GENETIC IMPROVEMENT BY EMBRYO TRANSFER WITHIN AN OPEN SELECTION NUCLEUS IN DAIRY CATTLE.

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SUMMARY

The selection nucleus with early embryo transfer is designed for a systematic production of very young bull dams, evaluated from their 1st lactation following 2 embryo recoveries. Sire-son selection path is identical to that involved in conventional schemes.

With the present technical parameters for transfer, the superiority of this new scheme over conventional ones is already clear in closed populations and enhanced in populations opened to better foreign populations, due to a quicker diffusion of the superior foreign genes into the commercial population.

INTRODUCTION

Use of superovulation and embryo transfer have often been mentioned in connection with dairy cattle selection. Within conventional schemes, this technique contributes to the increase in selection intensities at constant generation intervals and therefore to improve the genetic gain per year. However all the published investigations show that a substantial acceleration of this gain (>20%) requires an improvement of all the gene transmission paths, requiring higher superovulation rates and lower costs.

As indicated by Nicholas and Smith (1983), another possibility would arise from systemically reducing the generation interval by means of embryo recoveries prior to first calving of the future breeding females. According to these authors, the superiority of such schemes (MOET) as compared to the conventional ones might be around 30 to 50%.

In fact, the schemes proposed by these authors include innovations other than early embryo transfer which would lead to comparatively large changes to the present situation, so that the overall schemes (transfer included) could be refused by the breeding organizations. This is the reason why we have undertaken (Colleau, 1985) the analysis of conceptually hybrid selection schemes, combining some MOET features (early embryo transfer) and the main feature of conventional schemes (in field progeny testing). According to the numerical analysis, the genetic gain within the closed selection nucleus producing the young bulls to be tested is 20 to 30% higher than that obtained by a very efficient conventional scheme (yearly genetic gain = 0.23 genetic standard deviation). This was obtained when nucleus size was about the same as the annual number of bulls to be tested (present parameters : number of embryos per recovery = 4-5 ; embryo survival rate = 40-60%). This confirms the value of the idea expressed by Nicholas and Smith. MOETs as strictly defined by these authors are only clearly better than our hybrid schemes if the technical parameters are close to their present upper limit.

The purpose of this paper was to continue the numerical analysis of "MOET x conventional" selection nuclei when performing some outbreeding on the male or female paths. The question was to investigate whether additional acceleration of genetic gain can be obtained by either collecting females born out of the nucleus, by importing semen of bulls tested within a foreign population or by importing embryos.

CLOSED SCHEMES : DESCRIPTION AND RESULTS

Conventional scheme

This scheme is fully described in the paper of Colleau (1985) and leads to a yearly genetic gain of 0.23 genetic standard deviation. It will not be discussed here due to lack of space. The main figures to keep in mind are that 100 bulls are tested each year, that the best 13 among the newly tested ones are used for usual service and that the best 3 are used as bull sires. It is assumed that all the semen stock is used within a year and no semen is collected after sire evaluation.

Selection scheme (MOET x conventional)

Because of previous studies, we only used one category of selection nucleus. In that category, embryo transfer was performed as soon as possible since it took place at the age of 16-18 months (2 successive recoveries). The numerical example treated here is described by the following main parameters : Nucleus size = 200 females ; number of embryos per recovery = 5 ; embryo survival rate = 40%.

Selection of the donors was made after 6 months of lactation, the offspring born from transfer was 9 months old. This selection was only made according to own performance. No family information was used to avoid performing a paternal family selection.

The selection pressures along the dam-son and dam-daughter paths only depended on the replacement needs. They were constant for the first path (130 bulls 9 months old corresponding to 100 bulls to be tested, after culling 25% of the bulls on semen quality, as for the conventional reference scheme). They were related to nucleus size for the second path.

The ordinary calves were used according to the same rules as the transfer calves, i.e. the milk yield of their mothers. The parameters of the sire-son path was exactly the same as in the conventional scheme.

In order to avoid overloading of presentation, we shall only analyse the aforementioned example of nucleus. The asymptotic genetic gain was then 19% above that of the conventional scheme. However, a detailed analysis of the diffusion of genetic gain within the commercial females (calculating from monthly series to fit with the very short generation intervals along some paths) showed the existence of a time lag. This appears at the first line of table 1 : during 30 years, the improvement of yearly genetic gain for commercial females was only 14%.

OPEN SCHEMES : DESCRIPTION AND RESULTS

Conventional scheme

It was assumed that the only opening consisted in semen purchase to produce young bulls (sire-son path). A larger outbreeding, i.e. involving the

Table 1 - Diffusion of genetic gain within closed selection nuclei or opened on the general population.
year 1 = birth of the first calves from transfer
♂ = males born during the year in the nucleus
♀ = females born during the year out of the nucleus
(conventions used for tables 2 and 3 as well).

	Yearly genetic gain (% of the conventional one)								Proportion of replacement females in the nucleus born from commercial females (%)			
	0-10 years		10-20 years		20-30 years		0-30 years		0-10 years	10-20 years	20-30 years	0-30 years
	♂	♀	♂	♀	♂	♀	♂	♀				
Totaly closed nucleus	120	106	119	116	119	118	118	114	0	0	0	0
Nucleus open by the females	126	108	119	118	120	120	120	117	64	74	73	70

Table 2 - Diffusion of genetic gain within conventional schemes opened on a foreign population by the sire-son path (population applying the reference selection scheme).

		Yearly genetic gain (% of the conventional one)								Proportion of foreign sire bulls (%)			
		0-10 years		10-20 years		20-30 years		0-30 years		0-10 years	10-20 years	20-30 years	0-30 years
A	B	♂	♀	♂	♀	♂	♀	♂	♀				
0	100	104	102	102	103	102	102	102	103	42	39	35	39
0	500	107	106	105	105	103	105	104	106	70	64	56	63
1	100	111	112	109	109	105	107	107	111	82	79	69	77
1	500	115	118	113	113	107	110	109	116	88	91	82	87

A: Initial genetic superiority of the foreign bulls (σ_G).
B: Number of yearly tested bulls in the foreign population.

sire-daughter path, is not used very much by French breeders or breeding units.

Different situations were studied according as the requested external population included newly tested bulls with an initial genetic level equal or one genetic standard deviation higher than the contemporary bulls of the population studied. Besides, their number was equal or much higher (X5). The best three bulls were therefore chosen among all the possible bulls, assuming that the selection indices were unbiased and especially that the between population genetic differences could be accurately estimated at any moment. Under these conditions, the outcome of this selection within a heterogenous population (mixture of normal distributions) was calculated as indicated by Colleau and Tanguy (1984).

Results are given in table 2. They show that choosing bull sires in a larger population (200 or 600 bulls) leads to a small improvement in genetic gain (+3-5 %). Use of a much better external population leads to a more pronounced effect (+10-15%). Because of these results, the proportion of bull sires from outside declined only slowly.

Selection nucleus with semen purchase

As in the previous situation, the imports were strictly limited to elite bulls (the best 3 bulls per year) used within the nucleus to produce males and females at the same time. The parameters were the same as in the former situation. The results are shown in table 3. This table shows that a possible genetic superiority due to external bulls was quickly transmitted to the males of the nucleus, leading to very high instantaneous genetic gains so that an initial genetic lag of 1 genetic standard deviation can be cought up in about 10 years. Later on, the bulls of the nucleus became better than those from outside, leading to a decreasing use of foreign semen. The transmission to the commercial females was slower. However, calculated over 30 years, use of an initially much better population of external bulls led to a pronounced acceleration (+30-40%). This acceleration remained better (+25%) in comparison with a conventional scheme improved by semen purchase. It was higher than that obtained with a closed selection nucleus (14%) and this clearly shows that selection nuclei allow a quicker utilization of a possible foreign superiority than with the conventional schemes.

Selection nucleus with semen and embryo purchase

An additional purchase of embryos was more difficult to parametrize than importation of semen. We assumed firstly that the embryo importation fullfilled at most 50% of the needs for replacing young bulls to be tested and secondly that the genetic level of young males born from purchased embryos was the same as that of the young bulls of the foreign population.

Results are shown on the last two lines of table 3 for the case of an external population of an initially better genetic level. They show that within the chosen hypothesis, the import of embryos adds only little to semen import because the males from the nucleus become rapidly better than those from purchased embryos.

Selection nucleus with embryo recoveries within the commercial population

Screening of commercial females was performed on their production level after 6 months of lactation. The best ones were then superovulated during the following lactation (at 2 and 4 months of lactation) and their embryos

Table 3 - Diffusion of genetic gain within selection nuclei opened on a foreign population by semen or embryo purchase (population applying the reference selection scheme).

		Yearly genetic gain (% of the conventional one)								Proportion from the foreign population(%) 1st line: purchased semen used in the nucleus 2nd line: replacement females from purchase embryos			
		0-10 years		10-20 years		20-30 years		0-30 years					
A	B	♂	♀	♂	♀	♂	♀	♂	♀	0-10 years	10-20 years	20-30 years	0-30 years
0	100	127	109	119	120	119	120	121	118	36 0	11 0	2 0	1 0
	500	137	115	120	125	119	121	123	124	62 0	18 0	3 0	2 0
1	100	151	121	121	133	120	125	126	131	75 0	25 0	6 0	3 0
	500	165	130	121	140	120	127	129	138	81 0	29 0	6 0	3 0
1	100	152	128	122	136	122	127	128	134	69 15	17 2	3 0	30 6
	500	166	133	123	142	122	129	130	140	78 9	23 0	3 0	35 3

A: Initial genetic superiority of the foreign bulls (σ_G).
B: Number of yearly tested bulls in the foreign population.

transferred immediately . A time interval of 18 months separates the birth of the offspring from the time of selection decision. This is why the production levels of the general population were artificially penalized by a value corresponding to the genetic gain obtained within the nucleus during 18 months. The nucleus born females and the commercial females were then matched on the basis of their actual production for the former, their average penalized yield for the latter. In these conditions (table 1) about 70% of the nucleus female replacement came from the general population, but the additional gain was small (1-3%) because of the high genetic superiority (1.1σ_g) of the nucleus females above their contemporary females at birth.

CONCLUSION

The setting up of closed selection nuclei with an early embryo transfer led to a very large genetic gain on milk yield. Moreover, they allow a rapide diffusion of a possible genetic superiority from outside leading to an even higher genetic gain.

The present simulation was based on selection on one trait only i.e. milk yield. However, other traits can readily be introduced provided that they do not affect the very short generation intervals obtained in the selection nuclei (e.g. udder morphology of bull daughters obtained simultaneously with dairy sire evaluation). An extreme possibility of managing these nuclei would be to search for the same genetic gain on milk yield than in the previous conventional scheme, but together with a much larger gain on some secondary traits.

Thus, the overall potentiality of the "MOET x conventional" hybrid schemes seems likely to exceed that of the conventional schemes.

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