Developing Superior Genetics for Canada: Results from the Canadian Swine Improvement Program

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INTRODUCTION

One objective of this workshop is to examine how new technology in molecular genetics can contribute to the improvement of pork production. Another is to review what has been achieved to-date through traditional or new selection methods. The two objectives are complementary, since charting new territory starts with knowing where one stands. In this talk, I will therefore review the progress made in Canada through the Canadian Swine Improvement Program. At the same time, I will try to point to some major directions for the future of the program.

THE CANADIAN SWINE IMPROVEMENT PROGRAM (CSIP)

The program is one of the largest of its kind in the world. It serves about 150 herds, with a total of more than 9,300 nucleus sows. About 100,000 pigs are tested each year. Because all animals are evaluated jointly, there is an opportunity for selection across the entire program, which leads to rapid genetic progress for traits of economic importance. Program participants include breeding companies, breeder groups and breeders. They are served by four regional centres (WSTA, OSI, CDPQ, ASC) and CCSI. The program has a long history, starting with the establishment of swine testing stations as far back as 1935. Some milestones are the development of the farm test program in 1956, the introduction of ultrasonic probing in 1971, halothane gas testing in 1982, the use of BLUP genetic evaluations in 1985 (a world first for a large swine population), the halothane DNA probe in 1992, and privatization of the program in 1995.

THE RESULTS

Lean yield

In the herds on the program, lean yield has increased by 3.5% from 1980 to 1999. The trends for the Yorkshire breed are shown in figure 1, but trends in the Duroc and Landrace breeds were similar. Most of this progress is genetic (about 90%). This successful selection leads to the question: should we keep selecting for lean yield? Factors such as the continuous increase in the slaughter weight of market hogs, the greater cost-efficiency of leaner pigs, negative consumer attitudes towards excessive fat and the current payment system all weigh in favour of a positive answer. On the other hand, excessive leanness has been linked to skinning problems, reduced meat quality due to softer fat and lack of adequate marbling, and potential negative effects on the longevity of sows. Given this, a sensible approach might be to keep selecting for lean yield as long as the slaughter weight increases, in order to compensate for the inherent increase in fatness, but at the same time take palliative measures to counter any negative effects. These include monitoring and if necessary selecting for meat quality (marbling, belly thickness, fat structure) and adjusting feeding and management practices to adapt them to leaner sows.

Loin eye area

The correlation between measurements of lean depth on the live animal, taken with the US50 real-time ultrasonic machine used in the program, and actual loin eye area is 0.76 (Pomar et al, 2000). Selection can therefore progress at 76% of the rate possible with a perfect measurement. This is more than enough to quickly increase loin eye area in situations where the market demands it.

Growth rate

The average age at 100 kg for herds on the program has moved from 186 days in 1980 to 153 days in 1999 (average of males and females). Selection was responsible for about two thirds of that progress of 33 days. The trends for the Duroc breed are shown in figure 2, but trends for other breeds are similar. A consequence of faster growing, leaner hogs has been better feed efficiency. From 1980 to 1999, selection has reduced the feed conversion ratio by about 0.34 kg feed/kg gain. Non-genetic factors (health, feeding, etc...) have also contributed to improvements in feed efficiency. In the two test stations within the program, which are equipped with individual feeding machines, average feed conversion ratios from 30 to 108 kg for 1999 tests were 2.56 and 2.35 kg feed per kg of gain respectively, ie. considerably lower than what would have been thought possible 10 years ago.

Meat quality

Meat quality traits can be improved through selection, since 16 to 50% of the variation in pH, meat colour, drip loss, marbling, tenderness and structure is of genetic origin. Measurements of meat quality have been taken routinely in test stations for research purposes and to monitor trends. One development which has directly impacted meat quality in the program has been the use of the halothane gene probe. Although halothane gene carriers do benefit from a slightly higher lean yield, they tend to produce lower quality meat (Aubry et al, 2000). Most participants in the CSIP are taking the view that Canadian pork should keep its reputation for superior meat quality. Therefore, they are making intensive use of the Duroc as a terminal breed, have eliminated the halothane gene from their Yorkshire and Landrace herds, and have maintained the pressure on lean yield to compensate for the “handicap” in this area created by the absence of the gene. Given the Duroc pool available in Canada, and the likelihood that contracts between producers, packers and trade houses will reflect more and more the quality of the product, this seems to be a good strategy.

Litter size

The number of pigs born per litter in the white breeds has increased slightly from 1985 to 1993, but started declining after 1994, probably due of the use of early weaning (which has a negative effect on the size of the next litter). However, since the introduction of genetic evaluation for litter size in 1995, genetic progress for this trait has been made at the rate of

0.2 to 0.3 pigs per year. As a result, litter size has been rising again over the last 2-3 years. The trends for the Yorkshire breed are shown in figure 3. The trends for the Landrace breed are, if anything, even more pronounced over the last 2 years. We have therefore gone from a situation before 1995 where genetic trends for litter size were flat, and the trait was considered difficult to improve genetically, to one where genetic improvement has become a key factor.

Foreign boars or semen have been imported periodically and used in the program along with domestic sires. Their progeny performance can then be compared directly and from this we can establish how genetics in the program are performing compared to outside genetics. The results of such comparisons are shown in Table 1 for litter size in the Landrace breed. Essentially, imported genetics from the US and the UK ranked below the CSIP average for litter size, while those from France and Scandinavia ranked above average. The lines originating from two other genetics suppliers were clearly below average. The top 5% of animals in the program was superior to all importations. Results from the Yorkshire breed were similar, except that importations from France and Scandinavia fared even better, and slightly exceeded the top 5% of CSIP animals. In conclusion, CSIP maternal lines do very well for litter size compared to other genetic sources imported to date. However, there might be some merit in sourcing genetics from France or Scandinavia, particularly in the Yorkshire breed.

Total economic gains

A conservative estimate of the economic gains resulting from genetic improvement in several of the traits above is shown in Table 2. The gains are for a commercial producer using Yorkshire x Landrace sows and mating them to Duroc boars to produce market hogs. With the current rates of genetic change in the CSIP they amount to $14 per year per litter (for litters of 10 pigs). Since genetic gains are cumulative, a producer using 5-year old genetics instead of those currently available would actually be losing $72 per litter.

Resistance to disease

Selection of disease-resistant animals may offer an efficient and acceptable alternative to the routine use of medication or medicated feed to control diseases in swine. In an experiment conducted at the University of Guelph, separate lines were selected for and against immune response (Mallard et al, 1998). After several generations, animals from the high immune response line responded more readily to vaccines and in fact grew faster than control or low immune response pigs (figure 4). CCSI will be computing genetic evaluations for high immune response for a new company, Integragen, which will make selected gilts and semen available to the industry.

THE USE OF MOLECULAR GENETICS

CSIP herds have made extensive use of the DNA probe for the halothane gene. As indicated in the previous talk, several other genes or markers of interest are likely to become available in the future, for example the RN gene, or genes or markers influencing marbling, muscle fibre, reproduction, etc... CCSI’s research and development strategy calls for evaluating these genes and markers, in cooperation with universities and government laboratories, and integrating the most useful ones to the current genetic evaluation methods. This area will be covered in more detail later in the workshop by Drs. Dekkers and Mathur.

CHALLENGES AND OPPORTUNITIES

Having succeeded in developing world-class genetics is not sufficient. These genetics must be packaged and marketed in a way that meets the needs of commercial producers. This entails being able to supply large volumes of gilts of uniform genetic merit and health, and providing advice on how best to use them. Many participants in the program are forming alliances so they can acquire the size and make the investments necessary to market and deliver this package. The alliances also include routine exchanges of genetic material, ensuring the existence of a wide genetic pool and leading to increased rates of genetic improvement.

CONCLUSION

Considerable genetic progress has been made in CSIP herds for lean yield, growth rate and feed efficiency. In addition, progress has been made for meat quality with the elimination of the halothane gene and the widespread use of the Duroc breed, and recently genetic progress has been made for litter size. Some promising areas in CSIP include the integration of new genes and markers to selection methods and further work on meat quality and resistance to disease.

One reason for the Canadian pork industry's current success has been having access to high quality genetics not available elsewhere, which the CSIP has been able to provide. Continued success will require capitalizing on existing strengths, including superior meat quality, excellent reproductive performance, and the existence of genetic improvement structures that can quickly incorporate new developments and provide the industry with third-party assessments of new methods and products.

REFERENCES

Aubry A., B. Ligonesche , R. Guéblez , D. Gaudré (2000). Comparaison de porcs charcutiers NN et Nn pour les performances de croissance, carcasse et qualité de viande, et l'apltitude à produire du jambon cuit. Journées Rech. Porcine en France. 32: 361-367

Mallard B. A., B. N. Wilkie, B. W. Kennedy, J. Gibson and M. Quinton (1998). Immune responsiveness in swine: eight generations of selection for high and low immune response in Yorkshire pigs. Proceedings of 6^{th} World Congress on Genetics Applied to Livestock Production . 27 : 257-264

Pomar C., J. Rivest, P. Jean Dit Bailleul and M. Marcoux (2000). Predicting loin-eye area from ultrasound and grading probe linear measurements of fat and muscle depths in carcasses. Can. J. Anim. Sci. (submitted)

Figure 1: Genetic Progress for Lean yield
in the Canadian Swine Improvement Program

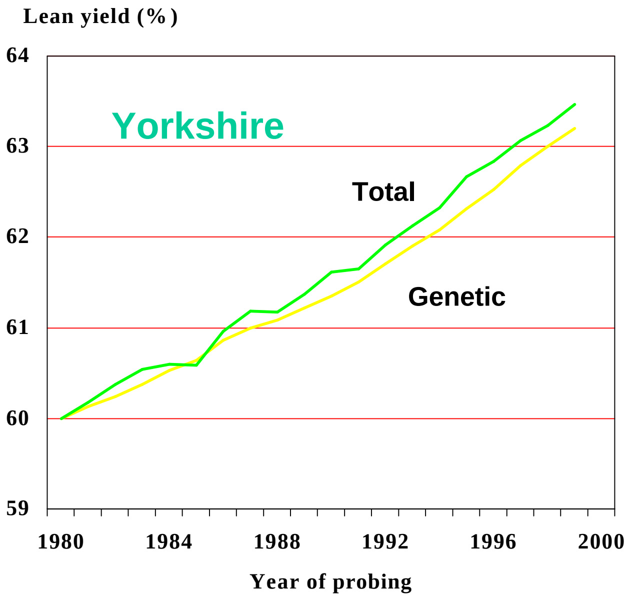

Figure 2: Genetic Progress for Age at 100 kg
in the Canadian Swine Improvement Program

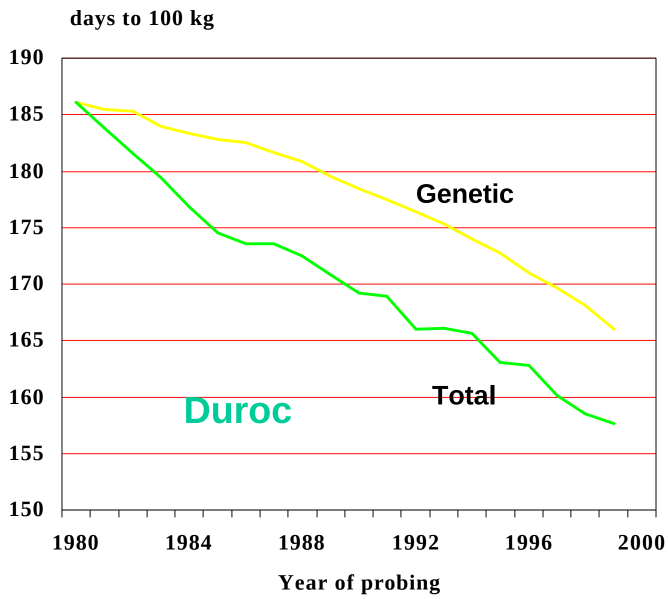

Figure 3: Genetic Progress for Litter Size
in the Canadian Swine Improvement Program

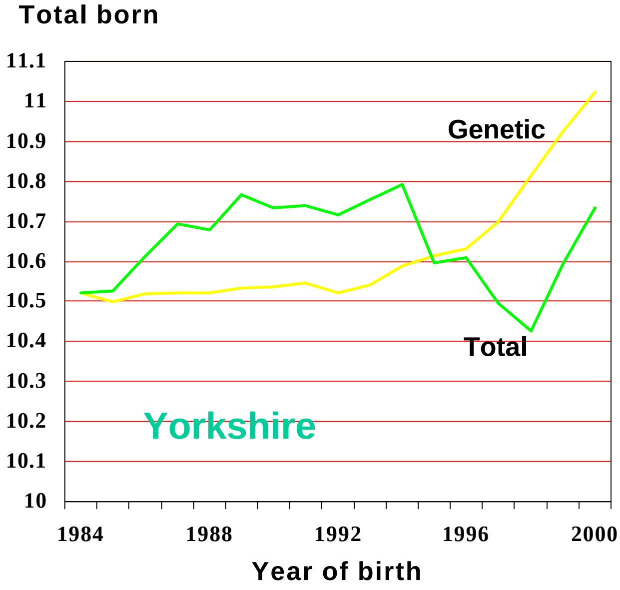

Figure 4: Frequency of Non-response to
Actinobacillus pleuropneumonia Vaccine
in High and Low Immune Response Pigs

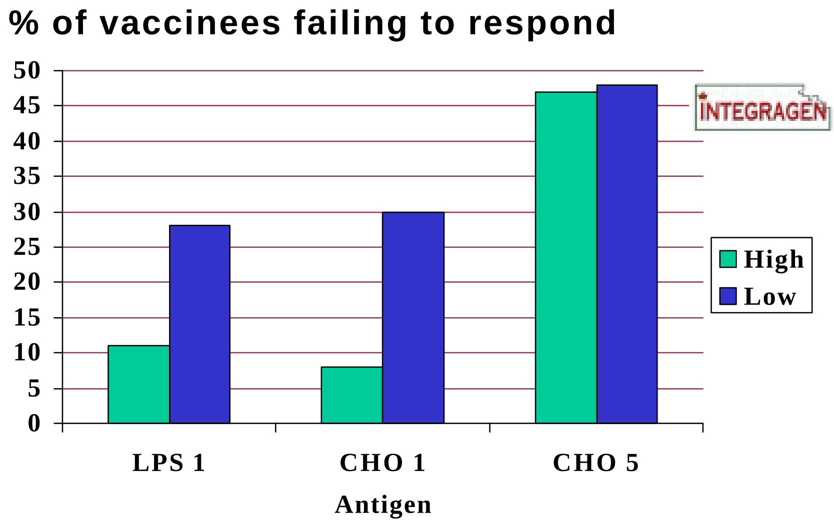

Table 1: Average genetic merit of imported boars or semen for litter size against sires in the program

LANDRACE BREED Origin	EBV for total Number born
Canada (average)	+0.13
Canada (top 5%)	+1.44
USA	-0.62
England	-0.43
France	+0.64
Scandinavia	+0.46
Other Canadian sources	-2.04

Table 2: Economic gains from genetic improvement at the producer level

Traits	Current genetic rate of gain per year	$/litter/year*
Litter size (pigs)	0.14	$3.46
Lean yield (%)	0.20	$2.34
Growth rate (days)	1.5	$4.05
Feed conversion (kg/kg)	0.024	$4.50
Total per year		$14.35
Total over 5 years		$71.75

* based on a production system with Duroc sires and Yorkshire x Landrace sows, litters of 10 pigs, and average hog and feed prices for the last 3 years.