



Report on the design of Breeding Programs for Irish Beef Cattle Breeds

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INTRODUCTION

At present Irish beef breeding schemes are rather small in scale compared to their international counterparts. This results in the danger that most of Irish beef breeders will be using semen of foreign bulls, which implies that (1) in the long term Irish beef breeders will have to follow international genetic trends, while the Irish situation might ask for more specific genetics; (2) a substantial part of the revenues from beef cattle breeding will go abroad.

The aim of this report was therefore to perform a preliminary study on the competitiveness of larger scale Irish beef breeding programs. The focus will be on two questions for the breeding program:

- (1) Can Irish beef breeding programs achieve substantial genetic gain on their own;
- (2) Can Irish beef breeding programs compete with foreign / "home country" programs for the beef breeds used in Ireland. The foreign programs will be called "home country" programs here, because the biggest programs tend to exist in the country of origin of the breed, which are usually the France, UK, Germany, and Belgium.
- (3) How large should Irish beef breeding programmes be in terms of number of elite breeding animals and size of progeny tests.

An advantage that Irish beef breeding has is that, although the pure breeding populations are small, there is a much larger population of crossbreds, which can be used for progeny testing of the purebred bulls.

MATERIAL AND METHODS

Sizes of Pure Breeding Populations

The sizes of the 'active' pure breeding populations for the Charolais, Limousin, Simmental, Angus, Hereford, Salers, Blonde d'Aquitaine, Belgian Blue and Aubrac breeds are summarized in Table 1. With the 'active' purebreeding population is meant the population that is born out of AI bulls. The number of AI sires being used is an 'effective' number based on the report 'Beef Breeding Design - Development Report' (ICBF, 2006). The 'effective' number of AI bulls being used is reported here, because the actual number is much larger with

many bulls having very few offspring. The sizes reported in Table 1 are used for the calculations in this report.

Table 1. The sizes of the ‘active’ purebreeding populations and the ‘effective’ number of AI bulls being used (ICBF, 2006).

Breed	‘Active’ size ¹	‘Effective’ number of AI bulls being used
Charolais	6800	20
Limousin	5000	20
Simmental	1400	20
Angus	1700	15
Hereford	1100	10
Salers	220	10
Blonde d’aquitaine	145	7
Belgium Blue	260	7
Aubrac	32	7

¹ Number of calves born per year sired by AI bulls.

The active sizes in Table 3 result in two types of schemes: (2tier) large schemes whose size is large enough for an elite breeding nucleus and a pedigreed cow population; (1tier) small schemes where the entire pure breeding population has to enter the elite breeding nucleus in order to make this nucleus of sufficient size. To the 2tier schemes belong: Charolais, Limousin, Simmental, Hereford, and Angus. To the 1tier schemes belong: Salers, Blonde d’aquitaine, and Belgium Blue, and the Aubrac, although the Aubrac’s size is so small that it is questionable whether a stand-alone Irish breeding scheme can be established.

The traits, their genetic parameters and economic weights

The traits considered are carcase weight (CW), Feed Intake (FI), Carcase conformation (Conf), calving difficulties (CD), and Survival (SUR). The genetic parameters are in Table 2, the economic weights are in Table 3. The economic values in the home country are assumed approximately the same as in Ireland. Differences in economic values between Ireland and ‘home country’ have a similar effect as a smaller than 1 correlation between the recorded traits in both countries: both reduce the correlation between the breeding objectives in the two countries. In view of the substantially smaller than 1 correlations between the traits in Ireland and the home country (Table 2), the effect of differences in economic value are expected to be minor.

Beef Breeding Scheme Design.

Table 3. Genetic parameters of the traits (I=Ireland; H=home country). Genetic standard deviation on bottom row, heritability on diagonal, genetic correlation above diagonal and environmental correlation below diagonal.

	I-CW	I-FI	I-Conf	I-CD	I-SUR	H-CW	H-FI	H-Conf	H-CD	H-SUR
I-CW	.3	.7	.7	.3	-.1	.9	.6	.6	.25	-.1
I-FI	.85	.3	.4	.2	.4	.6	.7	.25	.1	.1
I-Conf	.85	.5	.3	.5	-.3	.6	.25	.9	.4	-.25
I-CD	.4	0	0	.15	0	.25	.1	.4	.7	0
I-SUR	0	0	-.3	0	.05	-.1	.1	-.25	0	.6
H-CW	-	-	-	-	-	.3	.7	.7	.3	-.1
H-FI	-	-	-	-	-	.85	.3	.4	.2	.4
H-Conf	-	-	-	-	-	.85	.5	.3	.5	-.3
H-CD	-	-	-	-	-	.4	0	0	.15	0
H-SUR	-	-	-	-	-	0	0	-.3	0	.05
GenSD	20	460	1.5	2.9	3.6	20	460	1.5	2.9	3.6

Table 3. Economic values of the traits.

Ireland	Growth ¹	Feed intake ²	Carcase conformation ³	Calving difficult ⁴	Survival ⁵
Charolais	3.5	-.03	3.5	-2	3
Limousin	3.5	-.03	3.5	-2	3
Hereford	3.5	-.03	3.1	-2	3
Angus	3.5	-.03	3.1	-2	3
Simmental	3.5	-.03	3.5	-2	3
Blonde	3.5	-.03	3.5	-2	0
Belgium Blue	3.5	-.03	3.5	-2	0
Saler	3.5	-.03	3.1	-2	3
Aubrac	3.5	-.03	3.1	-2	3

¹ Euro per kg carcass weight

² Euro per kg of lifetime dry matter intake

³ Euro per pt on 15 pt scale

⁴ Euro per % difficult calving (allowing for mortality and gestation length selection benefits)

⁵ Euro per % increase in daughters surviving to have a 4th calf given a first calf accounting for relative emphasis on maternal versus direct and calving interval benefits in maternal breeds only.

The structure of the breeding schemes

The structure of the 2tier schemes is depicted in Figure 1. Elite bulls and cows are born out of elite matings between the best elite bulls, the best elite cows and the very best pedigreed cows. Pedigreed replacement heifers are born out of matings between elite bulls and pedigreed cows. In the 1tier scheme, all animals belong to the group of elite animals, ie.

technically there is no distinction between elite and pedigreed cows. The sizes of the elite population were assumed either 100 or 200 animals born per year, which were assumed to be born from 50 or 100 selected cows, respectively. The latter requires a moderate use of embryo transfer, ie. there are on average 2 calves per cow per year. The number of selected elite bulls was varied in order to achieve a rate of inbreeding of 0.25 % per year, ie. with a generation interval of 4 years this implies 1% per generation. The number of elite sires used as AI sire for the pedigreed cow population is as in Table 1.

Figure 1. The structure of the 1tier and 2tier breeding schemes.

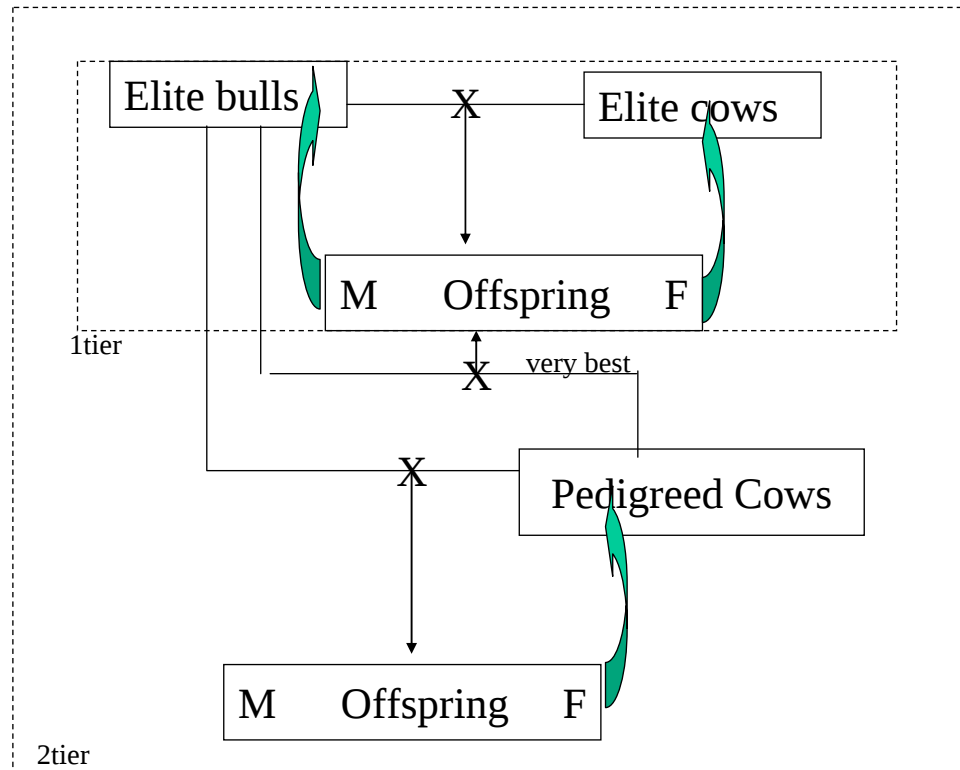
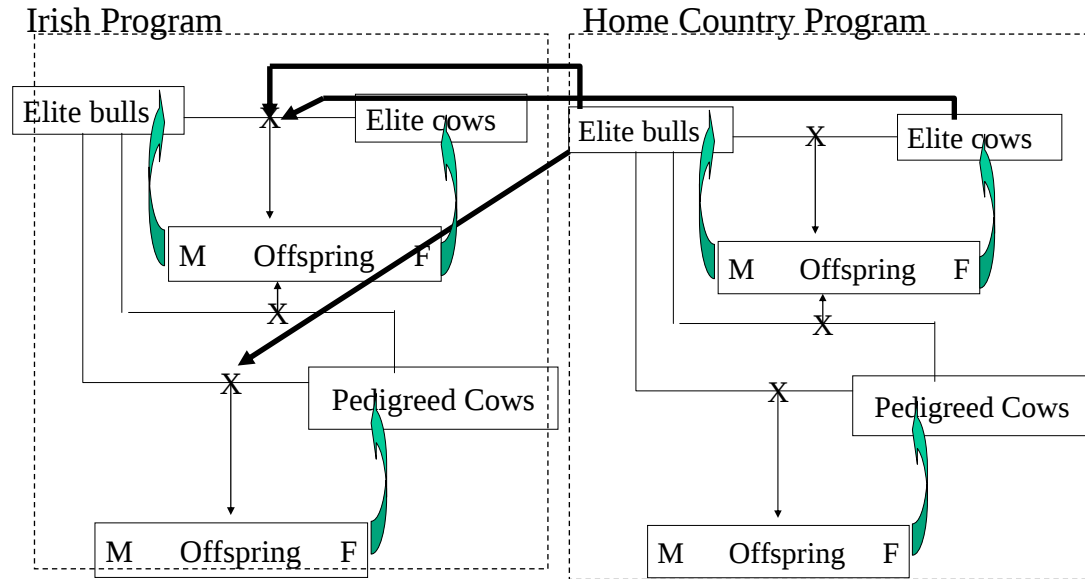


Figure 2 shows the use of bulls across the Irish and Home-country programmes. It is assumed that the Home-country programme is a 2tier programme of substantially bigger size than the Irish programme: twice as big with a minimum of 400 calves out of elite matings per year and 4000 pedigreed calves born each year (i.e. the home country programme is of a substantial size even if the Irish programme is small). In the home country also some Multiple Ovulation and Embryo Transfer is used, such the e.g. 400 elite calves are born out of 200 elite dams. The 200 or more elite bull calves are progeny tested with 100 daughters each. The 25 bulls highest ranking on the economic index are selected as for the elite matings and for the matings with pedigreed cows. There is no control of inbreeding in the home country. The elite bulls in the

home country are eligible for selection in elite and pedigreed cow matings of the Irish programme. Elite home country cows are only eligible for the elite matings in Ireland. Irish bulls and cows are not considered by the home country for selection.

Figure 2: The use of elite bulls and cows across the Irish Program and the Home-country Program.



Trait recording

The assumed age of recording of the traits was CW at 2 yr, FI at 2 yr, Conf at 2 yr, CD at 2 yr, and SUR at 4 yr. Progeny test results were assumed available at 4 years of age of the bull for all traits (the computer simulation programme had the limitation that all progeny test results should become available at similar age). In the home country FI is not recorded, and SUR not for the terminal sire breeds: Belgium Blue, Blonde d'aquitaine and Charolais, and was only available at 5 yr of age in the home country.

Computer simulations

The breeding schemes were simulated in the computer by simulating the individual animals, their true breeding values (which is unknown in real life), and their phenotypic recordings. Breeding value estimation (EBV) was by a multi-trait animal model, and selection was either by truncation selection (ie. selecting the best on EBV) or by optimal contribution selection (Meuwissen, 1997; Meuwissen and Sonesson, 1998), which controls the rate of inbreeding. Matings of the selected animals were performed at random. Breeding schemes were run for 15 years, and were replicated 50 times for the Figure 1 schemes and 25 times for the Figure 2

schemes. Results were averaged over the years 11 – 15. At the start of the schemes, genetic levels between the Irish and home country schemes were assumed equal, which is realistic because the Irish elite matings are performed with home-country elite bulls and cows, if they outperform their Irish counterparts.

RESULTS

The genetic gains in the stand-alone Irish schemes are given in Table 4. The breeds Charolais, Angus, Hereford, and Simmental achieve substantial genetic gains of about 20 Euro per year. Furthermore, their genetic gains across the traits were very similar, with most of the gain coming from growth and conformation, and accepting an increase of FI. Also calving difficulties increased and survival deteriorated somewhat due to this strong response in growth and conformation. The smaller breeds Belgium Blue Salers and Blonde d'Aquitaine have considerably less genetic gain, but the pattern is about the same. The Aubrac breed did not achieve much genetic gain, and breeding efforts seem to have been mainly directed at controlling the inbreeding.

Table 4. Annual genetic gains in Irish beef breeding schemes with 200 elite calves born per year (except for Blonde (140) and Aubrac (30)) of which the bull calves will be progeny tested with 100 daughters each (INDEX in Euros/yr; traits in their genetic standard deviations/yr).

	INDEX	CW	FI	Conf	CD	SUR
Char	21.5	0.348	0.235	0.244	0.0860	-0.0404
Lim	20.2	0.328	0.225	0.231	0.0825	-0.0400
Ang	18.7	0.306	0.210	0.205	0.0907	-0.0258
Heref	18.9	0.306	0.210	0.217	0.0777	-0.0220
Simm	18.2	0.295	0.198	0.210	0.0786	-0.0277
BelgB	17.0	0.264	0.154	0.197	0.0670	-0.0622
Salers	16.5	0.269	0.186	0.190	0.0636	-0.0272
Blonde	15.6	0.244	0.148	0.179	0.0658	-0.0575
Aubrac	3.3	0.053	0.029	0.036	0.0179	-0.0044

Table 5. Parameters of the optimised breeding schemes.

breed	ΔF (%/yr)	Generation Interval		No selected	Fraction Elite dams
		Sire	Dam	Sires	from pedigreed cows
Char	0.257	3.5	2.3	23	92 %
Lim	0.238	3.8	2.3	24	90
Ang	0.246	3.8	2.4	23	90
Heref	0.291	4.0	2.5	24	89
Simm	0.284	4.2	2.5	24	90
BelgB	0.282	3.3	2.7	18	-
Salers	0.287	3.3	2.7	19	-
Blonde	0.240	3.4	2.8	18	-
Aubrac	0.160	5.3	3.4	21	-

Table 5 shows some of the optimised parameters of the schemes. Rates of inbreeding were generally between 0.24 – 0.30% per year, i.e. around the planned rate of 0.25%. Only in Aubrac rate of inbreeding was smaller than expected, because the optimum contribution programme had difficulties to control the inbreeding, and than automatically enters minimisation of inbreeding mode. Generation intervals were rather constant across breeds with a tendency for smaller generation intervals for the larger breeds. The latter is because in the larger breeds more animals can be selected while maintaining a substantial selection differential. Thus, the effect that reducing generation intervals increases the annual rate of inbreeding (because generations turn-over more quickly) is compensated by selecting somewhat more sires (Table 5). The sire generation intervals show that there is a substantial use of unproven bulls in the schemes (approx. 50%). In the 2tier schemes, the pedigreed cows were very important in providing elite dams (about 90%), which is probably because the number of selected elite dams was rather large (due to the limited use of multiple ovulation and embryo transfer).

Reducing the number of testdaughters: decreasing the number of daughters per bull

The planned progeny testing of 100 young bulls on 100 daughters is expensive, and one way to reduce the costs is to progeny test the bulls on fewer daughters. Table 6 shows the genetic gains with only 50 or 25 test-daughters per young bull. Across the schemes this resulted in a relatively small reduction in genetic gain of about 2.5 - 5%. However, in competition with other breeding schemes, the accurate progeny testing of bulls may be very important, because a bull in the top10 requires a) having a very good bull; and b) proving that this bull is very good bull. In the dairy cattle situation, accounting for the latter leads to an optimum of 100 daughters per bull (ICBF report, 2001).

Table 6. Annual genetic gain of the economic index (in Euros/yr) when the number of daughters per test bull is reduced.

	No test daughters per bull		
	100	50	25
Char	21.5	19.9	19.7
Lim	20.2	19.8	19.5
Ang	18.7	19.1	17.1
Heref	18.9	17.7	17.0
Simm	18.2	18.2	17.0
BelgB	17.0	16.6	16.0
Salers	16.6	16.5	15.3
Blonde	15.6	15.6	14.6
Aubrac	3.3	3.3	3.1

Reducing the number of testdaughters: preselecting the bulls entering the progeny test

In beef breeding, quite a lot of information is available on the young bulls before they enter the progeny test. This is in marked contrast with the dairy breeding situation, where only pedigree information is available on young bulls. The young bulls have own performance records on growth, feed intake, and conformation, which can be used to construct a selection index with an accuracy of selection of 0.543. The young bulls could be preselected on this index before entering the progeny test in order to reduce the number of test-daughters required and the total size and costs of the progeny test. Table 7 shows the combined selection response from the preselection and the ultimate selection of the progeny tested bulls. It was assumed that ultimately the 2 best bulls were selected out of a total of 100 young bulls, the

accuracy of selection after progeny testing was 0.939 (assuming 100 test-daughters per progeny tested bull), and the number of preselected bulls was varied. About 5% selection differential was lost when only 20 – 30 preselected bulls were progeny tested, which reduces the total progeny test size by 70 to 80%. Note that the accuracy with which the 2 best bulls are selected is same as when all bulls are progeny tested.

Table 7. Overall genetic gain from the preselection and ultimate selection of the 2 best bulls out of a total of 100 candidates. The number of preselected bulls was varied. Every preselected bull obtained 100 testdaughters.

Npreselected	Total number of testdaughters	ΔG (in σ_g units)
No preselection	10,000	2.09
50	5,000	2.05
30	3,000	2.02
20	2,000	1.97
10	1,000	1.85

Reducing the number of elite calves born per year

Another way to reduce the costs of the breeding scheme is to have fewer elite contracted matings and thus fewer elite calves born per year. Table 8 shows genetic gains when the number of elite calves born per year was reduced to 100. For the Belgian Blue, Salers, Blonde d’aquitaine, and Aubrac breed, this reduction of the number of elite calves was not considered, because all calves born out of AI matings had to be considered as elite in these schemes, to make these schemes of a reasonable size. Genetic gains were reduced by about 10% when the number of elite contract matings was reduced. This may be a substantial reduction, when we are in competition with other breeding schemes (see next Section).

Table 8. Annual genetic gain of the economic index (in Euros/yr) when number of elite calves born per year was reduced.

	Number of elite calves born per year	
	200	100
Char	21.5	17.9
Lim	20.2	17.3
Ang	18.7	16.5
Heref	18.9	15.9
Simm	18.2	15.0

Sensitivity Analysis of the Selection Indices

A sensitivity analysis of the own-performance sire indices (i.e. Carcase Weight, Feed Intake, Body Confirmation) is shown in Table 9. The accuracy of the index is quite high, but reduces somewhat if the low heritability traits get more weight. The negative genetic gains (expressed in Euros) for Feed Intake, Calving Difficulties, and Survival imply that these traits deteriorate. Doubling the economic value of Carcase Weight increases, the gains for the other traits relatively little, although the deterioration of survival is somewhat smaller. The little change implies that the economic weight of Carcase Weight is already high. Doubling the economic value of Feed Intake, reduces the deterioration of feed intake, but this is at the costs of an increased reduction in Survival Rate (which is doubled). Doubling the economic value of Conformation, increases the deterioration of Survival Rate increases by about 10%. Doubling the economic value of Calving Difficulties, reduces the deterioration of calving difficulties and Survival Rate decrease both by about 6%. Doubling the economic value of Survival, reduces the deterioration of Survival Rate by a factor of about two-third (at twice the economic weight, the expected reduction with the original index is $-0.783 \times 2 = -1.566$, but with the optimised index it is only -0.561).

Table 9. Sensitivity analysis of the Own-Performance index of the sire.

Index	Accur.	ΔG (in Euros per unit selection intensity)					
		Tot.	CW	FI	Conf.	CDif.	Surv.
CW,FI,Cf	.5428	33.58	38.28	-4.989	1.998	-0.934	-0.783¹
└ CW*2	.5467	71.89	76.66	-5.152	2.007	-0.944	-0.681 ²
└ FI*2	.5413	29.15	37.14	-7.574	2.003	-0.911	-1.516
└ Conf*2	.5434	35.63	38.24	-4.945	4.229	-1.008	-0.881
└ CD*2	.5382	32.67	38.23	-4.981	1.914	-1.759	-0.733
└ SU*2	.5311	33.04	38.22	-5.611	1.876	-0.878	-0.561
SIRE PROOF	.9388	58.07	65.62	-8.573	3.428	-1.337	-1.072 ³
CW,CF	.5420	33.53	38.34	-5.297	2.001	-0.946	-0.580

¹Original index. Note that the gains in the traits are also expressed in Euros for ease of comparison.

²└ **CW*2** means that the economic value of Carcase Weight is doubled. Note that, without any change in index, this would lead to a doubling of the economic gain in Carcase Weight. The index is however re-optimised and the gain is slightly higher than $2 \times 38.28 = 76.56$.

³The sire-proof index consist of 100 test-daughters with CW, Cf, CD and SUR recordings.

The results for the sire-proof index are also given in Table 9 for comparison. As expected, the accuracy of selection and the selection response per unit of selection intensity is much higher than that of the own performance index. However, also the deterioration of calving difficulties and survival is relatively low compared to the original index. This is probably due to the recording of these traits on the test-daughters.

Because the recording of Feed Intake is expensive, also an index without Feed Intake records is considered in Table 9. This index results in an about a 5% larger deterioration of feed intake, but also in an about 25% reduction in the deterioration of Survival compared to the original index. The improved survival is due to the antagonistic relationship between survival and feed intake (high feed intake goes together with better survival).

A sensitivity analysis of the own-performance dam indices (i.e. Carcase Weight, Body Conformation, Calving Difficulties, and Survival) is shown in Table 10. Again accuracies of selection are not much affected by the doublings of the economic weights, but they are reduced when the lowly heritable traits obtain more economic weight. A doubling of the economic value of Carcase Weight increases feed intake, and the deterioration of survival somewhat. Doubling the economic value of Feed Intake, increases the deterioration of survival by 20%. Doubling the economic value of Conformation, increases calving difficulties by 20%, and the deterioration of survival by 13%. Doubling the economic value of Calving Difficulties, reduces Conformation by 15%, calving difficulties by 75%, and the deterioration of survival by 7%. Doubling the economic value of survival, reduces the deterioration of survival by 35% and calving difficulties by 5%.

Using an index without survival information, i.e. selection of cows before Survival is recorded, leads to slight decrease in the deterioration of survival. This counter-intuitive result occurs because 1) the increase in accuracy of survival EBV due to the recording of survival is small in multitrait index; and 2) the accuracy of other traits' EBV, especially feed intake and conformation, also increase due the recording of survival, and these traits have high economic value. The latter implies that the relative economic value of survival is small relative to that of feed intake and conformation.

Table 10. Sensitivity analysis of the Own-Performance index of the dam.

Index	Accur.	ΔG (in Euros per unit selection intensity)					
		Tot.	CW	FI	Conf.	CDif.	Surv.
CW,Cf,CD,SU	.5424	33.55	38.28	-5.278	1.939	-0.778	-0.608
$\perp$ CW*2	.5466	71.89	76.73	-5.270	1.997	-0.942	-0.627
$\perp$ FI*2	.5257	28.31	38.23	-10.40	1.971	-0.762	-0.740
$\perp$ Conf*2	.5426	35.58	38.30	-5.237	4.246	-1.034	-0.687
$\perp$ CD*2	.5448	33.07	37.57	-5.218	1.644	-0.360	-0.571
$\perp$ SU*2	.5311	33.05	38.11	-5.375	1.846	-0.744	-0.793
CW,Cf,CD	.5424	33.55	38.26	-5.293	1.947	-0.787	-0.583

¹Original index. Note that the gains in the traits are also expressed in Euros for ease of comparison.

² $\perp$ **CW*2** means that the economic value of Carcase Weight is doubled. Note that, without any change in index, this would lead to a doubling of the economic gain in Carcase Weight. The index is however re-optimised and the gain is slightly higher than $2 \times 38.16 = 76.32$.

A terminal + maternal breeding goal vs. a terminal only breeding goal

The question whether a sire should follow a terminal sire breeding goal or also should include maternal traits in the breeding goal is most pertinent for the Charolais breed, and thus is investigated for that breed in Table 11. The difference between the two breeding goals is that in the terminal sire only breeding goal, there was no economic value for survival of the cows. The zero economic value of Survival made the Feed Intake improve (reduce) substantially, which is probably due to the antagonistic relationship between Feed Intake and Survival. The reduction in Feed Intake caused also a small reduction in Carcase Weight and Conformation. Thus, the terminal only breeding goal mainly results in a larger improvement of Feed Intake.

Table 11. Genetic gains when using a Terminal only versus Terminal + Maternal breeding goals for the Charolais breed.

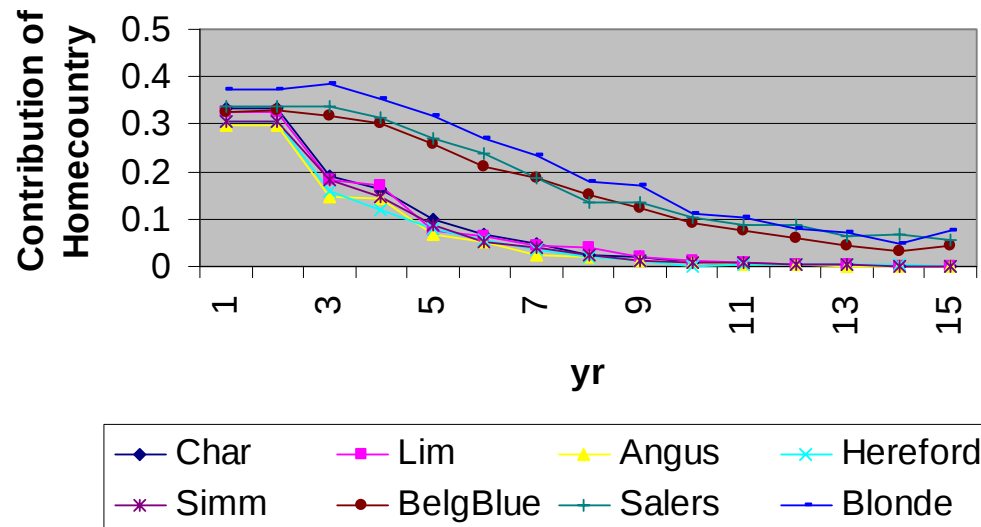
	INDEX	CW	FI	Conf	CD	SUR
Terminal only	20.4	0.321	0.200	0.231	0.0944	-0.0620
Term. + mater.	21.5	0.348	0.235	0.244	0.0860	-0.0404

Irish Breeding schemes in competition with home-country schemes

Figure 3 show the genetic contribution of Homecountry schemes to their Irish counterparts over time. During early years of the breeding program home-country contributions are

between 30-40%, where the latter figure holds for the small schemes. However, as soon as genetic progress starts to take off, the contributions drop steadily. The large schemes

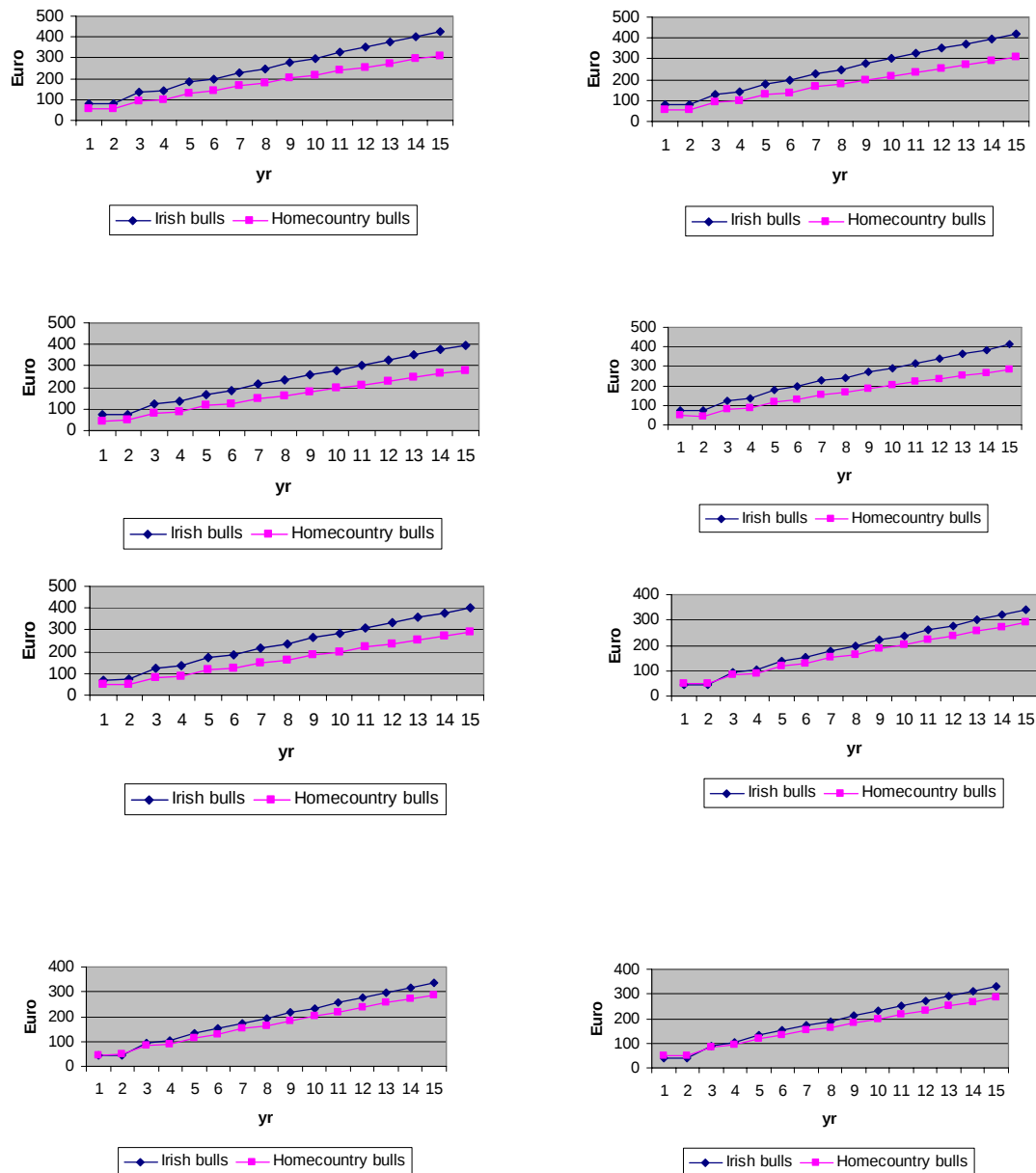
Figure 3. The genetic contribution of the homecountry schemes to the Irish breeding schemes.



Charolais, Limousin, Angus, Hereford, and Simmental use after about 10 years no homecountry genetics anymore. The smaller schemes Belgian Blue, Salers, and Blonde d’aquitaine seem to asymptote to a 5% usage of the homecountry genes.

The true genetic levels, which are known in a simulation study, for production in Ireland weighted by their economic values are plotted in Figure4. Genetic levels of bulls (expressed in Euros of the Irish economic index) are plotted against their year of birth. For the large breeds, the difference in genetic potential clearly increases over time in favour of the Irish bulls. For the smaller breeds, genetic potential of the Irish bulls is also higher than that of the homecountry bulls, but the differences are much smaller and seem stable over time.

Figure 4. True economic index value for production in Ireland of the Irish and homecountry bulls by their year of birth (from left to right and top to bottom: Charolais, Limousin, Angus, Hereford, Simmental, Belgian Blue, Salers and Blonde d'Aquitaine).



The differences in genetic potential, as shown in the Figure 4, do not entirely explain the competitive advantage of the Irish bulls. The homecountry bulls have a further disadvantage in that they are not tested under Irish conditions, and thus have not been able to show their potential in Ireland. This implies that if a homecountry bulls get very good EBV in the homecountry, his EBV in Ireland will be much less extreme, because he is very good in traits *correlated* to performance in Ireland, which does not proof that he is very good in Ireland. The latter uncertainty will be reflected in his Irish EBV, which will be less extreme than that in the homecountry.

It may also be noted that the relative genetic changes in the figures X1-X9 depend heavily on the between country genetic correlations between the traits that were assumed in Table X. If these correlations would be higher, the homecountry genetic progress for Irish performance increases, and if they would be lower the homecountry genetic progress decreases.

CONCLUSIONS

- Substantial genetic gains are possible in Irish beef breeding breeds of up to 20 Euros / yr.
- Most of the gain came from gain in growth and conformation, accepting an increase of FI.
- calving difficulties increased and survival decreased somewhat.
- Rates of inbreeding could be set at predefined 'acceptable' values.
- Reducing the size of the progeny test gave little reduction in gains
- Preselection of young bulls could reduce the size of the overall progeny-test by 70-80% whilst incurring only a 5% reduction in selection differential of the sires.
- Reducing the number of elite breeding animals reduced gains by 10%
- Contribution of homecountry schemes to the Irish schemes reduced over time, and vanished for the large breeds.
- The Irish schemes achieved more genetic progress for the Irish index than the homecountry schemes did.

References: