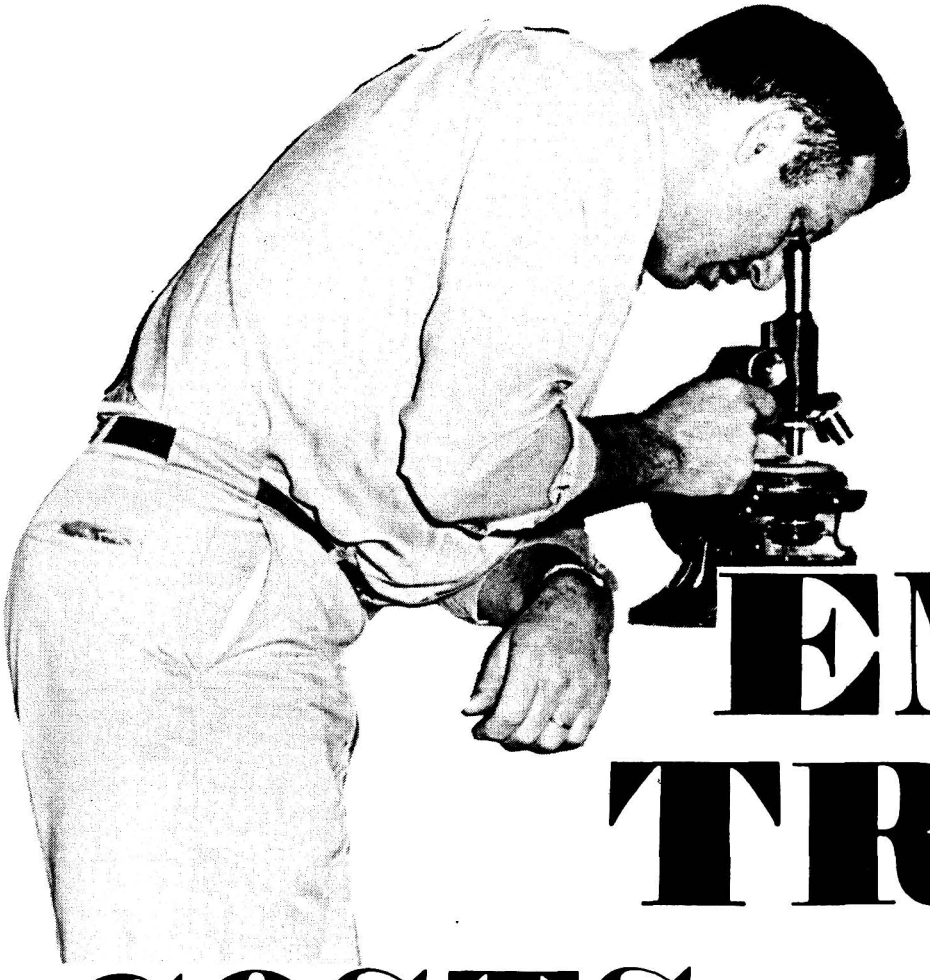

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COSTS and SU

By G.E. SEIDEL, JR. & S.M. SEIDEL

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We estimate that more than 10,000 pregnancies will res from embryo transfer with cattle in North America in 1978. 1979, this figure will probably be higher. This activity will only affect those of us who provide embryo transfer services who use them in breeding programs, it will also affect the b and dairy industries in general. In this article, we will consic current applications, success rates, and costs of embryo trans with cattle.

Methods of Embryo Transfer

The methodology of embryo transfer has been presented ma times before, so we will only review it briefly. Usually, the fi step is to treat donors with pregnant mare's serum gonadotro or follicle stimulating hormone to induce superovulatic although single-ovum recoveries are feasible. T superovulatory treatment is generally begun between 9 and days after estrus. Two or 3 days later, prostaglandin F^2a or analog such as cloprostenol is injected to lyse the corpus luteu One can expect the donor to be in estrus 2 days later. M superovulated cows are inseminated two to four times wi multiple doses of semen, although the necessity for such schedule has not yet been proven conclusively.

Embryos are usually recovered six to eight days after estr with a Foley catheter (Figure 1), a latex rubber tube which

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introduced into the uterus in the same manner as an artificial insemination catheter and held in place with an inflatable cuff. Approximately 800 ml of fluid are flushed through the anterior half of each uterine horn. It takes about half an hour to recover the embryos from a cow and it can easily be done on the farm. Since no surgery is involved with this method, there is little risk to the health or future fertility of the donor.

The embryos, which are about 1/200th of an inch in diameter, are isolated under a microscope. They may be kept for about half a day between 20 and 37°C with little loss in viability. Embryos may be stored for longer periods by cooling them to refrigerator temperature, storing them in the rabbit oviduct, or freezing them in liquid nitrogen. These methods are not yet in general use because, they result in decreased pregnancy rates or are impractical.

Embryos not stored at low temperatures must be transferred to a recipient that was in estrus within a day of the donor. The transfer is usually made through a flank incision with local anesthesia, or through an incision between the navel and udder with general anesthesia. Embryos may also be transferred non-surgically, much like artificial insemination with a French straw. However, pregnancy rates are lower than with surgical methods.

Highland Georgina 90, owned by the Highland Stock Farms of Calgary, Alberta was the very first registered Angus female to undergo an embryo transplant. She is pictured here with her "litter".

Current Uses of Embryo Transfer

The primary use of embryo transfer is to increase the reproductive rate of valuable females. This can be very profitable. At a recent national sale, the top-selling animal was from embryo transfer and sold for over $100,000; his maternal

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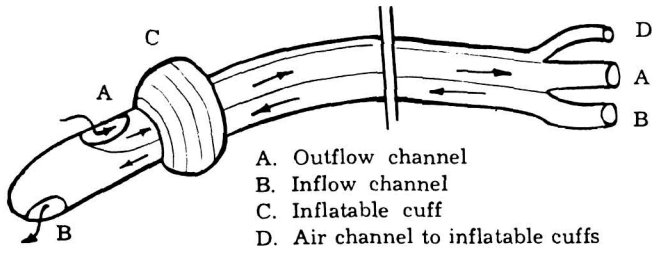
maternal sister, also from embryo transfer, was the third highest-selling animal in the same sale. On the other hand, many people have lost tremendous amounts of money, often because they were using donors whose worth was based on a passing fad rather than on important traits. Embryo transfer can be compared to a computer. If used correctly, computers really speed up computations; however, if there is an error in the instructions to the computer, or one uses the wrong assumptions, one merely has a faster method of making mistakes.

Embryo transfer is especially useful for obtaining progeny from valuable, but infertile cows. While it is foolish to propagate cows, and especially heifers, with infertility of a genetic nature, it is often appropriate to circumvent infertility due to disease, injury, or senescence with embryo transfer.

Often it is less expensive to import and export embryos than animals, and risks of transporting disease are lower. Moreover, the resulting calves will be born to acclimated mothers and exposed to the new environment as a fetus and newborn. This will probably result in much healthier animals. A disadvantage is the delay until adult cattle are available for use. In the same vein, embryo transfer can be used to introduce new genes into specific pathogen-free herds. This has already been used with swine and can be envisioned for cattle.

FIGURE 1: FOLEY CATHETER



A. Outflow channel
B. Inflow channel
C. Inflatable cuff
D. Air channel to inflatable cuffs

Finally, embryo transfer is being used to progeny test bulls for undesirable recessive traits. Such tests are often otherwise impractical because females of reproductive age with recessive traits such as dwarfism and syndactyly (mule-foot) are rare. Since about 10 calves are required to test a bull, one or two donors can usually provide sufficient embryos within a reasonable period of time.

Success Rates

Success rates with embryo transfer depend on all of the factors associated with artificial insemination plus a few more. Proper nutrition and management, fertile semen, properly trained personnel, adequate resources, and luck are all important.

The first example we will consider is single ovum recovery from normally cycling, unsuperovulated heifers or young cows without fertility problems. We will further assume that donors are inseminated properly with high-quality semen, that embryo recovery and transfer are done properly with highly skilled personnel, and that embryos are transferred surgically to recipients in estrus on the same day as the donors.

From 100 such donors, we should recover about 70 ova. Reasons for not recovering the remaining 30 may include failure of the donor to ovulate, loss of embryos from the reproductive tract, and failure of the method to recover all embryos. We would expect about 7 of the 70 embryos to be unfertilized and about 7 more to be morphologically abnormal or retarded in development. This leaves 56 normal embryos from which we can

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expect a 70% pregnancy rate or 39 pregnancies. We would also expect to get about one normal pregnancy from transferring the 7 apparently abnormal embryos. This means 40 total pregnancies from the 100 donors or a 40% chance of a pregnancy from one recovery. This procedure can be repeated every estrous cycle. Assuming 90% efficiency in estrus detection, this could result in 15 collection attempts per cow per year, or about six pregnancies. If one attempted two recoveries of a single embryo from each of his 10 best cows between 40 and 90 days of lactation prior to breeding them, this would mean eight additional top calves. These success rates may be compared to the 50-60% calving rate obtained from a single artificial insemination. Suboptimal conditions may lower the success rates drastically. For example, if the donors had histories of infertility, the number of pregnancies would probably be reduced by about half. This would still provide many more pregnancies than could have been obtained without embryo transfer.

If the same donors in the above example were superovulated with the best treatment available, one would expect an average of 10 ova from each. On the average, two ova will be unfertilized, two will be retarded or otherwise quite abnormal, and six will be normal. With superovulated ova, about 60% of the normal embryos (3.6) plus 20% of the abnormal or retarded embryos (.4) will develop to term after transfer, for a total of 4 pregnancies per donor from transferring eight embryos. This procedure can be repeated about every 2 months. However, the response to superovulation may decline with repeated treatments and it is unclear if superovulation can be recommended more than four or five times for each animal.

Thus, while superovulation increases the average number of pregnancies tenfold, from about .4 to 4, the frequency with which this technique may be used is limited. Often we alternate superovulation with single-ovum recovery.

Although superovulation is very effective on the average, there is great variability, which is illustrated by this typical example. If 10 donors were superovulated resulting in 40 pregnancies, the number of pregnancies from each of the donors will be distributed approximately as follows: 0, 0, 1, 2, 2, 4, 5, 7, 8, and 11. Thus, of the 10 donors, three have only 0 or 1 pregnant recipient, half have 2 or fewer, and only three have more than 5. Nearly half of the pregnancies are from two of the 10 donors. Consequently, superovulation and embryo transfer is a tremendous gamble with one attempt with one cow. There is less risk in averaging the pregnancies from three superovulations per donor although donors that do poorly on one occasion tend to do poorly on other occasions too. A typical distribution of total pregnancies from each donor superovulated three times would be something like 0, 2, 6, 7, 10, 13, 16, 19, 21, and 26. While the average number of pregnancies per superovulation is still 4, there is only one donor from which no pregnancy was obtained.

As with single-ovum recovery, success rates will be lowered if one or more factors are suboptimal. For example, pregnancies will not result from embryos that must be discarded because sufficient recipients are not available. Also, fewer pregnancies will result from donors with known fertility problems.

Costs of Embryo Transfer*

Costs of embryo transfer may be divided into three categories: (1) fees charged by the embryo transfer unit, (2) other direct costs, and (3) indirect costs. The fees charged by embryo transfer units vary somewhat and each unit may have several plans. One representative plan provides for resident donors at an embryo transfer unit. Typically it includes a non-refundable entrance fee of $500, which covers expenses such as health tests, veterinary care, and drugs

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for superovulation; a boarding fee for the donor of about $2 per day; and a pregnancy fee of about $1700 per pregnant recipient, as of late 1978

A plan for on-the-farm recovery with transfer to recipients at the embryo transfer center typically includes a fee of $150 for each recovery plus travel expenses in addition to $1700 per pregnant recipient. The drugs for superovulation are usually mailed to the owner and administered under the supervision of his veterinarian. Because the donors are not under direct and constant control of personnel at an embryo transfer unit, success rates are usually lower with on-the-farm recovery.

One adjustment that should be made to these fees is the salvage value of the recipient. Currently, this averages about $400.

Other direct costs include veterinary fees of all sorts, such as Caesarean sections on recipents and health tests; trucking costs; semen costs; blood-typing fees (for some breeds); registration fees (some associations have surcharges for progeny from embryo transfer); feed costs for the recipient and calf; interest; and miscellaneous costs such as postage, telephone, labor, and advertising. Many of the direct costs can be deducted as expenses for tax purposes, and profits can often be manipulated such that income is in the form of capital gain.

Indirect costs include: (1) potential interest on the investment, (2) loss from abortions, which seldom is over 3% after 90 days of gestation with good management, (3) loss from stillbirth or death of the calf, which should occur in less than 10% of cases with good management, (4) owner's time, (5) a margin of profit to compensate for the possibility of obtaining an unfavorable sex ratio among the calves produced by embryo transfer, and (6) profit required to justify the risks. A summary of typical costs for a resident donor superovulated three time over a 6-month period at an embryo transfer center is presented in Table 1.

The example presented in Table 1 does not take owner's time or profit into account, nor does it include a safety factor for unfavorable sex ratios for situations in which it is difficult to merchandise groups of full brothers profitably. With a 50-50 sex ratio, chances are greater than 17 out of 100 that 7 or more calves out of 10 will be of one sex. Another factor to consider is that there may be significant tax advantages, and if so, costs should be pro-rated.

It is clear that the break-even point is somewhere between $2000 and $3000 for each 6-month-old calf, depending on the specific circumstances. Pregnancy fees after adjustment for salvage value of recipients only account for about half of the costs. It should also be noted that

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some of the costs in Table 1 apply without embryo transfer too.

Intangible factors worth considering include satisfaction from working with advanced procedures and pride in breeding better cattle. Probably one should also mention frustration after having recovered 20 unfertilized ova from an outstanding donor bred with expensive semen.

The ET Industry

Next we would like briefly to consider the economics of embryo transfer from the viewpoint of the more than 20 legitimate firms currently offering embryo transfer services. It appears that gross revenues from embryo transfer in North America may be more than $15,000,000 per year. The artificial insemination industry is already involved and will become more involved. How much profit is there in providing embryo transfer services? Several firms have made substantial profit; on the other hand, many have gone out of business, some of them in a bankrupt condition. The industry is very competitive; consequently, profits on the whole will be limited. It is even more dependent on cattle prices than the artificial insemination industry, with the result that firms on the brink of bankruptcy one year may generate substantial profits the next year.

The major cost of embryo transfer is maintaining hundreds of potential recipients in prime reproductive condition. The size of the recipient herd should be calculated on the basis of having 20 recipients in estrus within a day of each donor in estrus. Even then, there will occasionally be too few appropriate recipients. With an average of three superovulated donors per week, about 200 recipients must be available for use; with one recovery per day, about 300 recipients are required. Replacements must be screened and passed through quarantine at the same rate as transfers are made. Because 50 to 80 recipients may

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TABLE 1
TYPICAL COSTS FOR ONE EMBRYO TRANSFER DONOR

Item	Cost
Initial entrance fee	$ 500.00
Board, 180 days @ $2/day	$ 360.00
Pregnant recipients, 11 @ $1300 ea.	$14,300.00
Semen, 15 doses @ $20 ea.	$ 300.00
Veterinary fees to truck donor	$ 50.00
Caesarean sections, 8 @ $75 ea.	$ 600.00
Veterinary fees for calves	$ 350.00
Trucking fees for donor and recipients	$ 700.00
Blood-typing fees, 22 samples @ $15 ea.	$ 330.00
Registration fees, 10 calves @ $50 ea.	$ 500.00
Feed and board for recipients, 11 recipients for 360 days ea. @ $1/day	$ 3,960.00
Feed and board for calves, 10 calves for 180 days @ $.50/day	$ 900.00
Interest, 366,000 dollar-months @ .75%/month	$ 2,745.00
Advertising, telephone, misc.	$ 1,000.00
	Total $26,595.00

Assumptions

Pregnancy fee is $1700, but salvage value is $400 per recipient resulting in net fee of $1300.
Recipients must be fed from 90 days of gestation to weaning of calves at 6 months of age.
Donor was at embryo transfer unit for 6 months during which time there were three single ovum recoveries and three superovulations resulting in 11 pregnant recipients.
Eleven calves (6 bulls and 5 heifers) were born but one heifer died of scours.
Calves are marketable at 6 months of age.
Donor is worth $10,000, which is invested for 6 months.

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be used some weeks, about 100 replacement recipients must be on hand in addition to the group already available for use. Another group of recipients will be awaiting pregnancy diagnosis; the pregnant recipients will have to be kept until they are picked up by the client after 90 days of gestation. If a firm produces 500 pregnancies per year, there will be more than 200 recipients at any given time to which embryos have been transferred. With very efficient management, such a firm can keep the number of total recipients on hand to about 500. Costs of locating recipients in reproductive prime are high, and premiums frequently must be paid for cattle of suitable quality. Feed, veterinary care, and routine health tests and vaccinations for an average daily inventory of 500 recipients are very expensive.

The second greatest expense is personnel. A workable staff includes veterinarians, a business manager, an embryologist, a secretary, and personnel capable of estrus detection and feeding, purchasing, and handling cattle. A third category of expenses includes drugs, surgical supplies, equipment, buildings, tractors, trucks, telephone, and interest.

Future Developments

The single technological advance that may make embryo transfer affordable to more breeders is freezing embryos to liquid nitrogen temperature. This would cut recipient cost enormously and provide much more flexibility. Currently, pregnancy rates after freezing and transferring unselected frozen embryos are about half of those with unfrozen embryos. This unfortunately means that twice as many embryos must be transferred to get the same number of pregnancies as without freezing. However, the cost per pregnancy may be less under certain conditions. We expect that freezing techniques will improve considerably over the next few years, and if they do, costs of embryo transfer will decline. Meanwhile, we foresee the maintenance of smaller recipient herds combined with the practice of freezing embryos when insufficient recipients are available for immediate transfer. Also, the export of frozen embryos is already practicable under some conditions, even with lowered pregnancy rates.

A second crucial advance will be improvement of non-surgical transfer methods. Under field conditions, current success rates are usually about half of those with surgery. However, there are several unpublished reports that are more optimistic. When non-surgical methods are perfected, on-the-farm transfer will become more feasible.

Several firms already offer on-the-farm transfers. Fees may be as low as $500 per pregnancy plus traveling expenses. Such programs may be effective in very large dairy herds or in large beef herds with extensive artificial insemination programs in which large numbers of potential recipients are available for certain periods. One must keep the principle in mind that increased reproductive rates of donors are usually at the expense of decreased reproductive rates of recipients. At embryo transfer units, each 90-day pregnancy requires feeding a recipient an average of 360 days. On-the-farm transfer programs can quickly put the herd owner in the same position as embryo transfer units; that is, ending up with an expensive recipient herd because of an increased calving interval and few pregnancies to repay these costs.

One final technique which will help make embryo transfer more feasible is sexing of embryos. Already, embryos can be sorted into three approximately equal groups, male, female, and unknown. The technique is expensive and pregnancy rates are reduced. However, this will improve with further research.

Currently, pregnancy rates with unselected frozen embryos transferred nonsurgically would likely be about 20%. If embryos were relatively inexpensive, two could be placed in each recipient. This would probably increase pregnancy rates to over 30% but would result in some twins with a small percentage of freemar-

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and $300 for each third place winner.

The scholarship winners will be announced in July at the American Angus Futurity in Louisville, Kentucky.

Interested high school seniors are encouraged to contact their state scholarship chairman for details, deadlines and a new scholarship application form. Information is also available from the National Scholarship Chairwoman, Mrs. Jack Rae, 3837 Crain Road, Onondaga, Michigan 49264.

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tins. When pregnancy rates with frozen embryos and non-surgical transfer approach 40%, the technique may partially replace artificial insemination. Dairy cows in estrus prior to 60 days of lactation and similar members of beef herds could be inovulated without greatly increasing calving intervals if the 60% that failed to become pregnant were subsequently inseminated.

Artificial inovulation should not cost much more than artificial insemination. Prices of frozen embryos, however, will be much greater than most doses of semen. In a few years, cost of collecting and freezing embryos may be less than $100 per embryo. It seems to us that frozen embryos from the upper tenth percentile of a good purebred herd might be sold for around $200 each and those from the top percentile for $400 or more each. If embryos cost $200 each with processing, inovulation fees were $10 each, and cost of the increased calving interval of non-pregnant recipients were $10 each, this would mean $220 per transfer or $550 per pregnancy with a 40% success rate. A few of the costs listed in Table 1 would be applicable and have to be added to this figure to determine how much more a calf from embryo transfer would cost than one produced by artificial insemination.

Pregnancy rates of 40% with frozen embryos transferred non-surgically can probably be attained in several years, and possibly sooner with sufficient research support.

REFERENCES

An excellent general review with comprehensive refernces is: Betteridge, K. J., ed. 1977. Embryo transfer in farm animals. Monograph 16, Canada Department of Agriculture. Copies can be obtained free of charge by writing: Information Division, Canada Department of Agriculture, Ottawa, Ontario, Canada K1A 0C7.

Recent authoritative reviews on freezing, sexing, twinning, and non-surgical transfer of embryos appear in the Proceedings of the 4th Annual Meeting of the International Embryo Transfer Society which constitutes volume 9 (1) of Theriogenology. Copies may be obtained by sending $15 to IETS, 3101 Arrowhead Road, LaPorte, CO 80535.

The techniques used in our laboratory are presented in detail in a bulletin entitled "Bovine Embryo Transfer Procedures." A copy may be obtained by sending a check for $5, payable to Colorado State University, to: Animal Reproduction Laboratory, Colorado State University, Fort Collins, CO 80523.

Ferguson Is Poweshiek President

Bill Ferguson, Searsboro, was elected president of the Poweshiek Angus Association (Iowa) at their annual meeting in Malcom.

Elected vice-president was Roger Hall, Malcom, and secretary-treasurer is Mrs. Susan Davis, Grinnell.

Directors are Steve Carson, Newton; Gerald Ferguson, New Sharon; Wayne Reinbrecht, Tama; and Edward Maschmann, Victor.

Plans are underway for their annual sale to be held April 18 in Grinnell.