PERSPECTIVES FOR GENETIC IMPROVEMENT OF FEED EFFICIENCY IN SWINE

B.P. Sullivan, J.P. Chesnais and J.R. Brisbane

Canadian Centre for Swine Improvement Inc., Central Experimental Farm, Bldg. # 54, Maple Drive, Ottawa, Ontario, K1A 0C6, Canada

INTRODUCTION

Food is a major cost of pig production. In the past, direct selection for improvement of feed efficiency has not always been effective (Kennedy, 1984). On the other hand, selection for growth rate and against backfat has improved feed conversion (Sather and Freeden, 1978). If the pigs are fed ad libitum, selection for lean growth rate does not appear to decrease appetite but leads to a favourable increase in feed intake (Ollivier, 1986 ; Mrode and Kennedy, 1993).
The Canadian Swine Improvement Program provides estimated breeding values (EBV) for feed conversion ratio (FCR) defined as kg of feed per kg of gain. The FCR EBVs are based on EBVs for age at 100 kg and backfat thickness, and their genetic correlations with FCR. FCR is then used as an explicit objective in selection indices for sire lines and dam lines. From FCR evaluations, it is estimated that cumulative genetic improvement for FCR has been 0.35 kg feed per kg of gain from 1980 to 2000, or 28 kg feed per hog over an 80 kg finishing period (25 kg to 105 kg). About 37 % of the gains have occurred in the last 5 years. Assuming an average feed cost of $200 per tonne, this improvement represents a saving of $5.60 per hog, a relatively high percentage of the current profit margin.
An important change in the pig industry has been the development of electronic feeding devices allowing pigs to be group-housed while feed intake is measured on an individual basis. Today, a number of breeding programs use these devices, but usually on a limited basis because of the high cost and maintenance requirements. Another change has been a reduction in emphasis for selection against backfat in some programs. When this occurs, gains in FCR may decrease significantly. Some form of direct selection for feed efficiency may then be required.
The objective of this study was three-fold : 1) to estimate the potential increase in genetic progress for FCR from using feed intake records in addition to backfat and age data ; 2) to evaluate improvements in FCR that could arise from the more accurate estimation of its relationship with production traits ; and 3) to assess the value of measuring feed intake during only part of the growing period.

MATERIAL AND METHODS

The data consisted of performance and individual feed intake records for Yorkshire, Landrace and Duroc pigs tested during 4 consecutive fills at the Deschambault test station in the province of Quebec between December 1997 and October 1999. Pigs were delivered to the test station at 10 to 14 days of age, placed in segregated early weaning facilities, and transferred to the test facilities at an average live weight of 28 kg. There were 607 gilts, 586 barrows and 68 boars. Each pen contained 12 to 14 pigs of the same sex, with about 0.9 m^2 of space per pig.

Animals were fed using INSENTEC IVOG electronic feeding stations. Each animal was weighed at the beginning of test (weight 1, at around 25 to 30 kg) at the end of the test (weight 4, at around 112 kg) and twice during the test at about one-month intervals (weights 2 and 3). Three-phase feeding was used with a diet of around 18 % crude protein (CP) until the second weighing, 16% CP between the second and third weighing, and 15 % CP afterwards. The diet was based on ground maize, soybean and wheat, with about 88 % dry matter.
FCR was calculated as the ratio of feed consumed, adjusted to a fixed metabolisable energy content of 14 MJ per kg, divided by weight gain during the period. Data for FCR and for backfat and age at 100 kg were analysed using a three-trait multivariate BLUP animal model. Several sets of breeding values for FCR were calculated based on feed intake data only, backfat and age data only, and all sources of data. For feed intake, six different possible periods were used : the full three-month period (from weights 1 to 4), each of the three one month periods (weights 1 to 2, 2 to 3 and 3 to 4), and two 2-month periods (weights 1 to 3 and 2 to 4). Breeding values based on FCR from the full three-month period as well as backfat and age data were used as a reference for evaluating the accuracy of other sets of breeding values.
The current official evaluations for FCR in Canada are based on assumed genetic correlations with FCR of 0.16 for backfat and 0.47 for age to 100 kg. In the data analysed in this study, phenotypic correlations with FCR were 0.40 for backfat and 0.25 for age to 100 kg. Evaluations were computed first using the correlations assumed in official evaluations, and second assuming the genetic correlations were equal to the phenotypic correlations found in this data.

RESULTS AND DISCUSSION

Correlations between each set of breeding values and the reference (best possible) breeding values are shown in table 1. With the current official system used in Canada, the correlation between EBVs based on backfat and age only (EBVO) and EBV based on all data (EBV1-4) was 0.50. Since the rate of genetic change is proportional to the accuracy of selection, using individual feed intake records for the full finishing period has the potential to double the current rate of genetic progress for FCR. Significant increases can also be achieved with smaller feed intake recording periods. For example, recording feed intake during the third month has the potential to increase progress for FCR by as much as 67 %, and recording during the last two months by 90 %. The potential gains appear smaller with the second set of parameters. Since these parameters were derived from the data itself, they automatically lead to a better prediction of FCR from backfat and age, so that the value of adding feed intake data is less. Using feed intake data from the full period of recording results in an increase of 39 % in accuracy for FCR and of 22 % when only the third month of recording is used.
The parameters estimated from the test station data are more recent than those currently assumed. A stronger relationship between FCR and backfat thickness than currently assumed, if confirmed, could have important implications. Selection against backfat has received less emphasis in some programs because of its potentially unfavourable effects on intra-muscular fat, fat quality and sow longevity. However, in North America, slaughter weight has continued to increase substantially because of the positive effect on slaughter costs per unit of product. With increased carcass weight comes increased fatness, and the need to keep selecting against backfat. Also, there is evidence that meat quality, including intra-muscular fat, can be

maintained even when extra-muscular fat is at a relatively low level (e.g. Duroc results, Chesnais, 2002). Selection against backfat may therefore continue for as long as slaughter weight increases. The corresponding benefits in the genetic improvement of FCR can then be realized and should be adequately accounted for in selection indices.

Table 1. Relative accuracy of FCR evaluations based on no feed intake recording and partial recording compared to full recording

	Parameters from official system		Parameters from recent data	
	Correlation with EBV1-4	Increase from EBV0	Correlation with EBV1-4	Increase from EBV0
EBV0*	0.50		0.72	
EBV1-2	0.72	44 %	0.81	13 %
EBV2-3	0.69	38 %	0.78	8 %
EBV3-4	0.83	67 %	0.88	22 %
EBV1-3	0.83	67 %	0.88	22 %
EBV2-4	0.95	90 %	0.96	33 %
EBV1-4	1.00	100 %	1.00	39 %

* EBV0 = estimated breeding values (EBV) based on backfat and growth only while other numbers indicate the period of feed intake recording that was included in addition to backfat and growth data e.g. EBV1-2 used FCR between the first and second weighing.

There are other avenues for improving selection for FCR besides refining the estimation of its relationships with backfat and age. One may be to use average daily gain (ADG) instead of age. ADG during the feeding period may be more closely related to FCR than days to 100 kg. The increase in genetic improvement for FCR may be worth the cost of weighing the pigs at 30 kg. It would be more economical for breeders to weigh pigs once more than to start recording individual feed intake. However, larger correlations between FCR and ADG than between FCR and age to market are partly to be expected since ADG is a measure of growth during the same period when feed intake is usually recorded. Variation for FCR prior to 25 kg live weight should be considered when examining the use of ADG rather than age to slaughter weight.

If not all animals are recorded for feed intake, the gains for FCR will be lower. How much lower depends on whether both sexes are recorded, and how many in each sex. In some selection programs, one or two boars per litter may be recorded for individual feed intake, each for a period of about 30 days. If it is impractical to record individual feed intake, recording data on a pen basis could be considered as an alternative. Various possibilities exist for using pen-recorded data. For example, Brisbane and Chesnais (1998) found that if pigs were penned in groups of 12 with littermates and half-sibs together, the expected increase in progress for FCR would be 77 % as much as with full individual recording. Thus, pen recording on all animals could give more improvement than partial individual recording.

There is a need to balance investment for progress in FCR with investment for progress in other traits such as litter size, growth or carcass and meat quality. Feed recording is less valuable for dam lines, because of the large value of maternal traits. For example, increasing number born by 0.4 pigs could be equivalent to 5 years of potential gain from feed intake recording. Even in sire lines, reducing days to market by an extra 2.5 days or increasing lean yield by 0.6 % would be just as valuable as the extra feed savings for Canadian pork producers. However, once breeding businesses have optimized selection for other traits, the potential value of improvements in FCR for commercial production is such that at least some feed intake recording at the breeder level would be worthwhile.

CONCLUSION

Selection for lean growth rate has improved FCR substantially in the past, and progress is increasing (currently about 2 kg of feed per hog per year in the Canadian Swine Improvement Program). It might be possible to improve gains made through lean growth by refining assumed genetic relationships between FCR and production traits, and by measuring other traits such as average daily gain. Recording individual feed intake could potentially double the progress for FCR. However, practical systems may involve recording males only, for a period of 1 to 2 months rather than the full growing period. Therefore, increases in progress for FCR of 50 % or lower are more likely. Partial recording for one month starting at 80 kg live weight or for two months starting at 25 kg live weight was 80 to 90 % as accurate as 3 months of recording. Pen recording of all animals may be more effective than limited individual recording. A combination of individual and pen recording might also be worthwhile, for example, individual recording for boars and pen recording for gilts. Feed intake recording may be less profitable than investments to improve traits such as growth, lean yield and litter size.

ACKNOWLEDGEMENTS

Financial support provided by National Research Council of Canada. Data provided by Centre de développement du porc du Québec inc. and Ontario Swine Improvement Inc.

REFERENCES

Brisbane, J.R. and Chesnais, J.P. (1998) *Proc. Nat. Swine Improv. Fed.* **23 :** 61-68.
Chesnais, J.P. (2002) *Adv.Pork Prod.* **13** : 217-226.
Kennedy, B.W. (1984) *Can. J. Anim. Sci.* **64** : 505-512.
Mrode, R.A. and Kennedy, B.W. (1993) *Anim. Prod.* **56** : 225-232.
Ollivier, L. (1986) *Proc. 3rd WCGALP* **XII** : 168-175.
Sather, A.P. and Fredeen, H.T. (1978) *Can. J. Anim. Sci.* **58 :** 285-289.