Selection for Daughter Superiority

No matter how great a cow may be, the aim of genetic selection is to produce daughters that are superior to their dam. One part of achieving this goal is making the proper mating according to each cow's strengths, weaknesses and bloodlines, but the genetic level of the mating sire compared to that of the cow to be bred has a major impact on increasing the chances of success.

Genetic evaluations are designed to rank bulls and cows according to their relative superiority within the population. Reference is often made to a "breed average" and whether or not a bull is a "breed improver". Although such terms are generally appropriate, the fact is that a specific bull should only be considered an improver if he is genetically better than the cow to be bred. Essentially any bull would be expected to produce a daughter that is better than her dam if the dam is extremely poor herself. The biggest challenge in breeding is producing a daughter from an elite cow that is even better than her dam. In these situations, there is little room for using anything but the most elite sires of the breed.

The principle of selecting sires to produce daughters that are superior to their dams can also be explained in theoretical terms. When a sire and dam are mated together, the best estimate of the genetic potential of any resulting daughter is simply the average of the parents, usually referred to as the "Parent Average". The Parent Average associated with a mating can be easily calculated for any trait such as production, type, Somatic Cell Score and even Lifetime Profit Index (LPI) as long as the genetic evaluation for both parents are available. Although the Parent Average represents the average genetic potential of all progeny that would result from a particular mating if performed many, many times, usually each mating produces only a single offspring and their genetic potential can vary significantly from the Parent Average, either higher or lower, depending on the specific genes inherited from each parent.

Theoretically speaking, the genetic variation amongst full-sisters would be half of the genetic variation of the whole population when both parents are not inbred. As the average level of inbreeding in the parents increases, the genetic variation amongst the resulting progeny would decrease accordingly. For example, the genetic variation (ie: standard deviation) of full-sisters for LPI in the Holstein breed is approximately 350 points. If the average inbreeding level of the parents is 10%, the genetic variation among full-sisters would be reduced proportionally by 35 points to 315.

For any given trait, the probability that a daughter will be better than her dam depends on the superiority of the sire chosen to mate the dam. If a cow is mated to a sire that has the same genetic potential as herself, the Parent Average of the resulting progeny would be the same as both parents. Even though there is expected to be genetic variation among the progeny from this mating, the chance of any specific daughter being genetically better than her dam would be 50%. If the same cow was bred to the highest sire in the breed, the probability of producing a superior daughter would be greater than 50% depending on how much higher the mating sire is above the cow.

Figure 1 shows the probability of producing an offspring that has an LPI higher than their dam, according to the superiority of the mating sire selected. For example, in order to have a 95% probability that a specific mating will result in an offspring that is genetically better than the dam, the sire must have an LPI that is at least 1150 points higher than the dam (Table 1). Similarly, for a 75% chance of producing a superior daughter, the sire must be 475 LPI points higher than the dam. If, on the other hand, the mating sire has an LPI that is 475 points lower than the dam, the probability of a superior daughter is reduced to only 25%.

Table 1 also provides the minimum difference in genetic evaluation for Protein, any type trait and Somatic Cell Score (Figures 2, 3 and 4, respectively) that is required between the mating sire and the dam to attain various levels of probability of producing a superior daughter compared to the dam. Since genetic evaluations for Somatic Cell Score are expressed whereby lower is better, the highest probabilities of achieving daughter superiority result when the sire's proof is below the dam's index.

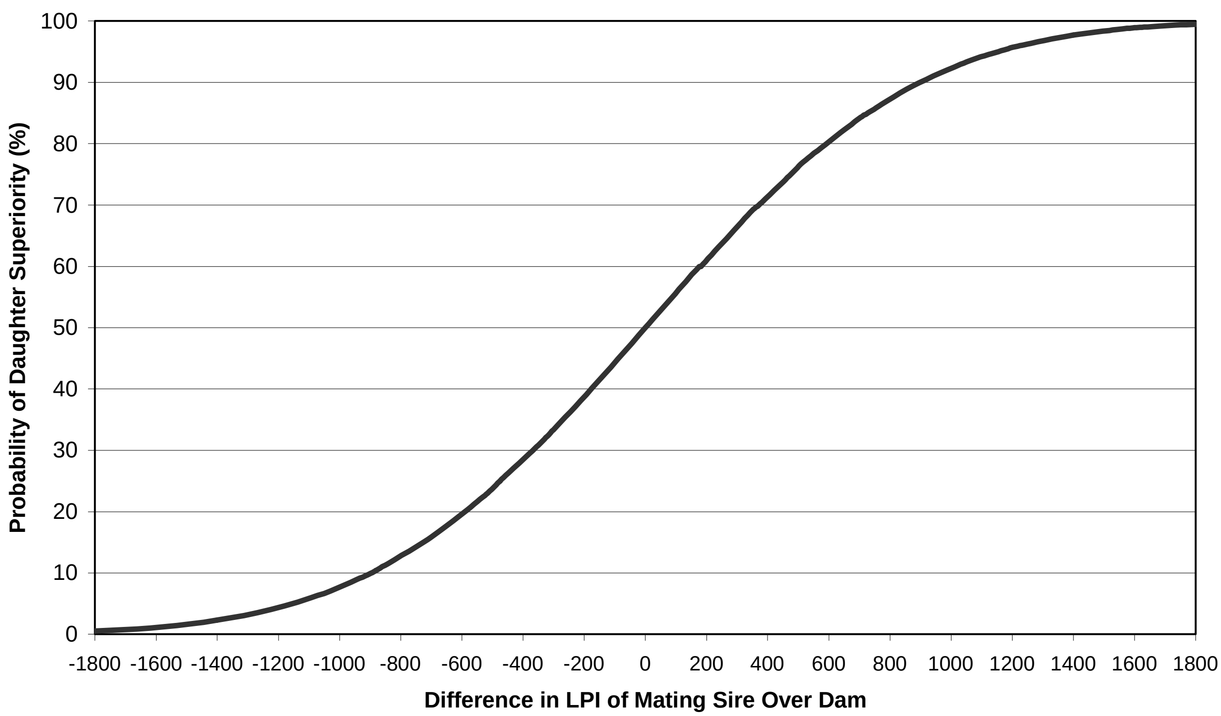
Table 1: Difference in Genetic Potential (Mating Sire – Dam) Required to Achieve Specific Probabilities of Producing an Offspring Superior to the Dam

Probability of Daughter Superiority	Minimum Difference Required (Mating Sire – Dam)			
	Lifetime Profit Index	Protein Yield (kg)	Type Trait	Somatic Cell Score (1)
99%	+1630	+58	+12	-.54
95%	+1150	+41	+8	-.38
85%	+730	+26	+5	-.24
75%	+475	+17	+3	-.16
60%	+180	+7	+1	-.06
50%	Mating Sire and Dam have Equal Genetic Potential			
33%	-300	-11	-2	+.10
25%	-475	-17	-3	+.16
10%	-900	-32	-6	+.29

Note (1): Higher probabilities are reached for Somatic Cell Score when the difference between the sire and the dam is negative since the lowest genetic evaluations are the most desirable.

Obviously, the highest LPI cows in the breed would have the lowest probabilities of producing a daughter that is genetically even better. Given that the highest proven sires are around +2000 LPI, owners of the elite LPI cows truly cannot risk using bulls that are less than the best. The practise of embryo transfer, however, to produce more daughters will indirectly increase the chances of having at least one that is better than the dam. On the other end of the spectrum, cows that are genetically below-average for LPI, or for any particular trait, can easily produce superior daughters by mating them to one of the most elite sires, which would result in probabilities of 95% or more. The bottom line, therefore, is that the most genetic progress, either as a breed population or in terms of producing a daughter that is better than her dam, is achieved by concentrating on the most elite sires available.

Figure 1: Probability of a Future Daughter Superior to her Dam for LPI According to the Difference in LPI of the Mating Sire Over the Dam



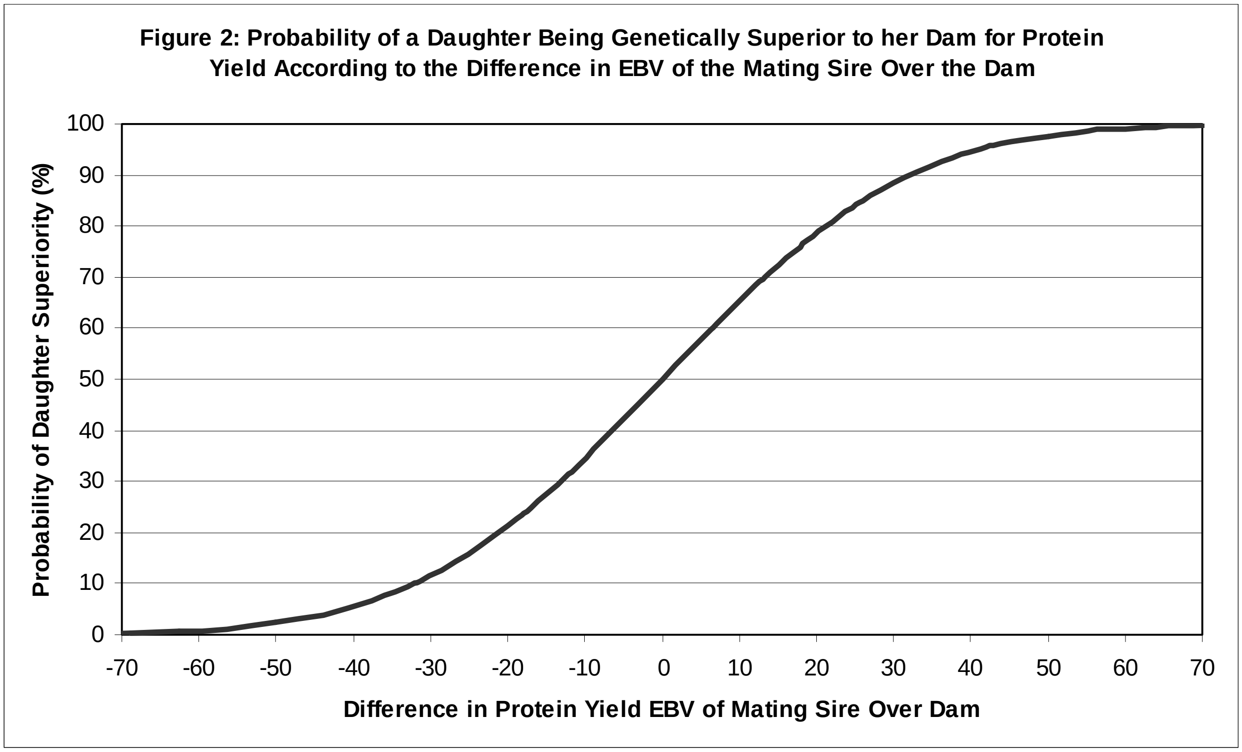


Figure 2: Probability of a Daughter Being Genetically Superior to her Dam for Protein Yield According to the Difference in EBV of the Mating Sire Over the Dam
Probability of Daughter Superiority (%)
0
10
20
30
40
50
60
70
80
90
100
-70
-60
-50
-40
-30
-20
-10
0
10
20
30
40
50
60
70
Difference in Protein Yield EBV of Mating Sire Over Dam

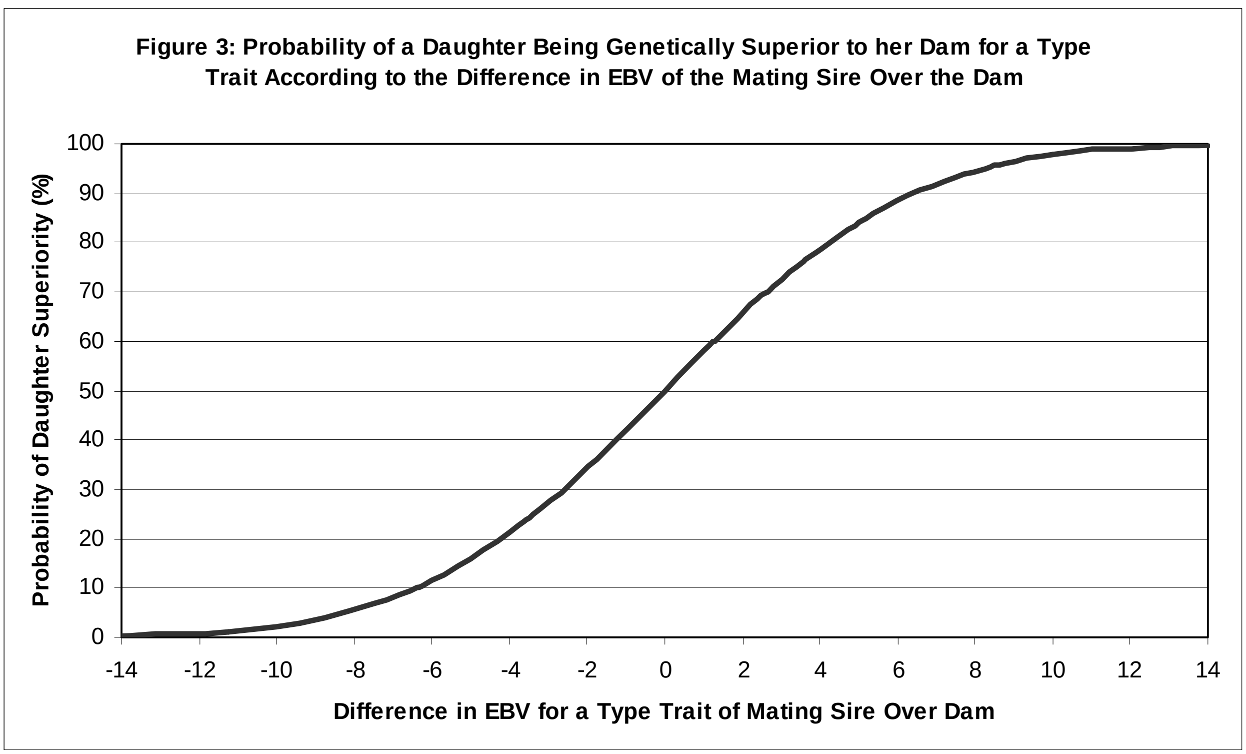


Figure 3: Probability of a Daughter Being Genetically Superior to her Dam for a Type Trait According to the Difference in EBV of the Mating Sire Over the Dam
Probability of Daughter Superiority (%)
0
10
20
30
40
50
60
70
80
90
100
-14
-12
-10
-8
-6
-4
-2
0
2
4
6
8
10
12
14
Difference in EBV for a Type Trait of Mating Sire Over Dam

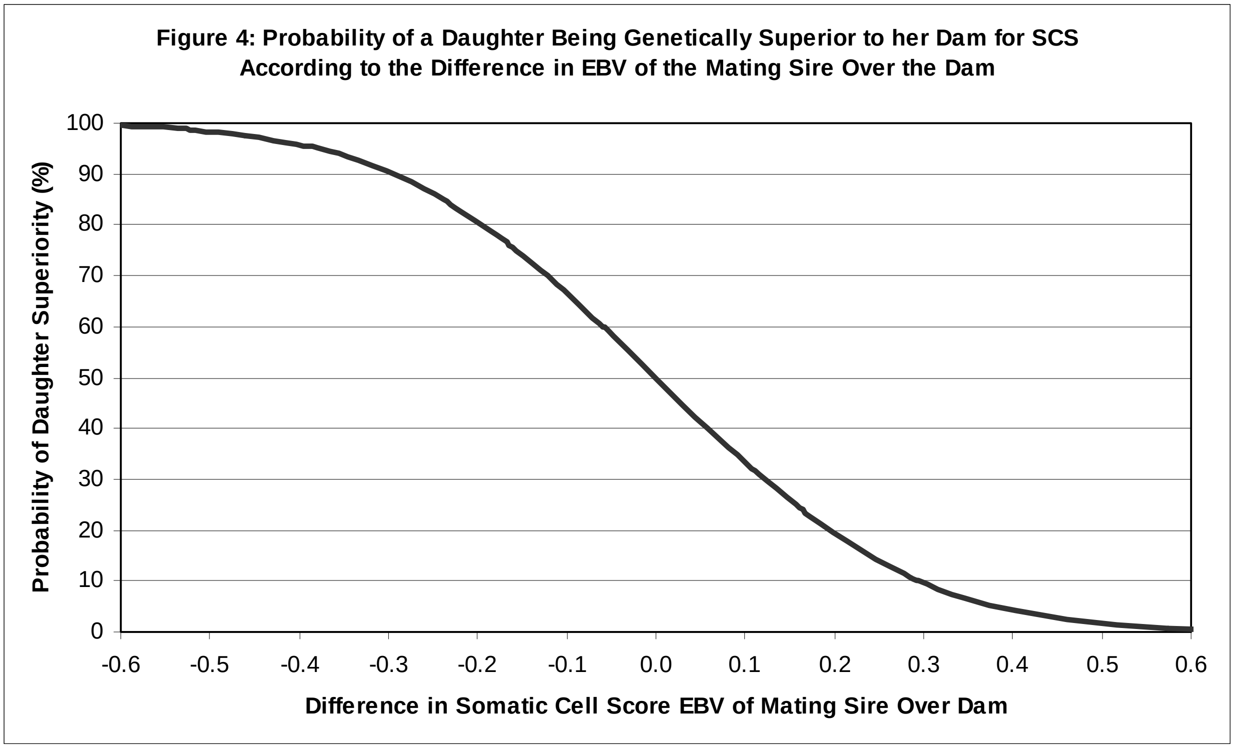


Figure 4: Probability of a Daughter Being Genetically Superior to her Dam for SCS According to the Difference in EBV of the Mating Sire Over the Dam
Probability of Daughter Superiority (%)
100
90
80
70
60
50
40
30
20
10
0
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Difference in Somatic Cell Score EBV of Mating Sire Over Dam