability of the defect showing up in the offspring.

However, sexually mature females with certain homozygous recessive alleles can be extremely rare. If a homozygous recessive female can be located and superovulated, embryo transfer can greatly expedite testing.

Summary

Embryo transfer is relatively expensive, and is most commonly used to increase the number of offspring from superior females. It requires considerable knowledge and skill for reasonable success, and can be done on-farm or at a transfer center.

Procedures include estrous synchronization of donor and recipient, and embryo collection and transplant. Superovulation and embryo splitting increase the number of embryos obtained from a flush. Embryo freezing allows flexibility in managing recipients, and in merchandising and transportation of embryos.

Improvements in technology and lower costs would likely increase future use of embryo transfer.

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