GENO GLOBAL

"Since man began to domesticate animals, and select parents for the next generation to form "breeds" or lines, the practice of crossbreeding, mating animals of two different breeds, has been a common practice. All of our modern classes of farm animals used for commercial food production (pigs, poultry, sheep and beef cattle) are crossbreds. Now there is opportunity to crossbreed dairy cattle!"

Edward B. Burnside, Ph.D., Geno Global Technical Advisor

Crossbreeding is the mating of individuals of different breeds, varieties or lines. This produces a hybrid; an animal produced by mating of individuals of different varieties or breeds.

This process combines the best of each individual breed's genes and creates a more "heterozygous" animal. This individual potentially carries two different genes at the same location (locus) on a chromosome. This is expressed by a phenomenon called "Hybrid Vigour" or "Heterosis."

An Englishman, Robert Bakewell, established the concept of creating breeds in the late 1700's.

Bakewell had traveled Europe extensively learning about other farming methods. In 1760 he took over control of his father's farm and implemented new ideas and concepts into his own farm.

Bakewell tried many alternative farming methods. His great leap was to begin breeding selectively. Previously, livestock of both sexes were kept together in the fields, breeding at random, resulting in many different breeds with their own unique, but random, characteristics. Bakewell separated the male from female, allowing mating only to occur deliberately and specifically. Furthermore, by inbreeding his livestock he fixed and exaggerated those traits he felt to be desirable.

Many farmers mated these different breeds together. Thus, crossbreeding was born.

Heterosis is an increase in characteristics such as vitality, disease resistance, growth rate, fertility and yield in a crossbred animal over its parents. Heterosis is also the marked vigour often exhibited by crossbred animals. Heterosis is also known as hybrid vigour.

Used interchangeably, hybrid vigor and heterosis are expressed as a percentage figure (%) for each trait. Percent heterosis is low (about 5%) for milk, fat and protein yield, but much higher for female fertility, resistance to mastitis and other diseases. Although this figure varies with management and environments, it is usually close from herd to herd.

Unfortunately we cannot accurately predict how much hybrid vigour a particular pair of breeds will exhibit when crossed. Many research trials are underway including an extensive trial at the Moorepark Research Centre in the Republic of Ireland. At this facility, tests are being conducted to determine the extent of hybrid vigour a Holstein x NRF will exhibit when crossed.

Figure 1 shows how hybrid vigour elevates the performance of the Holstein and NRF. This figure shows the protein production data reported for first lactation heifers in a comparison trial at the Hillsborough Agricutural Research Institute in Northern Ireland. The NRF heifers produced 408 lbs. of protein in 305 days, while their Holstein contemporaries produced 415 lbs. protein. If the offspring of these two breeds produced 432 lbs protein in the same herds, this is 5% more than average of the two parent breeds (411.5 lbs), therefore the hybrid vigour for protein is 5%.

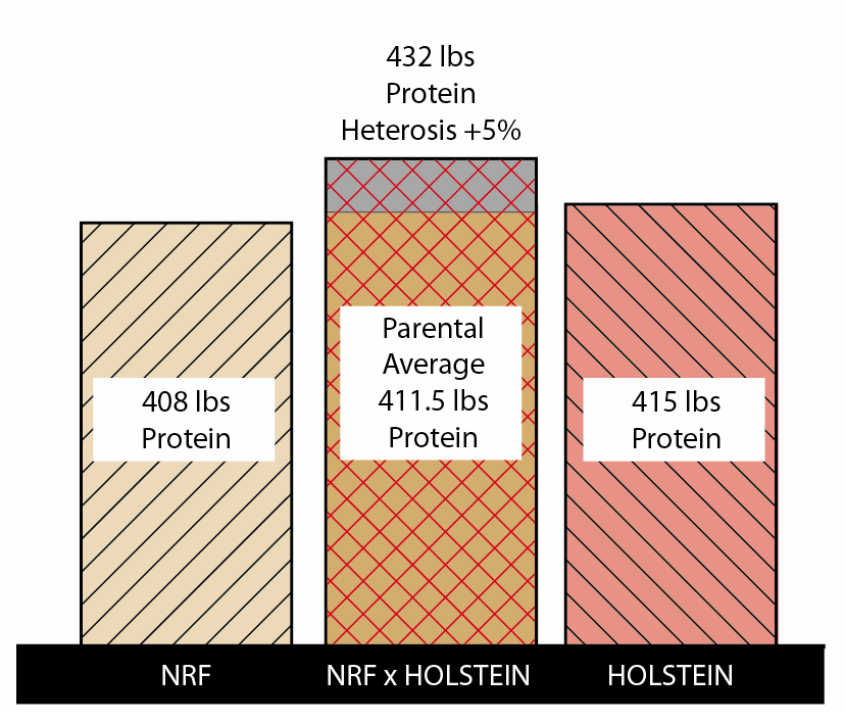


Figure 1. Example of Heterosis/Hybrid Vigour for Protein in a NRF x Holstein Cross

"To successfully crossbreed, it is essential to utilize breeds that are competitive and superior for individual traits,"
Edward B. Burnside, Ph.D., Geno Global Technical Advisor.

Effective crossbreeding begins with two superior breeds. These breeds must complement each other well and must independently have a large enough selection base to continue their own unique breeding goals.

The purebred Holstein is undeniably the top dairy breed globally, and it has been effectively selected since the 1950's for gross revenue per cow, excelling in milk, protein and fat production. The Holstein cow is a big roomy cow with excellent udder conformation, allowing for high production levels.

The Norwegian Red (NRF) is a breed that decreases costs through lower calf mortality rates, higher female fertility and lower disease incidence. The NRF has been selected for these traits for the past 30 years, with more modest selection for production and udder conformation. The NRF also carries the polled gene, which reduces calf setbacks and dehorning labor and materials and a solid black or red hoof color, which may lead to harder hooves. This bringing together of two breeds with desirable genes is called complementarity.

Complementarity describes breeds that are competitive production-wise and are distinctly superior for other traits offering a desirable outcome in the crossbred. Complementarity is the bringing together of desirable genes from two breeds.

Different from hybrid vigour, complementarity is dependent solely on the selection goals within each breed and the sires that are used in the crossbred matings. To successfully crossbreed, it is essential to utilize breeds that maximize complementarity. Based on current results from international crossing and breed comparison trials, the Holstein and the Geno NRF breeds will maximize complementarity.

Combining these two breeds into a carefully organized breed crossing system called TWOPLUS™ enables the commercial dairy sector to capitalize on the desirable genetic makeup of this "hybrid" cow.

She excels in production, conformation of udder, feet and legs, resistance to mastitis and other diseases, calf livability and fertility as a heifer and lactating cow.

A University of Minnesota study of California data shows that Holsteins crossed with seven NRF and two Swedish Red Breed (SRB) sires were 4% higher than pure Holsteins at 150 days in 1st lactations for fluid milk production. They were also 7% higher for fat and protein yield, had lower Somatic Cell Scores and had 5% less calving difficulties.

These differences, which are jointly the result of complementarity and hybrid vigour, may be what your commercial clients are looking for.

The University of Minnesota has just completed a study of pure Holsteins compared to crossbreds of Normande-Holstein, Montbeliarde-Holstein and Scandinavian Red-Holstein in seven California dairies. This information shows the profitability of the NRF crossbred heifers versus the pure Holsteins and other crosses.

Percent Two-Year-Old Calving Difficulties by Sire's Breed

Holstein Sires	16%
Montbeliarde	12%
Brown Swiss	11.9%
NRF	5.5%

Percent Two-Year Old Stillborn Calves by Sire's Breed

Holstein Sires	15.7%
Normande	13.2%
Brown Swiss	12.0%
NRF	7.9%

Percent Calving Performance By Breed

Holstein	9.3%
Normande x Holstein	9.2%
Montbeliarde x Holstein	8.1%
NRF x Holstein	4.7%

Percent Stillbirths By Breed

Holstein	11.8%
Normande x Holstein	9.2%
Montbeliarde x Holstein	8.1%
NRF x Holstein	4.7%

Percent Heifers That Died/Culled In First 305 Days
(Indicator of Unacceptability by Owner)

Holsteins	11.7% *(mostly due to reproduction problems)*
Normande x Holstein	6.4% *(mostly due to production problems)*
Montbeliarde	7.9%
NRF x Holstein	5.8%

Reproduction, expressed as days open, and conception rates on first service during the first lactation was significantly lower for Holsteins at 150 days open and 22% conception, in comparison to the three Holstein crosses, which ranged from 123 to 131 days open and 31% to 35% conception. None of the crosses differed for these two reproductive traits.

In summary, the NRF x Holstein heifers milked at very high production levels, (some over 30,000 lbs. in first lactations), were significantly easier calvers, had higher conception rates, and had fewer deaths and other health problems. These factors resulted in the NRF x Holstein heifers being kept in the herds longer than the other breeds and resulted in more profits for their owners.

How Many and Which Breeds?

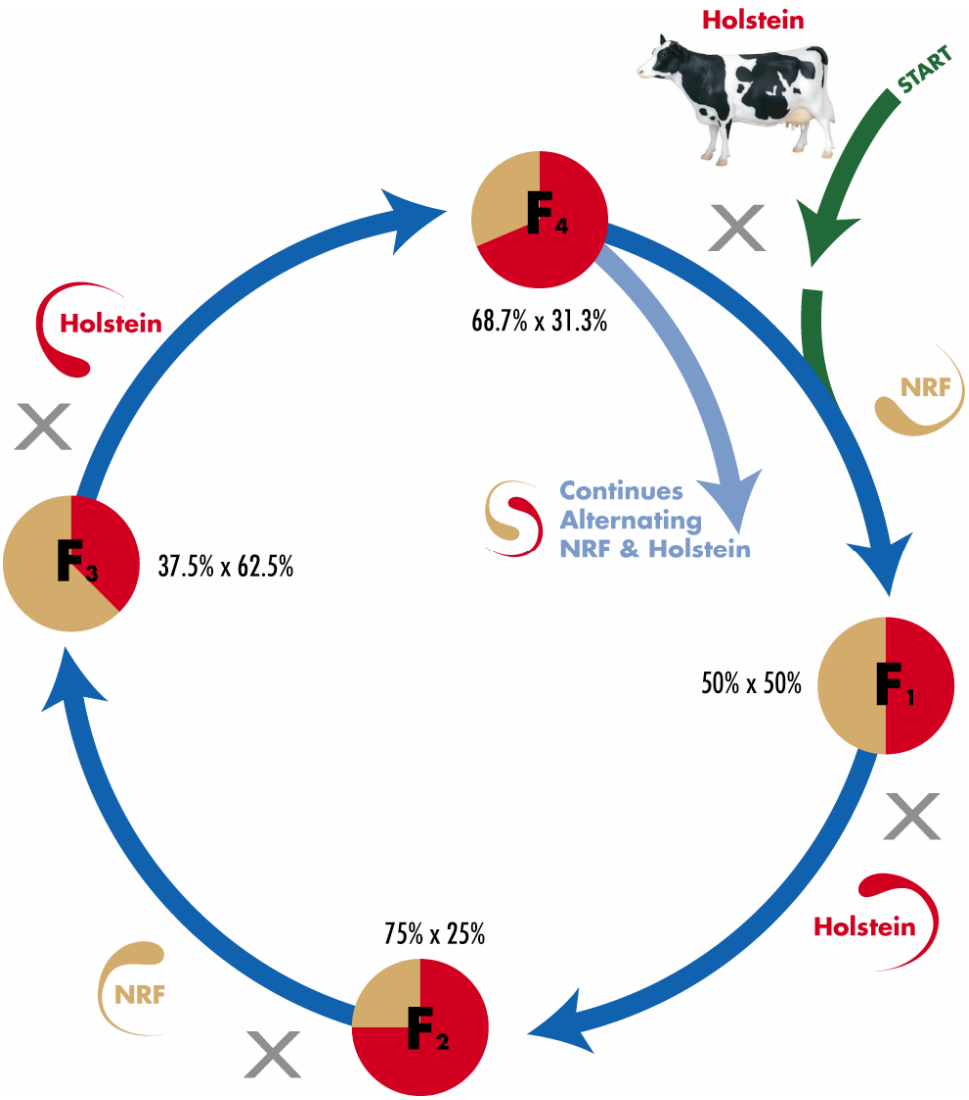
Often, attempts at crossbreeding dairy cattle have failed because there was no plan for the steps beyond the F1 cow. The TWOPLUS™ system does not end with the F1, but continues to balance between the breed that excels at increasing revenues and the breed that excels at decreasing costs in future generations.

TWOPLUS™ is a rotational crossbreeding system, whereby the Holstein and the NRF breeds are used alternately to produce the next generation. Thus, F1 heifers from NRF sires should be mated to purebred Holstein bulls; their progeny to NRF; the progeny of those to Holstein; and so on. With such a system, the level of hybrid vigor will be two-thirds of the F1, and the cross will become more and more uniform over time.

Several groups have recommended involving a third or even a fourth breed in the crossbreeding program. However, this could unnecessarily complicate the program. It will create more variation in the herd, and is likely to reduce over-all profitability. The superiority of the TWOPLUS™ system is largely based on the complementarity and high performance of the Holstein and the NRF breeds. Finding a third breed that can match these two and complement them well is a challenge, as it would require years to verify its improvement on the TWOPLUS™ program.

Crossbreeding programs must be designed to fit the species. In dairy cattle, the reproductive rate is low, and crossbred females must be used to produce the next generation of crossbreds. Therefore the most logical crossbreeding system in dairy cattle is rotational crossing.

The figure to the right is an example of the rotational crossbreeding process alternating between an NRF sire and a Holstein sire.



What will happen if more breeds are included?

Using more than two breeds in a rotational crossbreeding system will increase the level of hybrid vigour to 85%, but sacrifices genetic merit and increases herd variation. This genetic merit sacrifice occurs because the third breed does not complement the first two breeds, due to a smaller progeny testing program resulting in a loss rate of genetic improvement. Rotational crossing systems are easily managed if the number of breeds used is kept to a minimum. Crossbreeding with two breeds, both with high genetic merit and with complementary traits, is the simplest choice.

In order to examine the TWOPLUS™ system, Geno Geneticists developed a complex simulation model of a 200 cow herd that studied both two breed and three breed rotational crossbreeding.

In order to conduct this simulation the following was considered:

- To account for the varying animal distributions due to the different breeds and crosses, the 200 cow herd was analyzed over a period of 20 years. To ensure reliable results the simulation was repeated 30 times and the averages were plotted. In each figure year 1 represents the first year the F1 crosses entered the milking herd.

- The effect on milk yield, fertility, mastitis and calf survival was estimated by using results from California, Ireland and previously reported cross breeding experiments as well as comparison trials or results comparing different purebreds as base reference points. The important parameters are the additive genetic level of each breed, for each trait and the percent hybrid vigour assumed for each breed and trait. Realistic values were chosen for each of these.

The effects are presented relative to pure Holstein, which is set at a value of 100 for each trait. Figures 2-5 on pages 8-9 demonstrate the simulated average genetic merit for both a two-breed rotational crossbreeding herd and a three-breed rotational crossbreeding herd for each trait over time. A crossbreeding system always starts with the F1. The chosen breeding system then determines the succeeding generations. As expected there are always several breed combinations, as illustrated in the figure on pg. 6, making up each annual herd average. The first cross will be 50% Holstein : 50% NRF. Then as Holstein and NRF sires alternate generation after generation, the younger animals will alternate between 2/3 Holstein : 1/3 NRF and 1/3 Holstein : 2/3 NRF, determined by the individual's sire. In subsequent generations these will be the only breed combinations in the herd. The total effect of both hybrid vigour and additive genetic levels are accounted for the herd as a whole, from the first through the 22nd year after the first F1 heifers entered the milking line.

Figures 2-5 compare the mastitis resistance, milk yield, calf survival rate and fertility rates of a two-breed crossbreeding program and a three-breed rotational crossbreeding program. The third breed used in the three-breed rotational program is a Jersey. The Jersey was chosen because it is superior to the Holstein in fertility and milk solids, but inferior for milk yield, mastitis resistance and calf viability. These figures show that using a three-breed rotational crossbreeding program reduces mastitis resistance below the two-breed rotational average by 3%; reduces milk production below the Holstein average by 5%; decreases calf survival rate 3-4% below the two-breed rotational average; increases fertility by 3% over the two-breed rotational cross. Unfortunately, a higher fertility rate alone is not enough to endorse a three-breed rotational system as it lessens the genetic merit of the individuals produced, due to the greater scope of the NRF and Holstein sire testing programs. Further, the two-breed rotational cross cows will be more uniform in size, the herd's performance will experience less fluctuation and will be easier to manage as there are only two breeds to choose from when mating.

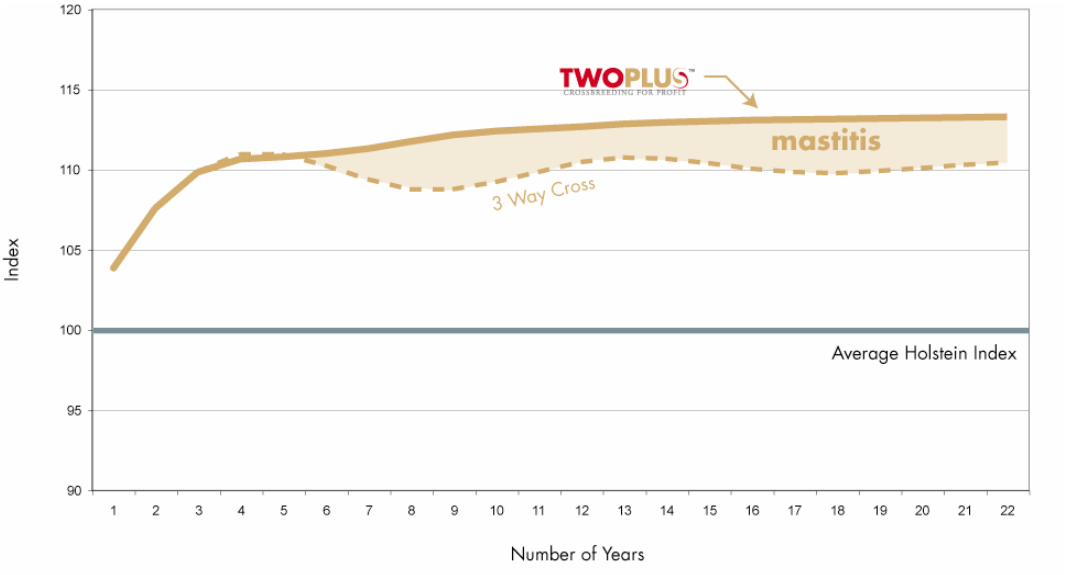


Figure 2: Source: Simulation Research by Geno geneticists comparing two and three-way crossbreds for resistance to mastitis.

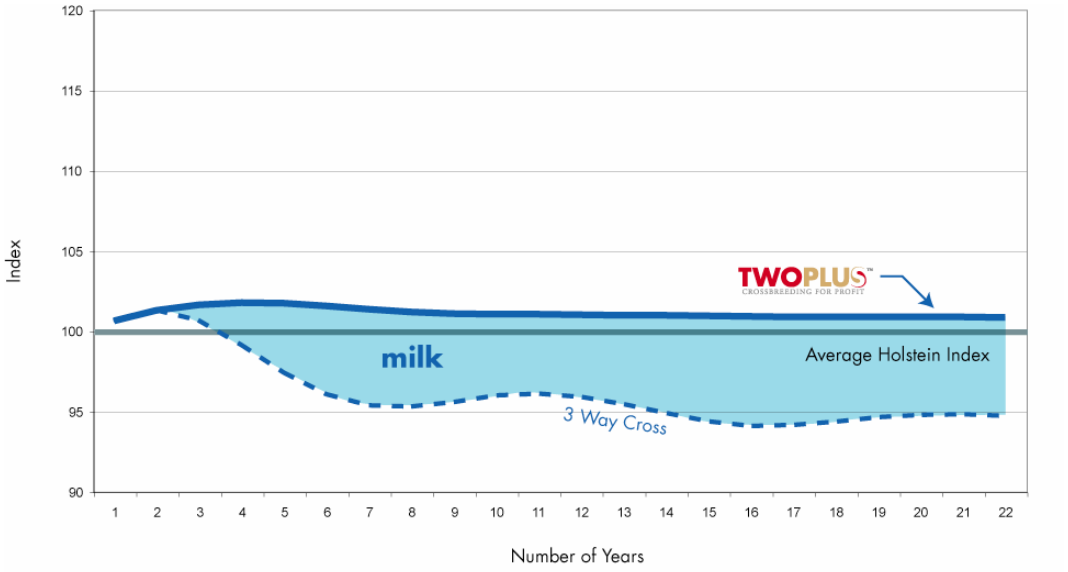


Figure 3: Source: Simulation Research by Geno geneticists comparing two and three-way crossbreds for milk production.

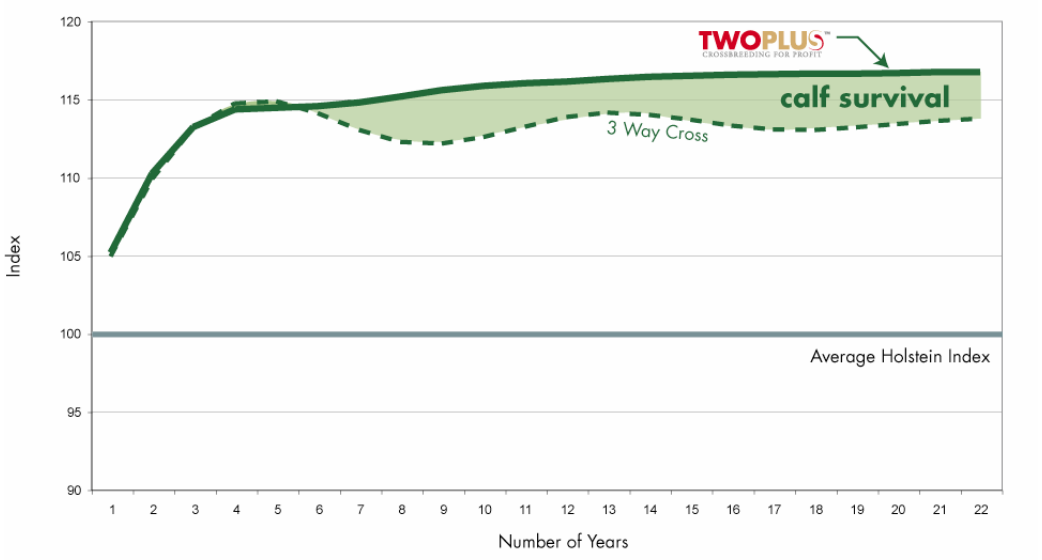


Figure 4: Source: Simulation Research by Geno geneticists comparing two and three-way crossbreds for calf survival rate.

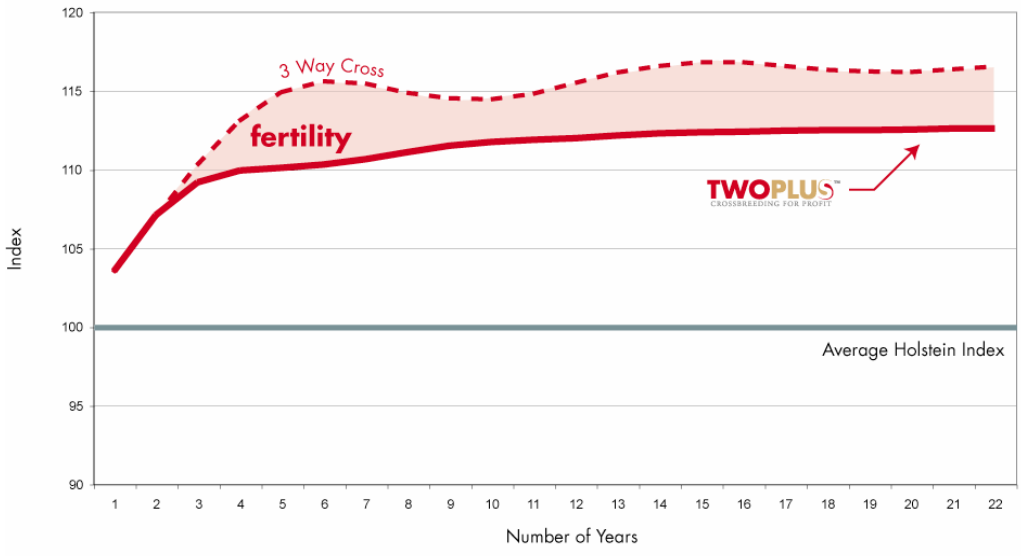


Figure 5: Source: Simulation Research by Geno geneticists comparing two and three-way crossbreds for fertility.

Selection Progress In Each Breed & Selection of Crossing Sires

As with any breeding program, selection of parent breeds and sires has a great effect on the success of the crossbreeding system.

The selection program within each breed plays a huge role in the success of the program as it provides an annual genetic change in the traits selected for. Figure 2 (page 7) demonstrates an annual rise for each trait due to the crossbreeding process, but there will be an additional rise as each breed rises for the given traits, and depending on the proofs of the sires chosen.

Selecting individual sires for use within the crossbreeding program is key to its success. It is possible to select sires with more emphasis on certain traits desired in a herd based on breed populations that test a large number of bulls annually. The Holstein breed and the NRF Progeny Testing Programs provide this opportunity within the TWOPLUS™ system. The TWOPLUS™ system for selecting sires allows the breeder to increase some traits while reducing the effect of others, allowing for a custom designed breeding program.

Geno's NRF Sire Proving Program

The Geno sire-proving program for the NRF breed is very carefully planned by its Director of Genetics Research, Dr. Torstein Steine, and his staff of seven geneticists. These scientists plan and supervise the genetic selection program, research sire and cow genetic evaluation systems and compute quarterly genetic evaluations.

The Geno staff is located on the Agricultural University of Norway campus and is in close collaboration with researchers in the university's animal genetics department. Each year nearly 125 young bulls are sampled on 40% of the females in each herd across Norway. These are drawn from a pool of 400 young sire prospects who are growth tested from 3-11 months. The 125 successful young NRF sires excel in growth, muscle development, feet and legs conformation and serving capacity.

The progeny test results are electronically collected for production, conformation, cow health, all A.I. breedings, calving performance and stillbirths. These data flow electronically into a central database, for analysis using techniques similar to other widely accepted proving systems. The systems are very similar, except that predicted incidence of diseases including mastitis, are recorded on each of the cows health records, and used to compute sire proofs. The sires receive an overall rating for total merit, based on a selection goal that places much more emphasis on female fertility, mastitis resistance and resistance to other diseases, than other programs.

Interpreting An NRF Sire Proof

Geno's total merit index is expressed as a difference from the current breed average index. This index places approximately 25% emphasis on each of the following: production, reproduction and calving performance, disease reistance and conformation. This system places substantially more emphasis on fertility and disease resistance than traditional indexing systems.

The highest indexing sire in the NRF breed has a Total Merit index of +26 at present. All sires are ranked every four months and an NRF sire gets up to 300 daughters recorded for female reproduction and disease resistanc and somewhat fewer, perhaps 150, for the production and conformation traits.

The breed average for a sire's individual trait proof averages 100, with a breed average standard deviation of 7 points. Nearly two-thirds of all NRF sires receive proofs ranging from 93-107, and 95% of all proven sires range between 86-114. Some traits with slightly higher heritability show slightly more variation, but outstanding sires may receive a proof of 110 to 120 or higher. Sires are also ranked for Disease Resistance and Fertility of their daughters. It is difficult to find a sire that improves all the important traits, as production and health traits are negatively related, but the sire proof is the best indication of what he will transmit.

5646 HEIGRE

S: 4680 Risa
- PGS: 3852 F. Aksland
- PGD: 252 Lina

D: 727 Gurina
- MGS: 4755 Leikvoll
- MGD: 661

Born: 7/8/1999 at Astrid and Enevald E. Heigre, 4312 Sandnes
Colour: Black **Horned/Polled:** Polled
Best Traits: • Protein % • Udder • Legs
Total Merit Index: 26

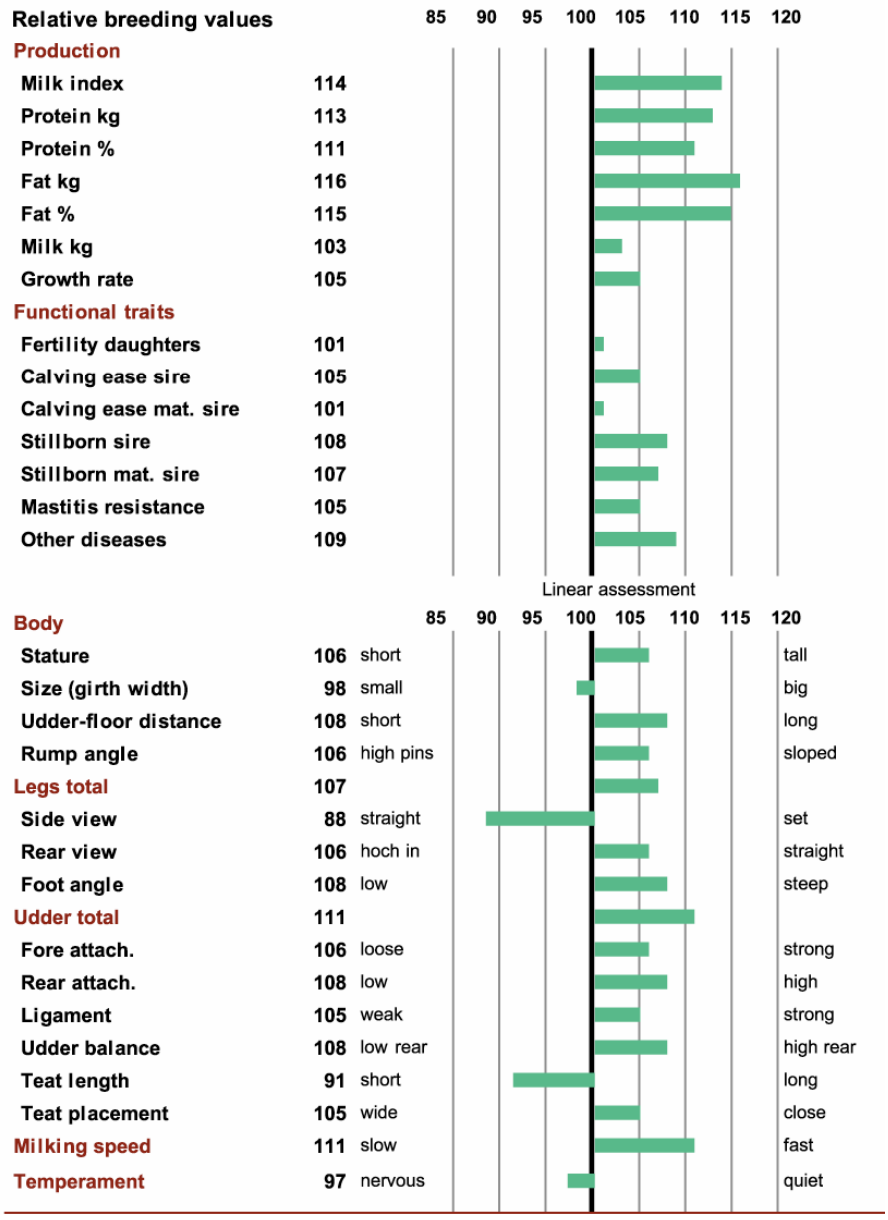


Figure 4: NRF Sire Proof of 5646 HEIGRE

The NRF sire 5646 HEIGRE's proof chart in Figure 4 is an excellent example of the NRF breeding program as he has a Total Merit Index of 26.

The detailed results show that although he is not at the top of the population for any one trait, he has no weak traits.

He is among the best for milk yield, health, calving ease, stillbirths, legs and udder type and it is probable that his daughters will receive increased production due to hybrid vigour. The same increase will apply to fertility, calving ease, calf survival and resistance to mastitis and other diseases.

How To Begin With A Commercial Dairy Herd

Complete Crossbreeding

The quickest way to begin seeing the results of hybrid vigour and complementarity in matings would be to mate all purebred Holsteins with NRF sires. The resulting F1 heifers are expected to be born with relative ease, breed easily and calve with ease. They should milk as well as their Holstein contemporaries and outlast them due to superior fertility and disease resistance.

In turn these F1 heifers should be bred to a calving ease Holstein sire who is known for superior conformation and production. Generation after generation, one alternates between a purebred Holstein and NRF sire with special attention being given to selecting Holstein sires for calving ease on the NRF sired yearling heifer.

Crossbreeding Young Heifers & Cows

Clients may wish to test the NRF x Holstein crosses in their herd before completely turning their entire breeding program over to crossbreeding. In such cases, breeding yearlings and two-year-old heifers to NRF sires while continuing to breed more mature females to purebred Holstein sires is an excellent alternative. This approach has the advantage of ensuring easy calvings in the two and three-year-olds, while building confidence in the TWOPLUS™ program.