PRESENT VALUE OF EMBRYO TRANSFER AS A TOOL FOR GENETIC IMPROVEMENT IN DAIRY HERDS

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SUMMARY

The advantage of using embryo transfer (ET) as a mean of increasing the intensity of selection through the female dairy cow was studied using a simulation model. Several degrees of reproductive success for ET were considered (between 3 and 100 calves per donor per year), which were compared with the results of selecting replacements from breeding without the use of ET. The maximum advantage expected under the present conditions (around 400 kg at lactation after 20 years of carring out selection with 15 offspring per donor cow and h^2=0.20) does not offer any advantage that could justify the use of such and expensive technique for the purpose of genetic improvement of a dairy herd.

INTRODUCTION

Genetic improvement is often mentioned as one of the main advantages of embryo transfer (ET) (Land and Hill, 1975; Cunningham, 1976; Church and Shea, 1977; Land, 1977). However, there are few quantitative studies about the potential impact of ET on genetic improvement programs.

From a reproductive point of view, the success of ET is often evaluated by partial parameters such as the conception rate of the receptor animals, or the number of calves obtained per donor. However, in considering the use of the technique at a commercial level, the global efficiency of the process, from the superovulation of the donor until the offspring is born, has to be taken into account (Esslewon, 1984). An index such as the one proposed by Navarro and Evertsz (1985) can be used for this purpose. As shown in table 1, the efficiency of each step of the ET process in low. When the results presented on the table were combined to calculate the overall efficiency of the process, the estimated number of calves obtained from each donor animal at the end of each reproductive cycle varied from 2 to 10.

The objective of this work is to determine the value of ET, at various hypothetical levels of reproductive success, as a method for genetic improvement of commercial dairy herds.

MATERIAL AND METHODS

We developed a deterministic model to simulate the genetic improvement expected on dairy herds that use their best cows for the production of replacements. Using the model we estimated the response to selection when a single calve is born every year from each cow, thus representing the progress expected under normal reproduction (control group). The simulation model was also used to estimate the response of hypothetical herds using ET with different degrees of reproductive success and getting 3,6,9,15,25,50 or 100 calves per donor per year. Although too high an expectation at the present, the last three levels were used to account for possible future improvements on the ET technique.

Assumptions of the model

The following assumptions were made:

1. The genetic merit of the males used is the same in all cases.
2. There is a 23% annual replacement rate.
3. All the replacements are produced within the herd.
4. Eight percent of the heifers selected as replacements will not reach their

first calving due to mortality or elimination for various reasons.
5. There is no embryo sexing, thus 50% of the born animals are males and 50% are females.
6. The herd structure is formed by 23%,21%,19%,16%,12%,7% and 2%, from 1st to 7th calving respectively and it considers that lactating cows have had an average of 3.02 calvings, and the average cow is eliminated from the herd after 4.35 calvings.
7. The average age at first calving is two years.
8. The calving interval is one year.
9. The conception rate for receptor females is the same as that obtained using artificial insemination.
10. Animals calving for the first time on year n were selected based on their mothers performance on year n-3.
11. Heritability (h2) of milk production is considered to be 0.20
12. Heritability, fenotipic variability and intensity of selection are constant through the time (Kennedy, 1984).
13. The initial production adjusted to mature equivalent is 5000 $\pm$ 1000 kg during a 305 day lactation. Unadjusted average production is 4397 kg.

Description of the model

A-Estimation of genetic improvement-

The improvement due to the use of the best females for the production of replacements was estimated with base on average milk production expressed as mature equivalent. The first part of the model is as follows:

$$Sn = EMn-3 + RS/2$$

where:

Sn= Average milk production of the replacements (daughters of selected cows) on year n, expressed as kg produced during 305 day lactations, adjusted to mature equivalent.

EMn-3= Average herd production during year n-3.

RS/2= Expected response to the selection of the best cows as mothers of the replacements.

The average production during the n-esime year was calculated as:

$$EMn = 0.23\ Sn + 0.77\ EMn-1$$

B- Estimation of expected milk production.

The expected real (unadjusted) average milk production is obtained by taking into account the herd structure and the inverse of the mature equivalent adjustement factors(McDaniel, 1967);

$$Pn = 1/1.35\ (0.23\ EMn) + 1/1.21\ (0.21\ Emn-1) + 1/1.10\ (0.19\ EMn-2) + 1/1.04\ (0.16\ EMn-3) + 1/1.01\ (0.12\ EMn-4) + (0.07\ EMn-5) + (0.02\ EMn-6).$$

where:

Pn= real average production expected on year n.

RESULTS

Table 2 shows the percentage of cows from which the replacements would be born in the control herd and in herds with the various levels of ET success. It also shows in each case the selection intensity obtained and the expected response to selection for each of the reproductive success levels.

Table 3 shows a 20-year projection of estimated production values under genetic improvement programs on control herds and herds using ET with various levels of reproductive success.

DISCUSSION

The results reflect only the increase in production due to selection of the best females either for normal reproduction or as donors for ET. The improvement that can be obtained by the use of superior bulls was considered to be the same for the control and ET groups, so that it does no affect the comparisons that are the object of this study.

It can be seen on table 3 that the increase in milk production does not justify the use of embryo transfer since even after 20 years of selecting the best cows as donors, and obtaining 15 calves per year per donor, the increase in milk production would only be about 400 kg more per cow per year than in the herd in which replacements were selected without using ET. It must be considered that, besides the high direct cost of the ET technique itself, there are associated cost that are not always evident, such as the reduced reproductive efficiency of receptor cows which may have a negative effect on calving intervals, or the cost associated with keeping the best cows out of the milking line while they are used as donors. In addition, the improvement will be slowed down if the reproductive parameters (age at first calving, calving interval, conception rate) are not as good as the ideal parameters assumed by the model.

The implementation of methods for in vitro ova maduration and fertilization might in the future improve the number of calves obtained per donor (Brackett, 1983). However, even when considering 100 calves per year per donor for 20 years the advantage in milk production would continue to be modest (589 kg), and the implementation of such sophisticated techniques would significantly increase the cost of the ET program, so that their potential use in commercial dairy herds would be limited.

When planning on the investment of resources for the genetic improvement of a herd, it is important to remember that artificial insemination allows the access to low cost, high-quality genetic material (Hinks, 1971), so that resources could be better employed by buying the highest-quality semen rather than diverting them to sophisticated techniques such as ET.

There are other factors that further limit the use of ET as a tool for genetic improvement, such as the fact that high-yield cows, and cows with high superovulation rates, tend to produce a reduced number of viable embryos (Donaldson and Perry, 1983). Also, it is known that a considerable proportion of cows selected as donors do not respond to superovulation treatments, decreasing in consequence the speed of genetic improvement (Donaldson and Perry, 1983; Hasler et.al. 1983; Mossiavx et.al., 1983; Donaldson, 1984) A further limitation is the recomendation not to superovulate a cow more than three consecutive times without allowing for a complete gestation (Donaldson and Perry, 1977).

The selection of a few animals to conform the breeding stock produces a sampling effect, which results in random changes in the genetic pool ("random genetic drift") (Van Uleck, 1974). As a result the actual intensity of selection decreases and, perhaps more important, the risk to fix unfavorable genes increase.

For the selection of donor cows it is required to know the production of each cow in the herd. The time needed before production data can be obtained results in an increased generation interval, decreasing the genetic improvement obtained per unit of time. It is even possible that the advantage obtained by the use of ET could be canceled by the increased generation interval (Land, 1977).

It is concluded that, at the present level of ET reproductive success, and even at hypothetical higher levels of success, the use of ET to increase the intensity of selection through selection of the female is not a valuable tool for genetic improvement. This conclusion is supported by results obtained in actual instance of commercial ET (Elson, 1977; New Comb, 1977).

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TABLE 1

EMBRYO TRANSFER PARAMETERS REPORTED IN THE LITERATURE

VARIABLE	AVERAGE VALUE	NUMBER OF OBSERVATIONS	NUMBER OF REFERENCES CONSULTED	COMMENTS
Donor with viable embryos	69%	1929	2	Does not include donors with previous problems
Embryos per productive donor	7.63	45	1	Colected after slaughter of the donor
	6.35	478	4	Experimental conditions
	5.85	493	3	Comercial operations
Transferible embryos per productive donor	4.83	45	1	Colected after slaughter
	3.82	223	2	Experimental conditions
	5.17	3799	2	Comercial operations
Conception rate of receptor animals	52%	85	2	Experimental conditions
	48%	5691	6	Comercial operations
	39%	618	7	Using frozen embryos

TABLE 2

SELECTION INTENSITY AND EXPECTED RESPONSE USING EMBRYO TRANSFER

Offspring per donor per year	1***	3	6	9	15	25	50	100
% of cows from which replacements would be born	50.0	16.7	8.3	5.6	3.3	2.0	1.0	0.5
Selection Intensity adjusted to the number of selected cows	0.793*	1.447*	1.799*	1.968*	2.149*	2.415*	2.593*	2.761**
Response to selection(h^2=0.20)	158.6	295.4	359.8	393.6	429.8	483.0	518.2	552.2

Intensity of selection was adjusted according to the number of selected animals as indicated by Van Vleck (1974).
* Adjusted considering a herd of 100 cows in production
** Adjusted considering a herd of 500 cows in production
***Natural reproduction without use of ET

TABLE 3

EXPECTED MILK PRODUCTION (KG/305 DAYS) AFTER SELECTING THE BEST COWS AS DONORS FOR THE PRODUCTION OF REPLACEMENT HEIFERS.

	OFFSPRING PER DONOR PER YEAR							
YEAR	1***	3	6	9	15	25	50	100
1	4397	4397	4397	4397	4397	4397	4397	4397
4*	4410	4422	4427	4430	4433	4438	4441	4444
7	4453	4501	4524	4536	4549	4568	4580	4592
10	4495	4580	4620	4641	4664	4697	4719	4740
16	4578	4735	4809	4848	4889	4951	4991	5030
20	4634	4835	4935	4986	5040	5120	5172	5223
**	20	205	301	352	406	486	538	589

* Incorporation of the first daughters of selected cows to the producing herd
** Difference with respect to natural reproduction after 20 years.
***Natural reproduction.